# Is taxing waste a waste of time? Evidence from a quasi-natural experiment in the Canton of Vaud, Switzerland*

Stefano Carattini[†,‡,§], Andrea Baranzini[‡] and Rafael Lalive[¶‖ **††‡‡§§]

1st June 2015

Preliminary version
(please do not cite without permission)

**Abstract**

This paper exploits a ruling decision of the Federal Supreme Court of Switzerland to causally assess the effectiveness of pricing garbage by the bag in the Canton of Vaud. We interview households twice and thus collect a panel of household waste data. We couple survey data with official cantonal data. With both datasets we find that pricing garbage by the bag reduces incinerated garbage per capita by about 40%. The reduction in incinerated garbage comes with an increase in the frequency of recycling. The seldom application of unit-pricing schemes does not seem to rely then on a lack of effectiveness. We address the question of political feasibility and assess an important gap between acceptability *ex-ante* and *ex-post*. The direct experience of pricing garbage by the bag improves the general public's perception in terms of both effectiveness and fairness. Willingness-to-pay per taxed bag more than doubles.

**Keywords:** Unit pricing; Recycling; Effectiveness; Policy evaluation; Acceptability; Social perceptions
**JEL Codes:** D62; D72; D78; H23; H31; Q53

*This paper is a chapter in the main author's thesis at the University of Barcelona, titled "Two to Tango: Trust, Taxation and the Economics of Environmental Policy". Comments from Jordi Roca are gratefully acknowledged.

[†]Corresponding author: stefano.carattini@hesge.ch.
[‡]Haute école de gestion de Genève, HES-SO // University of Applied Sciences Western Switzerland
[§]Faculty of Business and Economics, University of Barcelona
[¶]Faculty of Business and Economics, University of Lausanne
[‖]CEPR
[**]IFAU
[††]IZA
[‡‡]CESifo
[§§]IEW

# 1 Introduction

From an economic perspective, waste collection represents a private good since any additional bag or container generates additional costs to the community (rivalry) and since excludability can be introduced thanks to the use of e.g. special bags (Fullerton and Kinnaman 1996). Pricing garbage by the bag allows to attribute to households the relative waste management costs, according to the polluter pays principle, well-known since Pigou (1920). Pay-per-bag fees and other measures of waste taxation are not very diffused in developed countries, though (Halvorsen 2012). We see two potential reasons for this fact. First, local, subnational or national authorities may not have the interest to put these measures forward since their administrative costs may exceed the benefits from increased recycling and decreased incinerated waste. For instance, negative net benefits are suggested by the cost-benefit analysis of Kinnaman (2006), based on a series of estimates of unit pricing's effectiveness, including from pay-per-bag programs. However, most of these estimates are not driven by causal analysis. We target this issue by tackling the endogeneity and room for confounders inherent to most economic studies available so far. We thus shed new light on the question of effectiveness by providing a causal estimate. Second, unit-pricing schemes may face a lack of popularity hampering their political feasibility, as it is often the case for environmental taxes. Regressivity may be one of the reasons why the general public may dislike this type of measures (Fullerton and Kinnaman 1996, Husaini et al. 2007). Some mistrust surrounding the instrument, the 'real' rationale for its implementation and its effectiveness may also contribute to explain a potential lack of acceptability. We address these issues by evaluating pricing garbage by the bag's acceptability and perception by the public before and after its implementation. In this way, we provide empirical evidence on a question overly neglected by the existing literature.

To do so, we exploit the quasi-natural framework provided by a Federal Supreme Court of Switzerland's decision of July 4$^{\text{th}}$ 2011, which ordered the application of the polluter pays principle in the case of household's waste to all municipalities in the Canton of Vaud. This decision created a large wave of new implementations in the Canton's municipalities, having taken place on January 1$^{\text{st}}$ 2013. We use these municipalities as treatment group, whereas those already possessing such policy constitute the control group. We use interviews, before and after January 1$^{\text{st}}$ 2013, to assess the policy's effectiveness and changes in perception. Therefore we are able to isolate the effect of the policy on the amount of incinerated garbage produced by households, on the level of recycling and on its acceptability. This study is the first of its kind, to the best of our

knowledge.

Our results suggest that pricing garbage by the bag allows for a sharp drop in the volume of incinerated waste and spurs recycling of materials such as aluminum and organic waste. We compare estimates from the survey data with official data provided by the Canton. No matter the data used, on average the tax reduces incinerated garbage by about 10 liters per capita per week, to be compared to a prior level of about 27 liters per capita per week. Estimates are robust to the possible endogeneity of policy choice and simultaneity. We also find a large increase in acceptability following the implementation of the pay-per-bag fee, along with a better perception of the fee's effectiveness and a reduced feeling of injustice vis-à-vis the policy. In terms of stated willingness-to-pay for pricing garbage by the bag, the treatment generates an increase of at least 100% in the willingness-to-pay for a 35-liters bag.

## 2 Economic background

Since the '90s unit pricing has been the focus of many economic studies, which have attempted to assess its effectiveness (for a survey cf. Kinnaman 2006 or Yang and Innes 2007). Since unit pricing may have perverse effects, such as inciting to illegal dumping or to "waste tourism", when assessing its effectiveness it is important to look not only at the change in solid waste produced by households but also at the frequency of sorting, whose increase is the desired effect from taxation. Following Jenkins et al. (2003), the frequency of recycling should be assessed for each materials, facilitating in this way the possible conversion in monetary benefits which associates different prices to different raw materials.

The literature considers many of the different programs that have been implemented so far in different developed countries, namely pricing garbage by the bag (or by tags, stickers), weight pricing and subscription programs. In terms of effectiveness, subscription programs tend to underperform the other two schemes, as the marginal cost of additional garbage may be zero if households remain stuck with a given number of containers for which they subscribed (Kinnaman and Fullerton 2000; Kinnaman 2006). According to the review of Kinnaman (2006), pay-per-bag fees and weight programs perform in a very similar way (in common units, i.e. pounds of garbage reduction per dollar of user fee), but operating weight programs is generally much more costly. That is, it seems that the phenomenon of compressing waste to reduce volume under pay-per-bag fees (the so-called Seattle Stomp) does not represent a real issue for volume pricing. One would expect volume pricing to also incite consumers to look for less voluminous wrapping while

shopping (Jenkins et al. 2003).

The estimates for pricing garbage by the bag reviewed in Kinnaman (2006) range from about 1 to 10 kg of avoided incinerated waste per households per week per 1$ fee. Reported price elasticities of demand range approximately from -0.08 to -0.39 (Kinnaman 2006), pointing to incinerated garbage as a relatively but not completely inelastic good and thus supporting the fee's effectiveness. This reconciles unit-pricing schemes with other types of environmental taxes. Yet, we recall that the estimates in the literature may be biased due to endogeneity and confounders.

We should note at this point that recycling may exist also absent any price incentive, as a norm-lead private provision of a public good (cf. Bruvoll et al. 2002; Brekke et al. 2003; Halvorsen 2008; Hage et al. 2009; Viscusi et al. 2011; Halvorsen 2012; Abbott et al. 2013). That is, households may be willing to assume important costs to recycle and thus comply with norms. Bruvoll et al. (2002) estimate at 44 hours per year the time spent by Norwegian households in recycling activities. However, this private provision may not be sufficient to reach the social "optimum", as individuals can hardly participate to the provision of all public goods (Nyborg et al. 2006). Unit pricing thus introduces a monetary reward for the time spent recycling, decreasing its opportunity costs[1]. According to Thøgersen (1994), when unit pricing is implemented this monetary reward becomes the main rationale for recycling. Though, no evidence so far suggests the risk of motivational crowding-out, which may lead to a decrease in recycling as suggested in other fields of environmental taxation (see e.g. Bazin et al. 2004; Goeschl and Perino 2012).

On the question of public acceptability, the literature is much scantier. Distributional issues are evaluated by Kinnaman and Fullerton (2000), which estimate the income elasticity of incinerated garbage between 0.05 and 0.57 (thus making unit pricing regressive), and discussed by Husaini et al. (2007) with respect to the British legislation, which is very sensitive to this issue and as a result opposed so far to unit pricing. Besides their undesirable distributional effects, environmental taxes may be in general perceived as a constraining instrument, for instance as opposed to subsidies (Steg et al. 2006). Consistently, a recent strand of literature on the acceptability of carbon taxes emphasizes how the incentive effect of environmental taxes may be misunderstood by the public and this may make "Pigouvian" taxes be felt as Ramsey taxes unless revenues are earmarked (see e.g. Thalmann 2004; Dresner et al. 2006; Kallbekken and Sælen 2011; Kallbekken et al. 2011 and Carattini et al. forthcoming). Yet, the cross-country comparison of Husaini et al. (2007) suggests that, where implemented, unit pricing enjoys a relative popularity

[1]Facilitating recycling e.g. with curbside recycling also decreases its opportunity costs (see again Kinnaman 2006).

among the general public. This may be a signal that acceptability *ex-ante* and *ex-post* can differ. In this respect, the study of Thøgersen (1994) provides an interesting figure: public support for unit pricing is on average 51% in the Danish municipalities in its study, but increases to 79% when the interviewer emphasizes the net benefit that a standard household may enjoy once tax revenues are redistributed (lump sum) to the population.

In Switzerland unit pricing exists since about two decades, but in a very heterogeneous fashion. This heterogeneity is the result of the principle of subsidiarity, according to which municipalities have the right to decide their own way to deal with waste management unless cantonal or federal laws prescribe otherwise. While unit pricing is much diffused in the Swiss-German area, its application in the Latin parts of the country is limited to the Cantons of Fribourg and Neuchâtel (unit pricing introduced in 2012) and to some municipalities of the Cantons of Jura, Ticino and Vaud. These cantons, along with Geneva, are known to have been historically reticent to such policy. For instance, the population of Jura rejected unit pricing in a public ballot in 1998. A limit to the principle of subsidiarity comes however from a series of 1997's law articles aiming at protecting the environment and imposing a principle of causality in the way waste collection is managed, thus forcing in theory the implementation of unit pricing at the municipal level. In the Canton of Vaud these articles were nevertheless not enforced until a simple citizen of a municipality called Romanel-sur-Lausanne initiated a lawsuit against the local government for not respecting the principle of causality in financing waste collection. The final ruling of the Federal Supreme Court in favor of this citizen started a legislation process at the cantonal level that eventually lead to a large wave of unit pricing's implementations in the Canton's municipalities. Indeed, the Supreme Court required the implementation of unit-pricing schemes financing most of waste collection, while keeping lump-sum taxes as a complementary source of revenue. We exploit this exogenous source of variation as basis for the identification strategy.

# 3 Methodology

## 3.1 Empirical framework

We anticipated a general weakness common to the previous studies, which relies on the policy endogeneity and the possibility for confounders to bias the estimations (cf. Besley and Case 2000). Two sources of endogeneity are acknowledged by Kinnaman and Fullerton (2000). On the one hand, environmental-friendly communities may be relatively more likely than others to introduce a unit-pricing system. Cross-sectional comparisons

may thus overestimate the policy's effectiveness, since these communities may generate lower amounts of garbage anyway, i.e. regardless of the policy. On the other hand, communities with very high levels of garbage per capita may consider to implement such policy to converge towards a "standard" level of garbage production. Cross-sectional comparisons may thus underestimate the policy's effectiveness. Kinnaman and Fullerton (2000) attempt to identify the direction of (and correct for) this self-selection bias by estimating in a first stage the endogenous likelihood of implementing a unit-pricing system (see also Dijkgraaf and Gradus 2004, 2009 for similar attempts). Their finding suggests that the second source of bias may dominate, i.e. simple cross-sectional analysis would underestimate the policy's effectiveness. Time-series analyses for the same community, as in Fullerton and Kinnaman (1996), do not face this issue, but, absent any control group acting as counterfactual, estimates may be biased by confounders (i.e. simultaneity). This bias may be very large if garbage is measured at different moments of the year, as seasonal variation may be considerable (cf. Sterner and Bartelings 1999; Yang and Innes 2007). Other elements, such as citizen's environmental friendliness, may also change over time. Non-tax policies (e.g. awareness-raising campaigns) may also affect the amount of solid garbage produced by households. In Fullerton and Kinnaman (1996) the authors collect data for other communities, regarded as similar, in an attempt to correct their estimates.

Our empirical approach aims at overcoming these issues. We collect data for households both in a treatment and a control group before (in 2012) and after the treatment (in 2013) and apply a difference-in-difference approach. Our treatment and control groups are defined more in detail in the next subsection. To formalize and illustrate our approach (cf. Angrist and Pischke 2009), we apply it to two illustrative municipalities, say Begnins (Be, treatment group) and Agiez (Ag, control group). Household $i$'s garbage production in municipality $c$ at time $t$ is given by $\mathrm{Y}_{1ict}$ in presence of treatment and $\mathrm{Y}_{0ict}$ otherwise. We assume the level of garbage production absent any treatment to be dependent on time ($\lambda_t$) and municipality characteristics ($\gamma_c$ the municipality-specific fixed effect) such that:

$$E(Y_{0ict}|c,t) = \gamma_c + \lambda_t \tag{1}$$

Assuming parallel trends and given generally uniform and linear pricing across municipalities[2], we assume $\beta$ to measure the effect of treatment with the treatment status being defined by $D$, i.e. $\beta$=E($\mathrm{Y}_{1ict}$-$\mathrm{Y}_{0ict}|c,t$). Hence:

[2] 1 Swiss franc (close to parity with the US dollar at the time of writing) for a 17-liters bag and 2 Swiss francs for a 35-liters bag.

$$Y_{ict} = \gamma_c + \lambda_t + \beta D_{ct} + \epsilon_{ict} \tag{2}$$

where the error term $\epsilon$ is such that $\mathrm{E}(\epsilon_{ict}|c,t)=0$.

Taking the same example as before, the difference-in-difference approach implies estimating (2) with $Be_c$ being a dummy variable for the municipality of Begnins and thus taking value 1 for Be and 0 for Ag. $\gamma$ thus measures the fixed effect specific to Be, compared to Ag. Since we define $Be_c \cdot d_t = D_{c,t}$, with the dummy variable $d_t$ taking value 1 for 2013 and 0 otherwise, $\beta$ still measures the effect of treatment. Taking Begnins and Agiez as representative of the two groups and recalling that the treatment takes place in 2013, we can assess the counterfactual:

$$E(Y_{0ict}|c{=}Ag,t{=}2013) - E(Y_{0ict}|c{=}Ag,t{=}2012) = \lambda_{2013} - \lambda_{2012} \tag{3}$$

The effect of treatment $\beta$ can thus be isolated from what is observed in the treatment group as in (4), taking into account the counterfactual. (5) gives the difference in difference:

$$E(Y_{1ict}|c{=}Be,t{=}2013) - E(Y_{0ict}|c{=}Be,t{=}2012) = \lambda_{2013} - \lambda_{2012} + \beta \tag{4}$$

$$\begin{aligned} &E(Y_{1ict}|c{=}Be,t{=}2013) - E(Y_{0ict}|c{=}Be,t{=}2012) \\ &-(E(Y_{0ict}|c{=}Ag,t{=}2013) - E(Y_{0ict}|c{=}Ag,t{=}2012)) = \beta \end{aligned} \tag{5}$$

If the underlying assumptions are verified, $\beta$ is unbiased and measures the average causal effect of our treatment. In this framework, both *compliers* and *defiers* may be averaged out when computing the effect of treatment, since the treatment may crowd out the intrinsic motivation for recycling of some households. Municipality-specific fixed effects are evened out in the difference-in-difference approach, as shown by (6):

$$\Delta Y_{ict} = \Delta\lambda_t + \beta\Delta D_{ct} + \Delta\epsilon_{ict} \tag{6}$$

Since households characteristics may vary between municipalities and groups, we conservatively introduce a vector of control variables such as $X'_{ict}$ for household $i$ in municipality $c$ at time $t$ to test the robustness of (2):

$$Y_{ict} = \gamma Be_c + \lambda d_t + \beta(Be_c \cdot d_t) + X'_{ict}\delta + \epsilon_{ict} \tag{7}$$

However, some of the outcomes that we observe are binary. Hence, a linear model

may provide a poor approximation. We may thus want to compare linear estimates with models that are logically consistent with the binary $Y_{ict}$. For instance, a variable capturing whether a household $i$ in municipality $c$ sorts at time $t$ a given material takes either value 1 if the household does or value 0 if it does not. Independent variables, including the treatment, are thus expected to contribute to explain the likelihood of the observed sorting choice. In this case, a Probit model would be more appropriate. We may want to rewrite equation (2) as a probability model. The fixed-effect panel data model now writes as:

$$Pr(Y_{ict} = 1) = Pr(Y^*_{ict} > 0) = Pr(\epsilon_{ict} > -\gamma_c - \lambda_t - \beta D_{ct}) = F(\gamma_c + \lambda_t + \beta D_{ct}) \quad (8)$$

where F is supposed to follow a normal distribution. Hence, partial effects (PE) are given by
$PE = Pr(Y_{ict} = 1|\bar{x}_{(D_{ct})}, D_{ct} = 1) - Prob(Y_{ict} = 1|\bar{x}_{(D_{ct})}, D_{ct} = 0)$ if the change is discrete also in the independent variable, i.e. the treatment. In this case $\bar{x}_{(D_{ct})}$ stands for the mean of all variables but $D_{ct}$ (cf. Greene 2011). The same would apply to model (7). PE for continuous independent variables would be obtained as $PE = \frac{\partial F(.)}{\partial x}$ which is obtained by multiplying $\beta$ for the normal density so that $f(x'\hat{\beta})\hat{\beta} = \hat{f}\hat{\beta}$.

However, since for a fixed $T$ the number of unknown parameters $\gamma_c$ increases with $N$, such specification would face the incidental parameters problem, which implies that the coefficients for the municipality-specific fixed effect are inconsistent. Applying a random-effect model allowing for a Chamberlain/Mundlak correction introducing the mean of time-varying variables in the main specification would help, but this would not be possible absent time-varying independent variables. We can still estimate (8) by "brute force" (cf. Greene 2011), knowing that this technique introduces an upward bias of 100% when $T$=2 as in this context.

### 3.2 Treatment and control groups

Unit pricing in the Canton of Vaud exists since the early '90s. In July 2012, 78 municipalities over 326 had either a pay-per-bag fee, a weight-pricing system or an alternative scheme which consists in paying a fee anytime an individual opens one of the municipal containers at a drop-off center. We do not include in the control group municipalities introducing lump-sum taxes during the treatment period, municipalities changing their status due to merging processes as well as municipalities having opted for a pricing scheme which is not pricing garbage by the bag. Eventually, we keep 50 municipalities. The treat-

ment group is composed of all municipalities introducing a pay-per-bag fee on January 1st 2013 and whose decision was formalized at the time of starting the interviews[3]. We exclude municipalities implementing other pricing schemes or introducing lump-sum taxes in the same time as unit pricing, for sake of consistency with the control group. New lump-sum taxes are avoided not to bias the analysis of acceptability. Again, merging municipalities are dropped. For the treatment group we consider 20 municipalities.

Since households are the decision unit for garbage and recycling, Jenkins et al. (2003) advise to use household data to evaluate unit pricing's effectiveness. We thus asked a marketing firm to deliver 30 randomly-selected addresses for each of these 70 municipalities. For some municipalities less than 30 (but always more than 12) addresses were available. Overall we received 1380 and 599 addresses for the control and treatment groups, respectively. We administered the first round of interviews in November and December 2012 and the second round between April and June 2013. At the first round we collected data from 228 and 124 households for the control and treatment groups, respectively. In theory, this would imply a response rate around 20%. However, we note that due to time and budget constraints we could not contact all households whose addresses were available. Among these 352 households, 193 participated also to the second round. 193 is thus the size of our panel. The response rate at the second round is close to 55%. The sample is composed of 107 (86) households in the control (treatment) group. This panel is the main source of data for our estimations. Yet, in what follows we also compare household panel data with official data from municipalities. When official data is available, it is for all municipalities in the Canton. Control and treatment groups can thus be defined over the whole Canton (see subsection 4.3).

### 3.3 External validity

Use of survey data implies that we may face a selection bias. The question of external validity is particularly important when assessing pay-per-bag's effectiveness, whose estimate should be representative of the general treatment effect. However, since we select a series of municipalities in both groups and the number of addresses received is bounded at 30 disregarding the municipality's size, our sample is not conceived to be representative of the cantonal population[4].

[3]Despite the large uncertainty surrounding the legislative process at the municipal level in the autumn of 2012, most municipalities introduced the unit-pricing scheme on January 1st 2013. However, some municipalities postponed its implementation to later periods in the year or to 2014.

[4]For illustrative purposes, comparison of the sample with the cantonal population can be done on the basis of Tables 1 and 2, which show for a series of socioeconomic variables the average values for our sample and for the cantonal population.

We tackle the issue of external validity as follows. First, we use socioeconomic controls to compare for each group the characteristics of the households participating only to the first round of interviews with the sample interviewed twice, i.e. our panel. In Table 1 we highlight all variables for which the statistical test suggests that the averages are different between the samples. A few variables are concerned, e.g. education, income, distance from collection centers. Data in Table 1 allows also to compare the characteristics of the treatment and control groups. Indeed, since we approximate from the control group the unobserved counterfactual, we need the two groups to be as similar as possible (*ex-ante*). We exclude from this comparison data on solid waste and recycling, since in this specific context the control group has already been treated. We verify in a later stage that the choice of an already-treated control group has no implications for this study (see section 4). The comparison of panel data between the treatment and the control groups suggests that they are fairly homogeneous. However, given also the risk of sample selection, we present in the next section estimates from both models (2) and (7).

Second, we provide a series of robustness tests comparing estimates from our survey data with official data measured by municipalities. Municipalities provide yearly figures in kilos for aggregate solid garbage per capita[5]. We obtained data since 2008. This data allows us to perform the following tests. First, we can compare the evolution of solid garbage per capita and assess whether treatment and control groups follow parallel trends from 2008 to 2012 (cf. Angrist and Pischke 2009). Second, we can run estimations of model (2) with the official data for the subset of municipalities composing the survey sample and compare with the survey estimates. Densities are available to convert from weight (kilos) to volume (liters). In this way we can check whether the households answering to our questionnaire are different from the underlying population of the municipalities concerned. Third, we can exploit the full scope of the official data and run estimations of model (2) with all municipalities already pricing garbage by the bag by the end of 2012 as (extended) control group and all those starting to price garbage by the bag on January 1$^{st}$ 2013 as (extended) treatment group. This procedure is important to determine whether our selection of municipalities has any influence on the outcomes studied here. Fourth, comparison with other types of policy, such as based on weight, is also undertaken. Fifth, we exploit the municipalities postponing the implementation of unit pricing to 2014 and allow them to form a secondary control group. Model (2) is thus estimated with the usual treatment group and this secondary control group.

[5]Straightforwardly, we do not have official data on acceptability. In this case inference relies completely on survey data.

### 3.4 Data and descriptive statistics

This section presents the survey data used for the main estimations. The survey is structured in three parts. In the first part, we ask households about their behavior regarding solid waste and recycling of the following 9 materials: PET, carton, paper, clothes, glass, cans, organic waste, batteries, and aluminum. The second part of the questionnaire concerns unit pricing's perception and acceptability. The final questions provide us with the standard socioeconomic variables (cf. Table 1).

Table 3 presents the descriptive statistics for the outcome variables concerning unit pricing's effectiveness: solid garbage per household and per capita, recycling of the 9 materials and attention to voluminous wrapping. Solid waste is measured in liters per week. This value is obtained by multiplying the number of bags used per week with their volume (17 and 35 liters are the most common sizes in Switzerland). 15 households do not report their solid waste production in either 2012 or 2013 (or both). Taking into account these missing values, total observations for solid waste are 371. Recycling variables take value 1 if the household sort a given material and 0 otherwise. Hence, we do not measure the intensity of recycling but rather the probability of doing it. Arguably we can assume that households stating that they recycle a given material do it in most cases, even though probably not in all. Viscusi et al. (2011) describe recycling as a dichotomous choice with corner solutions, i.e. people recycle or do not recycle at all. This is the result of the following proposition: if for a given household is desirable to recycle $n$ units of material, then it is likely to be desirable to recycle $n+1$ units (Viscusi et al. 2011). The choice of frequency over intensity of recycling clearly simplifies the task to interviewees, which are not asked to estimate the share of a given material that is recycled. This estimation may indeed be cognitively demanding and possibly lead to a substantial difference between stated and reported behavior (Sterner and Bartelings 1999). We apply a binary simplification also to voluminous wrapping: we ask to households whether they pay attention to wrapping or not.

Descriptive statistics are given for the treatment and control groups for 2012 and 2013. According to Table 3, the percentage of households recycling e.g. carton in the treatment group rises from about 84.9% to 96.5%, the difference being statistical significant at 1%. However, this should not be interpreted as the treatment effect. To assess the treatment effect one has to take into account also the change in recycling that may take place in the control group.

# 4 Empirical results: effectiveness

## 4.1 Survey results

We start this section by assessing the treatment effect on the amount of solid waste produced by households. Provided that there is an effect on solid waste, we then need to verify that this is accompanied by an increase in recycling and in the concern for wrapping materials, to ensure that households respond to the fee in a desirable way, i.e. not by simply compressing their waste, throwing it in public bins, in the containers of municipalities without the fee or in the nature. The top panel of Figure 1 shows the variation over time in the volume of solid waste per capita per week in the treatment and control groups. The bottom panel zooms on the difference and provides a first approximation of the difference in difference, i.e. the treatment effect, which is of about -10 liters and statistically significant, as indicated by the confidence intervals.

Column (1) in Table 4 translates this effect into numbers, by estimating model (2) with ordinary least squares (OLS)[6]. We introduce control variables in column (2) and thus estimate model (7). Since some missing values affect control variables, in column (2) the number of observations is slightly reduced, from 371 to 359. In all columns the dummy associated with the year 2013 is statistically significant. This confirms the need for a counterfactual. In this specific case, the counterfactual implies a decline of about 3 liters per capita per week, regardless of unit pricing. The treatment effect amounts to about -10.5 liters per capita per week. By introducing control variables in column (2), we test whether this effect is robust to possible differences in the groups' socioeconomic characteristics. Column (2) shows that it is. The coefficient for the treatment is indeed statistically unchanged. However, several control variables are statistically significant and the goodness-of-fit as measured by the within-$R^2$ also substantially improves. We thus point to model (7) as the appropriate specification and discuss the estimates accordingly.

In 2012, the average solid waste volume per capita per week in the treatment group was slightly above 27 liters. This implies that the treatment generates a decline in solid waste of about 40%. Comparison with other studies is still relevant, in spite of the possible endogeneity and simultaneity. In this respect we remark that the effect of Table 4 is in the range of what found by e.g. Fullerton and Kinnaman (1996), a decrease in volume of about 37%, and Yang and Innes (2007), a decrease in volume of about 27%.

The negative coefficient is however obtained by averaging out the response of each

[6]OLS is used in all specifications unless otherwise specified. Fixed effects are justified by a $\chi^2(2)$ of 32.08 ($p > \chi^2(2) = 0.0000$) in the Hausman test for model (2) and a $\chi^2(20)$ of 43.35 ($p > \chi^2(20) = 0.0018$) for model (7). We use clustered standard errors (clusters per municipality) in all specifications where it is justified by the standard heteroscedasticity tests such as modified Wald and Breusch-Pagan/Cook-Weisberg tests.

household, everything else equal. Hence, it is not sufficient to rule out the possibility of some motivational crowding-out. However, a careful examination of the data indicate that although there are a few households increasing their solid waste production, their number or the magnitude of the increase does not appear to be more important in the treatment than in the control group. Based on this evidence, we refrain from further analyses on the unlikely presence of motivational crowding-out.

From Table 4 we see that EU nationals tend to produce per week about 4 liters more of solid waste than their Swiss homologues (the reference case), whereas no effect is found for citizens of countries other than the EU and Switzerland. A possible explanation for the coefficient for the EU may rely on cultural differences. Data inspection suggests however that such differences exist also within the country. Swiss nationals native from cantons such as Appenzell Inner Rhodes, Fribourg or Valais produce on average lower levels of garbage. Although important cultural differences exist also between cantons (cf. e.g. Basten and Betz 2013), a compelling explanation may be that people from other Cantons (countries) may have more (less) experience with recycling. Given the limited amount of observations we do not push this discussion too far and leave it for further research.

Not surprisingly, a high level of education as measured by possessing an university degree is related to less solid waste per week per capita (about 8 liters) compared to having completed only the compulsory education (the reference case). It is indeed common in the literature to have pro-environmental behavior positively associated with education (cf. e.g. Jenkins et al. 2003 for the case of garbage). Professional categories have instead no effect (with respect to students). We control for income using the six categories of the questionnaire and thus mirroring the classification in the official statistics. The sixth and highest category is the dummy of reference. To deal with the many missing values, we include another dummy variable taking value 1 if income is not reported. The coefficient for this variable is negative and statistically significant as are those for other low-income categories (income 1 and 3), suggesting some self-selection in the income question related with lower incomes. The negative effect for low-income households is in line with the economic prediction, since high-income households have larger levels of consumption and higher opportunity costs of recycling (cf. e.g. Hong 1999). Gender, age and green membership have no significant effect on the amount of solid waste produced by the household. We emphasize the following qualification: socioeconomic variables are given for the household's representative answering the questionnaire, whereas waste management is rather a household decision.

We find a negative effect for the number of adults in the household. The literature

points to economies of scale (cf. e.g. Sterner and Bartelings 1999; Halvorsen 2008, 2012) and especially to a better allocation of recycling tasks within large households, taking into account the differences in opportunity costs (cf. Sterner and Bartelings 1999). Unfortunately we cannot control for the living area (cf. Sterner and Bartelings 1999), which could also be contributing to this effect. We know however whether the household owns or rents its housing, and in the Swiss context ownership is usually associated to single houses rather than apartments (cf. also Halvorsen 2012; Abbott et al. 2013). Table 4 shows that the coefficient for renting (with respect to owning) is not statistically significant.

The statistically significant coefficient for distance from a collecting center shows the importance of installing collection centers close to the final users reducing the households' cost of recycling. We relate this finding to the vast literature on the effectiveness of drop-off centers and curbside recycling programs (cf. e.g. Jenkins et al. 2003; Halvorsen 2008; Hage et al. 2009).

A graphical analysis similar to the one presented in Figure 1 can be done for all 9 recycling materials plus wrapping. For sake of space we summarize the relative finding in Table 5. Table 5 describes the changes in the frequency of recycling for the 9 materials for both groups and derives the implications for the treatment effect. For instance, in the case of PET there is no observed statistical change in the treatment group. However, there is a decline in the frequency of sorting in the control group. Therefore, taking the control group as counterfactual implies that absent the treatment the frequency of recycling would have declined also in the treatment group. The treatment effect is thus positive. This is the case of all materials but clothes, based on Table 5. The case of clothes may be peculiar, since this type of material tends to be recycled with a lower frequency. This may imply that households in our sample have not faced the issue of whether to sort or not clothes during the period between the two interviews. Following Table 5, it seems that there is no change in behavior related to the attention to voluminous wrapping. This is for the graphical analysis.

Table 6 reproduces the same approach of Table 4 for all recycling materials plus wrapping and thus provides robust evidence on the treatment's recycling-side. These estimates are more conservative than those given by the graphical analysis summarized in Table 5, since relying on clustered standard errors and controlling for the relevant socioeconomic characteristics and municipality-specific fixed effects. Since dependent variables measure a discrete change, we also run a Probit model, as detailed with respect to equation (8). Estimates from Probit are reported in Table 7. Since estimates from Table 7 are very similar to those obtained with OLS, taking into account the brute-

force bias (cf. Greene 2011), and given the lost observations when success or failure are perfectly predicted, we comment the empirical results based on estimates from Table 6. Probit models do not substantially improve the estimations controlling for socioeconomic variables, either[7].

Odd columns apply model (2) to the frequency of recycling. Even with clustered standard errors, the treatment effect keeps sign and significance as in Table 5 for all materials but PET and batteries. The year dummy is never significant, which introduces a difference compared to Table 4. Hence, no significant "exogenous" change in the recycling behavior takes place between 2012 and 2013. Treatment effects are the largest in the case of aluminum and organic waste. The estimate for aluminum suggests that pricing garbage by the bag leads almost a quarter of the sample to start sorting this material. It does not surprise that these two materials enjoy the larger increase in the frequency of recycling. Organic waste is mainly associated with bad smell and other practical issues, whereas aluminum often comes in tiny quantities which, taken alone, may not induce people to start sorting without monetary incentives. Conversations with local practitioners indicate that the increase in the number of households involved in sorting organic waste is associated with a decrease in the quality of the latter, with a higher presence of "foreign bodies". It is however suggested that this practices are related with a lack of experience rather than an attempt of cheating. A telling example is the use of non-organic bags for organic waste. There is also little evidence of diffused illegal or undesired practices in the context under observation, which reconciles with the Swedish context of Sterner and Bartelings (1999).

Even columns introduce controls as in model (7). Again, the use of control variables implies a slight reduction in the sample size, e.g. from 386 to 368 for recycling materials. Only the treatment effects for aluminum and organic waste are robust to the inclusion of control variables. That is, the most conservative estimates from columns (2) and (12) confirm that there is an increase in the frequency of recycling of organic waste (of about 14%) and of aluminum (of about 20%). These effects are not only statistically significant but also considerably large from an economic perspective. They imply that at least 20% of households in the sample adapt their behavior to unit pricing and start sorting at least one additional material. Regarding batteries, carton, glass and paper the coefficients remain positive but are no longer large enough to reach significance.

Statistically significant control variables include (depending on the specification): age, EU and rest-of-the-world citizenship, some socio-professional categories such as jobless, self-employed workers or managers (compared to students), distance and a few income

[7] All additional tables are available by the authors upon request.

categories (mainly low-income). We discuss the possible rationales for some of these effects. Age is positively associated with the frequency of organic waste, paper and PET recycling. Age itself may determine the likelihood of sorting these materials (cf. e.g. Jenkins et al. 2003; Hage et al. 2009), but it is also common that elderly enjoy large apartments whose rents are not adjusted to the current market prices. Again, we are not in position to control for the size of living area. Cultural differences linked with the nationality seem supportive of the evidence provided in Table 4, with Swiss nationals being probably better trained to recycling (cf. Halvorsen 2012 for cross-country comparisons of recycling habits). The number of children in the household seems to increase the frequency of recycling of PET, perhaps because children are made particularly aware of it at school. When significant, the effect of income is in most cases as expected: low-income households have a lower opportunity cost and are thus supposed to be more inclined to sort waste. Differences in opportunity costs may also be related to the socio-professional categories, even though we control for income (but with many missing variables). Indeed, leisure time may be differently allocated to managers compared to students or homemakers, everything else equal.

Finally, the effect of distance from the collection center is negative and statistically significant for all materials except for aluminum and batteries, which may be less difficult to transport than other materials. From Table 6 we can infer that a decrease in distance of about 10 minutes would lead to an increase in the frequency of recycling of about 6%.

### 4.2 Testing for confounders

The results presented so far seem confirming the relevance of the difference-in-difference approach, especially in the case of solid waste wherein we find a significant and non-negligible effect associated with the year dummy. However, we note that despite the presence of a control group we cannot completely rule out the risk of simultaneity, if there are novelties that concern only the treatment group. This may be the case of policies developed at the same time of the fee and aimed at matching the expected increase in recycling (e.g. new or more developed collection centers, programs of curbside recycling) or at raising awareness and facilitating the transition to a higher level of recycling (e.g. raising-awareness campaigns). Neglecting these policies, we would tend to overstate the effectiveness of unit pricing.

Hence, we contacted the member of the municipality's council in charge of waste management for all municipalities in the sample and administered a supplementary questionnaire trying to capture the variation in the number of curbside programs, of collection

centers, of skips, in the opening hours of existing collection centers and in the frequency of raising-awareness initiatives taking place between the two interviews. Of the 82 municipalities for which we observe at least one household, we obtained answers for 44. All non-tax variables are dummy and coded such that any change that is expected to rise the frequency of recycling and decrease the amount of solid waste (e.g. increasing opening hours, launching a raising-awareness initiative) takes value 1, whereas no change takes value 0. We inspect the data and exclude from the analysis all variables for which a positive value concerns less than 5 households, i.e. awareness-raising tools such as street stands and specific online websites. Own estimations indicate that these variables do not significantly affect the amount of garbage produced and dropping them has generally no effect on the main results. We also face a problem of multicollinearity, since many variables display pairwise correlations between 0.6 and 0.9. This is particularly true among new skips, but also between new skips and better opening hours and of course between having a new collection center and having more skips available. Hence, we generate a continuous variable counting the number of materials covered by new skips, which allows to avoid plugging in correlated skip dummies for each material. Table 8 gives descriptive statistics for the variables considered in this analysis for both the control and the treatment groups. We observe in Table 8 that these non-tax measures are not a prerogative of the municipalities in the treatment group, even though they take place in a much lesser extent in the control group. This may allow us to explain the "exogenous" effect related to the year dummy in Table 4. Therefore, we perform the same analyses as in the previous section to the restricted sample of households living in municipalities for which we have non-tax policy data, to test for the role of possible confounders.

Estimates from the relevant regressions are presented in Table 9. Since non-tax variables are not available for the whole sample, column (1) recalculates the treatment effect as in the respective column of Table 4 for the subset of households living in municipalities for which we possess data on non-tax measures of waste management. The treatment effect is statistically unchanged with respect to Table 4. The time dummy is instead now statistically non-significant. Column (2) adds non-tax variables. The coefficient for the treatment effect is slightly reduced but remains statistically unchanged with respect to column (1). Most non-tax variables are statistically non-significant and the goodness-of-fit is only slightly affected. As one expects, the coefficient for the number of materials covered by new skips is negative, and statistically significant. The coefficient for the curb-side program is also negative, but does not reach significance. At odds with economic intuition, we find a positive estimate for better opening hours, new collection centers (statistically significant) and unaddressed mailshots (very small). We do not have a straight

interpretation to these coefficients, which, to the contrary of the treatment effect, should be considered as correlations and not causal effects. What is crucial for us is the impact that possible confounders may have on the treatment effect. We find no impact: estimates from column (2) and (3), with the latter including socioeconomic variables, suggest that simultaneity is not an issue in this framework, based on the variables at our disposal. That is, the coefficient estimated in Table 4 is robust to the addition of non-tax measures which may take place at the same time that the unit pricing scheme itself. Own estimations indicate that introducing non-tax variables to the regressions of Table 6 on the frequency of recycling does not change their spirit, even though with non-tax and socio-economic variables we get closer to the constraint represented by limited degrees of freedom. The coefficient for organic waste, for instance, becomes 0.130, statistically undistinguishable from the 0.144 of Table 4 and remains statistically significant.

### 4.3 Official data

#### Parallel trends

We exploit the official data reported by all municipalities in the Canton and follow the outline presented in section 3. We look at the parallel trends by comparing the average weight of incinerated waste produced by municipalities in the treatment and in the control group. Yearly data are available since 2008, normalized by the number of inhabitants (i.e. kilos per capita). To start we stick to the treatment and control groups as defined in the previous sections, i.e. the subsample of municipalities where we administered the interviews. We exclude from the control group those municipalities having introduced a unit-pricing program between 2008 and 2012, as they deviate from a proper counterfactual. 25 municipalities over 39 experience a policy change during the period. Hence, we compare the treatment group with a subsample of forerunner municipalities from the control group. We compare 14 with 19 municipalities. Figure 2 shows the parallel trends. Both groups follow a horizontal path with only a limited amount of variation around the steady line given by their level of incinerated waste in 2008. This variation is marginal compared with the large difference in solid waste production between the two groups, which is narrowed only in 2013 when the treatment group is subject to treatment. Data inspection confirms with placebo tests that the trends are statistically parallel.

Figure 2 supports the use of an already-treated control group, which could have represented a caveat since in theory the evolution over time may be different for households that are submitted to a tax compared to those that are not. In this respect, official data allows us to perform additional tests, since, despite the imperative given by the Supreme

Court's ruling, the implementation of an unit-pricing scheme in a group of municipality is postponed to January 2014 or a later period in 2013 (see below). This group of possible recalcitrants is composed of 121 municipalities and thus accounts for about one third of the total in the Canton.

Figure 3 shows the trends for the extended treatment and control groups, i.e. taking into account all municipalities in the Canton and not only those considered by the survey data, including the possible recalcitrants. Consistently with the survey approach merging municipalities are omitted from the analysis as well as three municipalities introducing a unit-pricing program during the summer of 2013 (Renens, Epalinges and Belmont-sur-Lausanne). Given the use of yearly data, these three municipality would bias the outcome downward if they would be considered as part of the treatment group. We first stick to pricing garbage by the bag as treatment and then expand to unit pricing in general, i.e. including the few weight programs implemented in the Canton. In 2008 only 7 municipalities have a weight program, compared to 27 with pay-per-bag fees. In 2012 (2013), 14 (18) municipalities have a weight program, compared to 58 (217) with pay-per-bag fees.

Figure 3 presents the same pattern as Figure 2 for the extended volume treatment (left diagram). Interestingly, the secondary control group almost perfectly matches the treatment group. A slight divergence appears after 2011 but in statistical terms we can still say that the three groups follow a parallel trend. The same observations apply to the whole sample of municipalities (including weight pricing, right diagram). There is thus no signal of selection into treatment. Thereafter, we consider the former possible recalcitrant municipalities as simple "postponers".

Finally, based on Figures 2 and 3, we also stress the persistence of unit pricing's effect on solid garbage per capita.

**Survey, pay-per-bag and unit pricing samples**

To estimate the treatment effect we focus first on the amount of solid waste sent to incineration in 2012 and 2013 by the subset of municipalities included in the survey data. Estimates are provided by Table 10. The first column shows that the implementation of pricing garbage by the bag causes a reduction in the amount of per capita solid waste of about 86 kilos per year. An "exogenous" reduction associated with the time dummy is again present, confirming the relevance of the difference-in-difference approach. The goodness-of-fit is much higher than in the survey estimations, probably due to a lower variability in the (average) per capita waste production between municipalities than be-

tween households. Albeit the treatment effect is now given in kilos, it may be converted in liters for the purpose of comparison using the solid waste density provided for Switzerland by BAFU (2014). On average the weight of one liter of solid waste is in the range of 0.125-0.146 kilos. Given a weekly reduction of about 1.65 kilos, in liters we obtain a treatment effect ranging from 11.3 to 13.2 liters per capita per week. This figure is only slightly above what assessed with the household data, over a shorter period. In percentage, with respect to a previous level without treatment of 244 kilos (some 30 liters), we find a reduction slightly above 35%. In theory, household and municipal data may differ since municipal data include waste production from firms, which may behave differently than households, in particular if the tax implementation may lead them to bring their waste directly to incineration. Nonetheless, the comparison of estimates from Tables 4 and 10 indicates that the two methods provide comparable and very close estimates for the effectiveness of pricing garbage by the bag. In this respect, we do not find such a difference between volume and weight measures as found in Fullerton and Kinnaman (1996). As noted by **?**, a difference is likely to exist mainly when volume pricing is represented by containers instead of smaller units such as bags. This consistency seems also very reassuring in view of the external validity of our survey results. Yet, further tests are provided in what follows.

Dealing with possible confounders, we extend once again the specification of column (1) to control for the other policies that municipalities may have implemented over the period of observation. We do this in column (3). Since we possess data on non-tax policies only for some of the municipalities concerned by the household survey, we shall compare the treatment effect with or without these controls based on the same sample. Hence, column (2) estimates the same specification as in column (1) on the restricted sample of municipalities whose non-tax policy change is known. Even though the reduction in the observations is non-negligible, the coefficients of interests are statistically unchanged between columns (1) and (2). As expected, introducing non-tax policies leads the coefficient for "exogenous" changes related with the time dummy to become statistically non-significant. Hence, it seems that we are able to capture the bulk of factors other than pricing garbage by the bag acting upon the amount of solid waste incinerated. Again, non-tax policies reduce the treatment effect but not in a statistically significant way. Most non-tax control variables are statistically non-significant and the goodness-of-fit improves only marginally. The coefficients for the number of materials covered by new skips and the better opening hours are negative as the economic intuition would suggest, but do not reach statistical significance. Statistically significant is instead the coefficient for a new collection center: controlling among others for the new skips for recycled materials,

a new collection center is related to about a dozen additional kilos of yearly solid waste per capita. We recall that an additional collection center does not represent an exogenous treatment.

Official data also allow us to test whether the treatment effect found so far applies only to the subset of municipalities chosen in the survey data or whether these are representative of the Canton as a whole. As a result, we reproduce in Table 11 the same approach of Table 10 using all municipalities in the Canton. Municipalities considered as "postponers" are excluded from columns (1) and (2) and used as secondary control group in column (3). The treatment in column (1) is still pricing garbage by the bag whereas in (2) all unit pricing schemes are taken as treatment. We recall that data on non-tax policies are not available for the full set of municipalities and thus not used here. Estimates from Table 11 provide further evidence on the external validity of the previous results. Based on 438 observations, the treatment effect is estimated in column (1) at about 80 kilos per capita per year of reduced solid waste. This figure is quantitatively undistinguishable from the previous estimates. Converted in liters per week, it implies a volume reduction going from 10.5 to 12.3. Introducing data also on weight programs does not affect the treatment effect in any statistically perceptible way, cf. column (2). However, since only 4 municipalities opt for a weight-based treatment it is difficult to infer from this outcome that effectiveness does not differ across specific pricing schemes.

Column (3) is estimated using the pricing garbage by the bag extended sample as in column (1) but with the secondary control group in place of the "standard" control group used so far. The magnitude of the treatment remains constant. This corroborates the graphical evidence provided by Figure 3: in this framework, using an already-treated control group rather than a not-yet-treated control group has no effect on the evaluation of the treatment. We do not find any significant difference also on the time dummy, even though in column (3) the relative coefficient does not reach statistical significance.

In sum, this section provides evidence of the following 8 empirical facts. First, pay-per-bag fees allow for a sharp reduction in the amount of solid waste produced by households, which is estimated at about 10 liters per capita per week no matter the type of data used (survey or official data). Second, this sharp reduction is accompanied by an increase in the frequency of recycling of e.g. organic waste and aluminum (amongst others, depending on the specification). Third, the difference-in-difference approach is completely justified in view of the presence of factors others than unit pricing affecting solid waste production. Fourth, this section shows that these factors can be associated with a series of non-tax policies put in place by municipalities in both the treatment and the control group. Fifth, this section addresses this source of simultaneity and shows that

the estimation of the treatment effect on solid waste production is robust to possible confounders such as non-tax policies. Sixth, this section tests whether the choice of an already-treated control group has implications on the estimation of the treatment effect and provides clear evidence that it does not. Seventh, this section provides graphical and regression-based evidence displaying the mechanics of pay-per-bag fees: treatment and control groups follow parallel trends with a constant gap in the amount of solid waste produced between the two groups as long as the treatment group is not subject to treatment. When it is, it converges "immediately" (i.e. within one year) to the treated "equilibrium". The secondary control group behaves as the treatment group until the latter is treated. Afterward, all groups follow the trend with a gap now between the treatment and the secondary control group. No signs are given of a vanishing effect of the treatment. Eighth, given that all conditions for the identification strategy are fulfilled (absence of endogeneity and simultaneity, parallel trends), causal interpretation of estimates is allowed.

# 5 Empirical results: acceptability

## 5.1 Regressivity

Regressive pay-per-bag fees as discussed in section 2 imply that as household income gets higher, the share of income spent in special garbage bags gets smaller. That is, incinerated garbage is a positive function of income, but the former reacts less than proportionally to a change in the latter. To estimate whether this is the case also in our data, we need to couple data on income with data on solid waste and estimate an income elasticity. Our data allow us to do it, since we possess both variables and a set of controls, but a few simplifications are required by the way income is coded. Since we possess only categorical and not continuous observations for income, we need to take a point in the income range such as the midpoint to build a continuous variable. Income is also censored at its highest value and so we take the bottom end of the interval as value for the category of income 6. We then take the log of this newly-built variable, as well as of others continuous variables such as solid waste per capita, age, distance and the number of individuals in the households (summing the number of children, which may be zero, and adults). 205 observations are available when regressing solid waste per capita on income (and controls). The estimate for income elasticity is displayed by Table 12. A value of 0.4 implies that, everything else equal, pricing garbage by the bag has indeed a regressive effect.

However, from an equity perspective a *ceteris paribus* analysis may not be necessarily justified in this framework, since in many municipalities the implementation of unit pricing comes with a reduction in the lump-sum taxes that households have to pay to finance waste management. Since lump-sum transfers are recurrent instruments to decrease the regressivity of environmental taxes (cf. e.g. Baranzini et al. 2000), the net distributional effects are thus ambiguous. We are also aware of other forms of social cushioning taking place in a minority of municipalities, such as the free distribution of a given amount of bags to families with infants. Determining which distributional effect dominates in the municipalities experiencing a reduction in the lump-sum taxes is beyond the scope of this paper, but we believe that there is room for a better assessment of the regressive impacts of unit pricing, which should go beyond the simple computation of income elasticity so common to the literature.

### 5.2 Perceptions

We address the questions of acceptability and policy perceptions by applying to the relative questions in the survey data the same difference-in-difference approach used with respect to the question of effectiveness. Though, we acknowledge that in this case a conservative stance would imply refraining from claiming causality, since a large policy change as the one under scrutiny may change perceptions also in the control group. A second difference with the previous section is that we do not attribute answers to the questions of acceptability and policy perception to the household but rather to the individual that is interviewed. Nevertheless, given our framework, we consider systematic bias in this respect unlikely.

Keeping this in mind, we proceed with the analysis of the main indicators linked with acceptability. Several variables are at our disposal. Summary statistics are reported in Table 13. Following the literature review of section 2, we select the outcomes of interest based on three axis: perceived effectiveness, fairness and acceptability. Based on the previous discussion, we may expect perceived effectiveness to increase in the treatment group once the fee is seen at work. This may help to reduce some hostility with respect to the fee and perhaps improves also the perception of fairness. Perceived effectiveness and fairness are plausible determinants of acceptability.

We have at our disposal three measures concerning perceived effectiveness. These are *perceived effect on own behavior*, *perceived effectiveness* and *perceived effect on the environment*. The latter is expected to capture the expectation that individuals have of the behavioral change driven by pricing garbage by the bag in terms of solid waste

produced by households (i.e. *perceived effectiveness*) and how this behavioral change would in turn affect the environment. *Perceived effectiveness* and *perceived effect on the environment* are thus expected to yield a very similar outcome, unless people would consider the environmental effect of reduced incinerated waste as negligible or would not expect proper management of recycled materials. As indicated by Table 13, answers to all the three questions present a very similar pattern. Hence, given a larger scope and a relative low number of missing values, we select *perceived effect on the environment* as dependent variable in the regressions (cf. columns (1) and (2) of Table 14). Socio-economic controls are included in even columns. Since all variables in this subsection are binary, we compare again estimates from OLS regressions with a fixed-effect Probit model estimated with Greene's (2011) brute force method (cf. Table 15). Taking into account the bias implied by the incidental parameters problem, we observe that both OLS and the uncorrected Probit estimates tend to overestimate the coefficient for the treatment effect. Though, the latter is clearly statistically significant, even when applying the correction suggested by Greene (2011). That is, the treatment is associated with at least one household over ten changing its opinion in favor of the fee's effectiveness. Causal interpretation may be allowed, given that no change affects the control group[8].

Another variable allows us to double check whether the experience of unit pricing improves the understanding of environmental taxes' incentive effect. This variable measures the support for the use of revenues in a different realm than waste management. Economic theory suggests indeed to design environmental taxes so that the tax rate is "optimal" (assuming that marginal benefits and costs are known) and leave the revenues free to fund the projects with the highest social return (which may include reducing existing distortionary taxes). However, most members of the general public ask instead to earmark environmental tax revenues for environmental purposes, since they do not understand how improvements in environmental quality can be obtained otherwise. That is, environmental taxes are perceived as a pretext for the government to raise new revenues, unless explicit earmarking for environmental purposes is introduced. We use *use of revenues for other purposes* as a second proxy for the understanding of unit pricing's incentive effect. Columns (3) and (4) of Tables 14 and 15 display a large and clearly significant coefficient for the treatment. Again, no change affects the control group. As a result, we may infer that following the experience of unit pricing, an important proportion of respondents (at least one fourth applying Greene's correction) becomes aware of the

[8] We acknowledge that there could be no effect in the control group because of the treatment in the treatment group, i.e. a correct estimation of the counterfactual might have yielded a non-zero coefficient. Though, it is arguably more plausible that the statistically non-significant effect for the time dummy suggests that the control group was not affected neither by the treatment nor by other factors taking place in 2013.

incentive effect of environmental taxes. Looking at Table 13, we observe that the *ex-post* mean of this variable in the treatment effect attains the level of the control group. The same applies for the variables directly related with perceived effectiveness.

In terms of fairness, we observe whether individuals believe (*ex-ante* and *ex-post*) that unit pricing is unfair based on the following two criteria: 1) households already pay enough taxes; 2) the tax is paid also by households that sort their garbage. We also explore the feeling of inequity, since this type of policy opposes two different concepts of justice, the polluter pays principle, advocating for higher fiscal revenues from bigger polluters, and a social equity principle, stating that fiscal revenues raised from a given individual should be a positive function of its income. Given the regressivity of this type of policy (cf. subsection 5.1), the two concepts may be in open conflict, absent any social cushioning or redistribution to households. We thus ask individuals whether they perceive pricing garbage by the bag as inequitable and legitimate and we assess their demand for social cushioning. Tables 14 and 15 include these variables.

Columns (5) to (8) reports the estimates for unfairness. Looking at the sign of the coefficients for treatment we observe that experiencing the functioning of unit pricing is related to a lower frequency of answers stating a feeling of unfairness driven by both 1) having to pay new (but not necessarily more) taxes (cf. columns (5) and (6)) and 2) having to pay a price on the residual garbage even after having sorted all materials (cf. columns (7) and (8)). Again, the mechanism behind unit pricing seems to be better understood. Environmental taxes aim at rather modifying behavior than raising new revenues and small polluters are actually rewarded and not punished despite recycling, since they pay relatively less taxes than bigger polluters. It seems that this message partly got through the population along with the treatment. In this respect, the intervention of the Federal price supervisor, who oversees all regulated prices in the country, might help in making sure (and people aware) that in each municipality lump-sum taxes, for instance, were adapted to offset the new revenues from unit-pricing schemes (cf. SPR 2013). Although the Federal price supervisor is known to give non-binding recommendations, his opinion is considered very influential and usually sufficient to persuade the regulated entity to correct its behavior accordingly.

Columns (9) and (10) present the estimates for the perception of inequitable treatment, while columns (11) and (12) display the estimates for social justice. As opposed to the previous columns, outcomes of columns (9) to (12) do display a significant coefficient for the time dummy, thus suggesting that the debate around the regressivity of pricing garbage by the bag extended to the municipalities in the control group and affected the opinion of their inhabitants. For these variables, the case for a causal interpretation of

estimates clearly no longer holds. In both treatment and control groups pricing garbage by the bag is perceived as much less inequitable after January 1st 2013, possibly because this large wave of implementations made individuals much more aware of the regressive impacts that alternative sources of revenues for waste management may have. The debate also highlighted the measures undertaken by municipalities to at least partly offset the possible distributional effects. It does not surprise then, in our opinion, that the tax is perceived as less inequitable but the demand for social cushioning increases (cf. columns (11) and (12)).

In short, experiencing the treatment seems to positively affect the fee's perception, in particular in what concerns its effectiveness and the related sentiments of unfairness associated to an additional tax that is collected also from households practicing recycling. Furthermore, the stigma of social injustice associated to unit pricing is smoothed in the whole Canton, according to the evidence in our sample. This probably happens because the large media coverage at the local level contributed to make clear that policy-induced distributional effects are not an inevitable condition of unit pricing. Sometimes compensation happens mechanically by the reduction of other regressive (e.g. lump-sum) taxes.

Our finding with respect to the fee's perceived effectiveness is consistent with the analysis of OFEFP (2003), which focuses on a bunch of Swiss municipalities and points to a similar gap in the way unit pricing is perceived as effective and workable between municipalities with and without the scheme. Perceived ineffectiveness *ex-ante* is a recurrent argument in the literature and common to environmental taxes in general. It is probably the main reason for the public resistance to revenue-neutral and possibly efficiency-enhancing tax reforms such as environmental tax reforms (ETR). It follows from perceived ineffectiveness that, as in this context, the general public is unwilling *ex-ante* to make room for a new tax, which is perceived as an additional source of revenue on top of those already existing. Revenue neutrality can hardly be understood, since the tax's environmental purpose cannot be met, for most of the general public, without earmarking. Accordingly, we observe in our data that only *ex-post* a large majority is willing not to earmark revenues for waste management.

These reasons are known to contribute to make subsidies much more popular than taxes. In addition, environmental taxes are perceived as a "punishment", whereas subsidies as a "reward" to a desirable behavior (Steg et al. 2006). Environmental taxes enjoy then a larger support when marketed as *bonus-malus* policies. Arguably, revenue-neutral policies reproduce a sort of *bonus-malus* scheme, but are not understood as such, *ex-ante*. *Ex-post*, we observe instead an important decrease in the feeling of unfairness related to

the tax being imposed to the residual garbage. Following the treatment some households may realize that even though they have to buy a positive amount of bags they may still be net winners through a decline in the lump-sum tax. That is, they receive a bonus. This change in perception requires however some salience in the redistribution of revenues. Carattini and Baranzini (2014) show for instance that 60% of Swiss respondents are not aware of the Swiss $CO_2$ levy on heating fuels, raised since 2008. In such framework, outcomes *ex-post* may be hardly distinguishable from *ex-ante*. In general, these findings suggest the existence of learning costs, which may be addressed *ex-ante* in this and other contexts by e.g. making potential benefits more salient.

### 5.3 Willingness-to-pay

Table 14 reports the estimates for the question on acceptability. We assess acceptability by estimating the willingness-to-pay (WTP) for a 35 liters bag. For simplicity's sake and given that a reference price for the bag already exists, we do not provide a randomized dichotomous choice but a simple scale going from 0 to 5 francs (CHF) with 50-cents intervals. The distribution of bids for 2012 and 2013 is given by Figure 4. For both years and groups the distribution is not normal and clusters at 0 and 2 (the official price for a 35 liters bag). We can interpret these values in terms of degrees of acceptance, with a value of 0 implying that the tax is clearly disliked, a value of 2 implying that the tax is fine as it is, a value between 0 and 2 implying a demand for a less aggressive taxation whereas people stating a WTP larger than 2 demand some policy tightening. As expected, in 2012 the cumulative distribution function (CDF) for the treatment group lies clearly at the left of the control group's one. That is, lower WTPs are expressed in 2012 in the treatment group compared to the control group. Instead, CDFs almost completely overlap in 2013, consistent with a common level of acceptability *ex-post*. We thus expect an effect of treatment on acceptability in the regressions.

We display in Table 16 estimates from both OLS (columns (1) to (3)) and Tobit (columns (4) to (6)) regressions. Columns (2), (3), (5) and (6) include socioeconomic controls, which clearly improve the goodness-of-fit, even though no clear pattern is identified for these variables[9]. We do not show the models in which we control for non-tax policies, since none of them has a significant impact on WTP and the overall goodness-of-fit is only slightly affected. The specifications of columns (3) and (6) control for the

[9]With respect to students, some professional categories display a recurrent and significant negative sign. These are homemakers, employees, self-employed workers and retired individuals. One may argue that in the case of students, current income may be a particularly bad proxy for permanent income. Yet, it seems that higher WTPs are associated with lower income categories, if anything. From a theoretical perspective, we were not expecting any specific pattern related to income, given the public-good property of waste management (cf. Roca 2003) and the ambiguous net distribution effects.

main variables discussed in section 5.2 and capturing the fee's perception. In all models the coefficient for treatment is positive and significant, robust across specifications both within OLS and Tobit regressions. No significant effect is associated to the time dummy. If interpreted causally, the estimate of column (3) ((6)) indicates that the treatment increases the WTP for a 35 liters bag by about 90 (160) cents. The 90 cents implies an increase of 100% with respect to the mean value in the treatment group (cf. Table 13). Actually, even the most conservative estimate would allow us to claim that the treatment generates a forceful spur in acceptability.

The variables of columns (3) and (6) only partially contribute to explain this jump in acceptability. Most variables have the expected sign, but only the feeling of unfairness related to having to pay new taxes is strongly negative and significant. This variable seems to capture the perceptional problems discussed in section 5.2 and to represent the main obstacle to unit pricing. As discussed, this may be symptomatic of learning costs related to the inexperience of environmental taxes. Yet, the coefficient for the treatment is increased rather than reduced by the inclusion of perception controls. This suggests that we are not able to completely capture the drivers of acceptability. It may well be that the treatment itself keeps a role. Not only it changes the fee's perception, which in turn may affect acceptability, but it also creates a new status-quo to which agents get used. This effect may not be related only to inertial dynamics, but perhaps also to a lag in re-assessing the relative-consumption equilibria (cf. Howarth 2006). With the words of Gowdy (2008, p.641), "[...] the presence of relative consumption effects might inform environmental tax policy. Accounting for such effects reduces the value of individual consumption and increases the willingness to pay for public goods such as environmental amenities. In terms of implementing this policy, a problem is the time lag between having your income decreased through a tax and realizing much later that your income relative to other is unchanged". Similar "shock" policies have shown to "crowd-in" pro-environmental behavior, for instance when the electricity-mix is all of a sudden made green by default, thus creating a new status-quo supported by a new, "green" social norm.

Overall, the difference in acceptability between *ex-ante* and *ex-post* assessments is consistent with the discussion of section 2 and in particular with the findings of Thøgersen (1994). As pointed out, the data at our disposal do not allow us to completely disentangle the behavioral and transactional mechanisms at play. Despite this qualification, we may still identify an important policy implication. The evidence provided in this section suggests that unpopular environmental policy should be given the chance to be tested by the population before being submitted to the population veto. In this sense, we agree with

Kallbekken and Sælen (2011) that trial periods may represent a very effective instrument to spur acceptability, as the example of the Stockholm congestion charge seems to prove. Since the policy studied here was endorsed by the Federal Supreme Court of Switzerland, the ultimate advocate of the constitution, we do not have ballot data to support our claim. Anyways, trial periods are not commonly used in Switzerland. Yet, we have to hand curious anecdotal evidence from two villages in the Canton of Vaud, where the population did vote on unit pricing. In the municipality of Moudon the population was asked to vote on a tax rate change, the policy being already in place. Unit pricing remained in place and the higher tax rate was accepted. In the municipality of Gland a unit-pricing scheme was opposed to the status-quo of no scheme. As in the Canton of Jura, the status-quo prevailed.

# 6 Conclusion

We address the question of unit-pricing programs' effectiveness. We provide causal estimates of pricing garbage by the bag's effect on the amount of solid waste incinerated in the Canton of Vaud, Switzerland. Pricing garbage by the bag causes a reduction in the amount of incinerated garbage per capita by about 40%. The identification strategy relies on the forced implementation on January 1$^{st}$ 2013 of pricing garbage by the bag in many municipalities of the Canton of Vaud following a ruling decision by the Federal Supreme Court of Switzerland. Both survey-based household panel data and official data are used. We find that estimates are consistent across datasets. Since some municipalities implemented unit-pricing schemes before January 1$^{st}$ 2013 while some others managed to postpone their implementation to January 1$^{st}$ 2014, we have at our disposal both already-treated and not-yet-treated control groups. We find that estimates are consistent between control groups. We provide evidence that the amount of solid waste incinerated follow parallel trends in all municipalities, regardless of policy. Yet, the policy determines if municipalities are at a high- or low-garbage steady-state. Once pricing garbage by the bag is implemented, municipalities switch to and remain in a low-garbage equilibrium. Lower incinerated garbage is accompanied by a higher frequency of recycling of e.g. organic waste and aluminum. We do not report any evidence of considerable non-desirable behavior in response to unit pricing.

The estimates provided in this paper, on the contrary of most of the literature, are robust to both endogeneity in the policy choice and simultaneity. Confounders are shown to be related to non-tax policies such as better collection services and awareness-raising campaigns. Neglecting simultaneity is thus likely to lead to biased estimates. On the

basis of these results, we argue that pricing gargage by the bag is an effective policy, which may well be justifiable on economic grounds, given also the large externalities associated with solid waste combustion, estimated by Muller et al. (2011) at a level ways above the added value of this sector.

We also address the question of unit-pricing program's acceptability. We identify a clear gap between acceptability *ex-ante* and *ex-post*. Acceptability, measured in terms of willingness-to-pay for priced bag, more than doubles following the implementation of unit pricing. The implementation of unit pricing improves the program's perception of effectiveness and fairness. The incentive effect behind environmental taxes seems to be better understood once the policy is in place. We point to learning cost and behavioral elements to explain this gap. Yet, assessing the determinants of acceptability is by far not an easy task and we clearly do not settle the question. On the contrary, these findings pave the way for a new strand of research in the acceptability of waste taxation.

## References


Abbott, A., S. Nandeibam, and L. O'Shea (2013). Recycling: Social norms and warm-glow revisited. *Ecological Economics 90*, 10–18.

Angrist, J. D. and J.-S. Pischke (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton: Princeton University Press.

BAFU (2014). Erhebung der Kehrichtzusammensetzung 2012.

Baranzini, A., J. Goldemberg, and S. Speck (2000). A future for carbon taxes. *Ecological Economics 32*(3), 395–412.

Basten, C. and F. Betz (2013). Beyond work ethic: Religion, individual, and political preferences. *American Economic Journal: Economic Policy 5*(3), 67–91.

Bazin, D., J. Ballet, and D. Touahri (2004). Environmental responsibility versus taxation. *Ecological Economics 49*(2), 129–134.

Besley, T. and A. Case (2000). Unnatural experiments? Estimating the incidence of endogenous policies. *Economic Journal 110*(467), F672–94.

Brekke, K. A., S. Kverndokk, and K. Nyborg (2003). An economic model of moral motivation. *Journal of Public Economics 87*(9-10), 1967–1983.

Bruvoll, A., B. Halvorsen, and K. Nyborg (2002). Households recycling efforts. *Resources, Conservation and Recycling 36*(4), 337–354.

Carattini, S. and A. Baranzini (2014). Paying enough taxes already? Testing the acceptability of carbon taxes with survey data. SSRN Scholarly Paper ID 2461674, Social Science Research Network.

Carattini, S., A. Baranzini, and J. Roca (forthcoming). Unconventional determinants of greenhouse gas emissions: The role of trust. *Environmental Policy and Governance*.

Dijkgraaf, E. and R. Gradus (2009). Environmental activism and dynamics of unit-based pricing systems. *Resource and Energy Economics 31*(1), 13–23.

Dijkgraaf, E. and R. H. J. M. Gradus (2004). Cost savings in unit-based pricing of household waste: The case of the Netherlands. *Resource and Energy Economics 26*(4), 353–371.

Dresner, S., L. Dunne, P. Clinch, and C. Beuermann (2006). Social and political responses to ecological tax reform in Europe: An introduction to the special issue. *Energy Policy 34*(8), 895–904.

Fullerton, D. and T. C. Kinnaman (1996). Household responses to pricing garbage by the bag. *American Economic Review 86*(4), 971–984.

Glaeser, E. L., D. I. Laibson, J. A. Scheinkman, and C. L. Soutter (2000). Measuring trust. *The Quarterly Journal of Economics 115*(3), 811–846.

Goeschl, T. and G. Perino (2012). Instrument choice and motivation: Evidence from a climate change experiment. *Environmental & Resource Economics 52*(2), 195–212.

Greene, W. H. (2011). *Econometric Analysis*. Prentice Hall.

Hage, O., P. Söderholm, and C. Berglund (2009). Norms and economic motivation in household recycling: Empirical evidence from Sweden. *Resources, Conservation and Recycling 53*(3), 155–165.

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.

Hong, S. (1999). The effects of unit pricing system upon household solid waste management: The Korean experience. *Journal of Environmental Management 57*(1), 1–10.

Husaini, I. G., A. Garg, K. H. Kim, J. Marchant, S. J. T. Pollard, and R. Smith (2007). European household waste management schemes: Their effectiveness and applicability in England. *Resources, Conservation and Recycling 51*(1), 248–263.

Jenkins, R. R., S. A. Martinez, K. Palmer, and M. J. Podolsky (2003). The determinants of household recycling: A material-specific analysis of recycling program features and unit pricing. *Journal of Environmental Economics and Management 45*(2), 294–318.

Kallbekken, S., S. Kroll, and T. L. Cherry (2011). Do you not like Pigou, or do you not understand him? Tax aversion and revenue recycling in the lab. *Journal of Environmental Economics and Management 62*(1), 53–64.

Kallbekken, S. and H. Sælen (2011). Public acceptance for environmental taxes: Self-interest, environmental and distributional concerns. *Energy Policy 39*(5), 2966–2973.

Kinnaman, T. C. (2006). Policy watch: Examining the justification for residential recycling. *Journal of Economic Perspectives 20*(4), 219–232.

Kinnaman, T. C. and D. Fullerton (2000). Garbage and recycling with endogenous local policy. *Journal of Urban Economics 48*(3), 419–442.

Muller, N. Z., R. Mendelsohn, and W. Nordhaus (2011). Environmental accounting for pollution in the United States economy. *American Economic Review 101*(5), 1649–1675.

Nyborg, K., R. B. Howarth, and K. A. Brekke (2006). Green consumers and public policy: On socially contingent moral motivation. *Resource and Energy Economics 28*(4), 351–366.

OFEFP (2003). La taxe au sac, vue par la population et les communes.

Pigou, A. C. (1920). *The economics of welfare*. London: Macmillan and Co.

Roca, J. (2003). Do individual preferences explain the environmental Kuznets curve? *Ecological Economics 45*(1), 3–10.

SPR (2013). Les taxes sur les déchets dans le canton de Vaud.

Steg, L., L. Dreijerink, and W. Abrahamse (2006). Why are energy policies acceptable and effective? *Environment and Behavior 38*(1), 92–111.

Sterner, T. and H. Bartelings (1999). Household waste management in a Swedish municipality: Determinants of waste disposal, recycling and composting. *Environmental and Resource Economics 13*(4), 473–491.

Thalmann, P. (2004). The public acceptance of green taxes: 2 million voters express their opinion. *Public Choice 119*, 179–217.

Thøgersen, J. (1994). Monetary incentives and environmental concern. Effects of a differentiated garbage fee. *Journal of Consumer Policy 17*(4), 407–442.

Viscusi, W. K., J. Huber, and J. Bell (2011). Promoting recycling: Private values, social norms, and economic incentives. *American Economic Review 101*(3), 65–70.

Yang, H.-L. and R. Innes (2007). Economic incentives and residential waste management in Taiwan: An empirical investigation. *Environmental and Resource Economics 37*(3), 489–519.

# Appendix

## A Figures

FIGURE 1: Treatment effect on solid waste per capita in liters per week

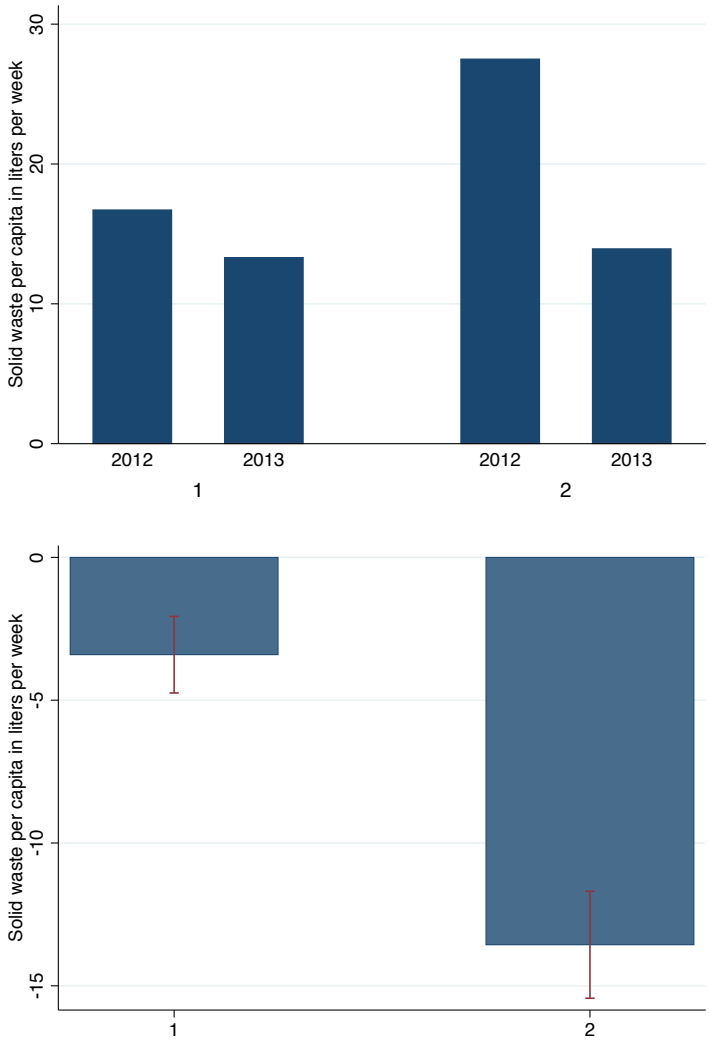


FIGURE 2: Parallel trends: treatment and control groups

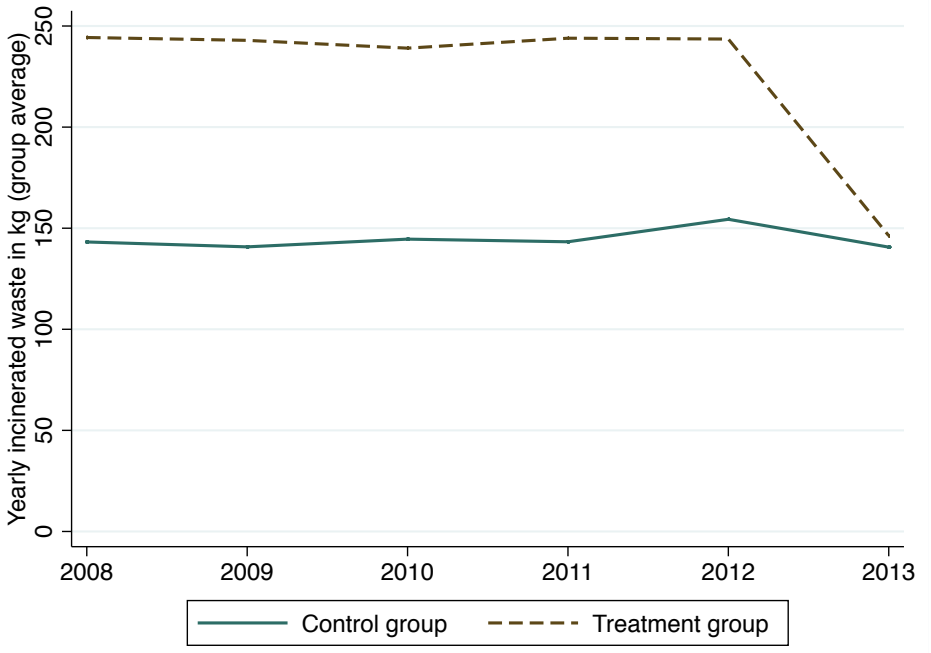


FIGURE 3: Parallel trends: extended treatment and control groups

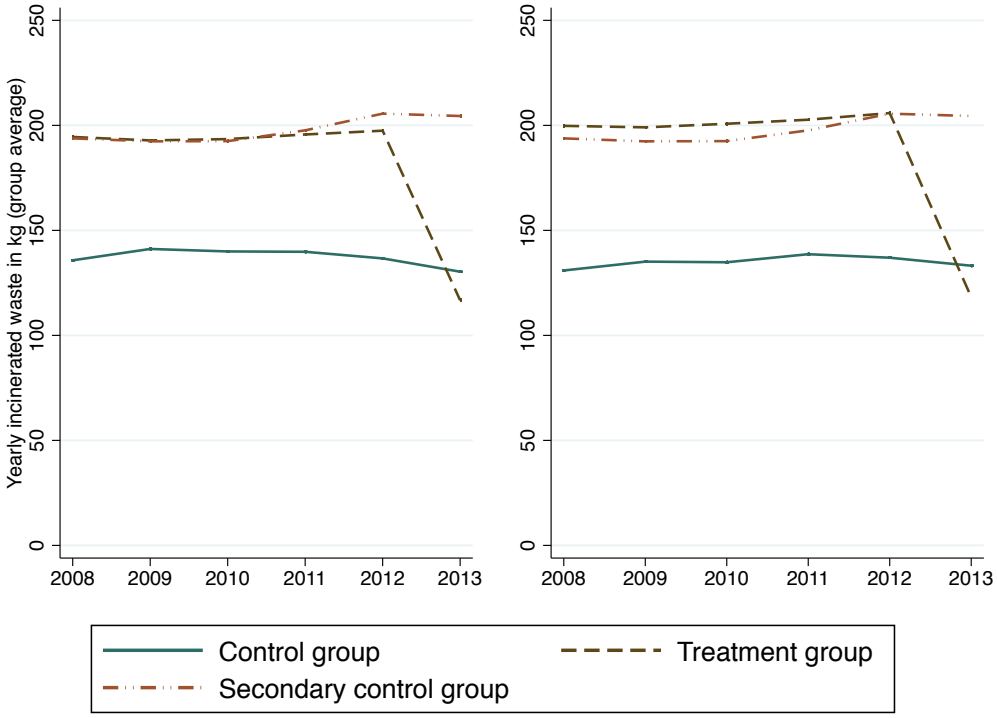
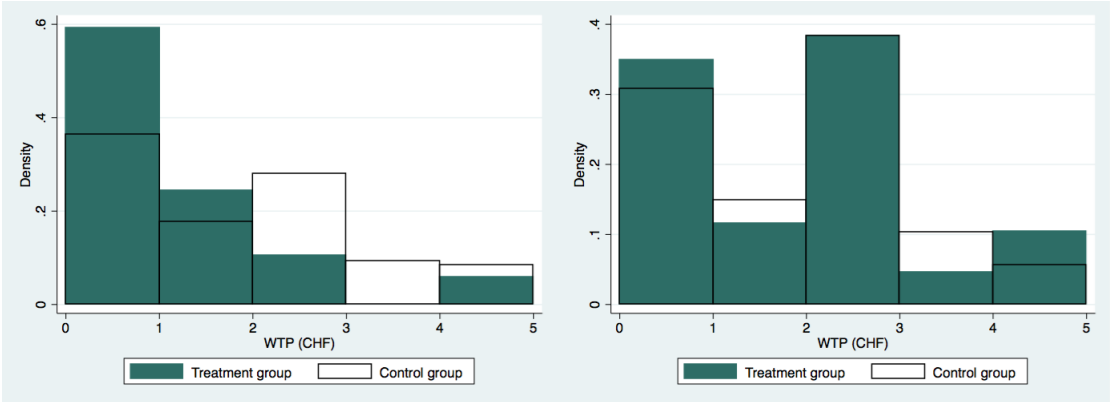



FIGURE 4: Willingness-to-pay: frequency of bids



# B Tables

TABLE 1 – Sample's socioeconomic characteristics: mean comparisons and tests

| | Interviewed only in 2012 | | Panel | |
|---|---|---|---|---|
| | Treatment group | Control group | Treatment group | Control group |
| Gender (M) | 0.41 | 0.331 | 0.43 | 0.327 |
| Age | 54.615 | 58.392 | 56.395 | 56.093 |
| Switzerland | 0.821 | 0.842 | 0.791 | 0.879 |
| European Union | 0.154 | 0.133 | 0.186 | 0.075* |
| Rest of the world | 0.026 | 0.025 | 0.023 | 0.047 |
| Adults in households | 2.103 | 2.042 | 1.942* | 2.131 |
| Children in households | 0.974 | 0.587 | 0.674* | 0.71 |
| Households | 38 | 121 | 86 | 107 |
| Total households | 159 | | 193 | |
| Compulsory schooling | 0.135 | 0.153 | 0.070 | 0.190 |
| Apprenticeship | 0.405 | 0.369 | 0.477 | 0.343 |
| High school | 0.135 | 0.234 | 0.104 | 0.143** |
| University | 0.324 | 0.243 | 0.349 | 0.324* |
| Jobless | 0.026 | 0.008 | 0.023 | 0 |
| Student | 0 | 0 | 0 | 0 |
| Homemaker | 0.079 | 0.084 | 0.058 | 0.066 |
| Employee | 0.447 | 0.303 | 0.384 | 0.34 |
| Self-employed | 0.184 | 0.151 | 0.151 | 0.094* |
| Manager | 0 | 0.042 | 0.047* | 0.075 |
| Retired | 0.237 | 0.403 | 0.337 | 0.387 |
| Income category 1 (<3'000 CHF) | 0.026 | 0.041 | 0.058 | 0.075 |
| Income category 2 (3'001-5'000 CHF) | 0.051 | 0.165 | 0.093 | 0.168 |
| Income category 3 (5'001-7'000 CHF) | 0.103 | 0.124 | 0.198* | 0.121 |
| Income category 4 (7'001-9'000 CHF) | 0.077 | 0.107 | 0.163* | 0.037** |
| Income cateory 5 (9'001-15'000 CHF) | 0.051 | 0.041 | 0.105 | 0.112* |
| Income category 6 (>15'001 CHF) | 0.051 | 0.033 | 0.081 | 0.065 |
| Missing value for income | 0.641 | 0.488 | 0.302*** | 0.421 |
| Distance from collecting center (in minutes) | 7.836 | 5.784 | 6.368 | 4.918* |
| Green | 0.135 | 0 | 0.093 | 0 |
| Households | 37 | 116 | 85 | 103 |
| Total households | 153 | | 188 | |

*Note:* *, ** and *** imply statistically-significant differences in the mean for the same group between samples at 10%, 5% and 1%, respectively. No missing values affect the first block of variables (from gender to children in the household). Income is measured as household monthly gross income in Swiss francs (CHF). We also obtain a measure of distance from the closest collecting center (in kilometers and in minutes with the appropriate transport mode) from respondents, which is however not available in the official statistics. To avoid excessive missing values we impute distance in time from distance in space whenever needed and use the former as variable. We qualify as "green" the members of environmental organizations. A measure of general trust as used by the World Values Survey and other large surveys (cf. e.g. Glaeser et al. 2000) is included only in the survey of 2013 and does not allow for comparison between samples. The same applies to the proportion of renters (versus homeowners). Trust is 0.5 in the treatment group and 0.42 in the control group. Renters are 0.34 in the treatment group and 0.33 in the control group.

TABLE 2: Canton of Vaud's socioeconomic characteristics

| | Cantonal mean |
|---|---|
| Gender (M) | 0.489 |
| Age <20 | 0.222 |
| Age 20-39 | 0.276 |
| Age 40-64 | 0.340 |
| Age >65 | 0.162 |
| Switzerland | 0.682 |
| European Union (EU) | 0.230 |
| Rest of the world | 0.088 |
| Adults | 0.776 |
| Children | 0.224 |
| Single-adult households | 0.386 |
| Households without children | 0.247 |
| Households with children | 0.277 |
| Single-member households | 0.063 |
| Household size | 2.2 |
| Compulsory schooling | 0.268 |
| Apprenticeship | 0.300 |
| High school | 0.091 |
| University | 0.321 |
| Jobless | 0.049 |
| Student | 0.080 |
| Homemaker | 0.127 |
| Employee | 0.480 |
| Manager | 0.065 |
| Retired | 0.094 |
| Income <35'000 CHF | 0.192 |
| Income 35'001-60'000 CHF | 0.220 |
| Income 60'001-80'000 CHF | 0.160 |
| Income 80'001-100'000 CHF | 0.114 |
| Income 100'001-175'000 CHF | 0.207 |
| Income >175'001 CHF | 0.107 |
| Renters | 0.694 |

*Source:* Swiss Federal Statistical Office and Statistique Vaud.

*Note:* Cantonal statistics refer to years 2012 or 2013 whenever data are available, to year 2011 otherwise. Cantonal data define as children individuals from age 0 to 19. Educational achievements are given only for population over 30 years. The level of education of 2% of the Canton is not know. The share of self-employed workers is not given. Income is measured as yearly gross income in Swiss francs (CHF). The proportion of renters is obtained from the negative of the share of housing assets with owners living in. No measure for trust is available at the Cantonal level. The World Values Survey wave of 2007 reports a level of trust of 0.539 for Switzerland. More recent data are available from the European Social Survey, which however uses a 10 points scale instead of a binary variable as in our survey.

TABLE 3: Solid waste production, recycling and attention to voluminous wrapping: comparison between 2012 and 2013

| | 2012 | | | | | | 2013 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treatment group | | | Control group | | | Treatment group | | | Control group | | |
| Variable | Mean | Std. Dev. | N | Mean | Std. Dev. | N | Mean | Std. Dev. | N | Mean | Std. Dev. | N |
| Per capita | 27.385 | 19.229 | 85 | 16.187 | 10.618 | 103 | 13.875*** | 12.821 | 85 | 13.153** | 12.987 | 98 |
| Per household | 65.906 | 46.203 | 85 | 39.728 | 30.946 | 103 | 33.647*** | 40.698 | 85 | 35.061 | 32.634 | 98 |
| PET | 0.919 | 0.275 | 86 | 0.981 | 0.136 | 107 | 0.953 | 0.212 | 86 | 0.944* | 0.231 | 107 |
| Carton | 0.849 | 0.36 | 86 | 0.944 | 0.231 | 107 | 0.965*** | 0.185 | 86 | 0.907* | 0.292 | 107 |
| Paper | 0.895 | 0.308 | 86 | 0.972 | 0.166 | 107 | 0.953** | 0.212 | 86 | 0.935 | 0.248 | 107 |
| Clothes | 0.872 | 0.336 | 86 | 0.897 | 0.305 | 107 | 0.907 | 0.292 | 86 | 0.841 | 0.367 | 107 |
| Cans | 0.733 | 0.445 | 86 | 0.925 | 0.264 | 107 | 0.756 | 0.432 | 86 | 0.738*** | 0.442 | 107 |
| Organic waste | 0.698 | 0.462 | 86 | 0.85 | 0.358 | 107 | 0.884*** | 0.322 | 86 | 0.841 | 0.367 | 107 |
| Batteries | 0.942 | 0.235 | 86 | 0.935 | 0.248 | 107 | 0.988** | 0.108 | 86 | 0.897 | 0.305 | 107 |
| Aluminum | 0.733 | 0.445 | 86 | 0.907 | 0.292 | 107 | 0.93*** | 0.256 | 86 | 0.869 | 0.339 | 107 |
| Attention to wrapping | 0.471 | 0.502 | 85 | 0.551 | 0.500 | 107 | 0.571* | 0.498 | 84 | 0.608 | 0.490 | 102 |

*Note:* *, ** and *** imply statistically-significant differences in the mean for the same group between years at 10%, 5% and 1%, respectively.

TABLE 4: Treatment effect on solid waste per capita in liters per week

| | (1) | | (2) | |
|---|---|---|---|---|
| Year 2013 | -2.847** | (1.184) | -2.845** | (1.360) |
| Pay-per-bag fee | -10.51*** | (1.921) | -9.668*** | (2.009) |
| Gender (M) | | | -2.192 | (2.079) |
| Age | | | -0.0904 | (0.0783) |
| EU | | | 4.012* | (2.319) |
| Rest of the world | | | -1.745 | (4.424) |
| Adults in households | | | -5.644*** | (1.453) |
| Children in households | | | -1.465 | (1.023) |
| Apprenticeship | | | -2.626 | (2.515) |
| High school | | | -2.275 | (3.738) |
| University | | | -8.055*** | (2.496) |
| Jobless | | | -1.462 | (12.73) |
| Homemaker | | | -11.32 | (12.36) |
| Employee | | | -8.208 | (11.23) |
| Self-employed | | | -6.783 | (10.45) |
| Manager | | | -8.632 | (12.55) |
| Retiree | | | -10.36 | (11.60) |
| Green | | | -0.159 | (3.440) |
| Renter | | | -2.110 | (1.822) |
| Distance | | | 0.268* | (0.142) |
| Income category 1 | | | -18.40*** | (3.487) |
| Income category 2 | | | -2.309 | (3.972) |
| Income category 3 | | | -5.919* | (3.282) |
| Income category 4 | | | -5.629 | (3.868) |
| Income category 5 | | | 0.733 | (3.956) |
| Income is missing | | | -7.642** | (3.242) |
| Constant | 21.23*** | (0.467) | 56.12*** | (12.70) |
| Within-$R^2$ | 0.117 | | 0.295 | |
| $N$ | 371 | | 359 | |

*Note:* Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

TABLE 5: Recycling: effect of treatment on the treated, counterfactual and treatment effect

| Material | Observed effect | Counterfactual | Treatment effect |
|---|---|---|---|
| PET | = | - | + |
| Carton | + | = | + |
| Paper | + | - | + |
| Clothes | = | = | = |
| Glass | + | = | + |
| Cans | = | - | + |
| Organic waste | + | = | + |
| Batteries | + | = | + |
| Aluminum | + | = | + |
| Wrapping | = | = | = |

*Note:* + (-) indicate a positive (negative) effect. = is used when the effect is not different from zero.

TABLE 6: Treatment effect on recycling and wrapping (OLS)

| | Aluminum | | | | Battery | | | | Carton | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | | (5) | | (6) | |
| Year 2013 | -0.0374 | (0.0401) | -0.00107 | (0.0423) | -0.0374 | (0.0403) | 0.0192 | (0.0373) | -0.0374 | (0.0391) | 0.00331 | (0.0360) |
| Pay-per-bag fee | 0.235*** | (0.0718) | 0.195** | (0.0745) | 0.0839 | (0.0519) | 0.0288 | (0.0511) | 0.154** | (0.0652) | 0.107 | (0.0656) |
| Gender (M) | | | -0.0174 | (0.0545) | | | 0.0110 | (0.0330) | | | 0.0176 | (0.0298) |
| Age | | | 0.00130 | (0.00184) | | | 0.00143 | (0.00145) | | | 0.0000438 | (0.00130) |
| EU | | | -0.0716 | (0.0541) | | | -0.0823** | (0.0371) | | | -0.00425 | (0.0376) |
| Rest of the world | | | 0.109 | (0.0892) | | | -0.0256 | (0.0877) | | | 0.0846 | (0.0591) |
| Adults in households | | | 0.0186 | (0.0240) | | | -0.0267 | (0.0268) | | | -0.0140 | (0.0247) |
| Children in households | | | -0.0293 | (0.0261) | | | -0.00880 | (0.0146) | | | -0.0279 | (0.0186) |
| Apprenticeship | | | -0.0120 | (0.0644) | | | 0.00162 | (0.0546) | | | -0.00998 | (0.0492) |
| High school | | | -0.0479 | (0.0685) | | | -0.00507 | (0.0560) | | | -0.00834 | (0.0436) |
| University | | | 0.0853 | (0.0621) | | | 0.0345 | (0.0543) | | | -0.00229 | (0.0510) |
| Jobless | | | 0.330 | (0.222) | | | -0.232** | (0.0928) | | | -0.102 | (0.113) |
| Homemaker | | | 0.278 | (0.217) | | | -0.128 | (0.0905) | | | -0.0445 | (0.102) |
| Employee | | | 0.235 | (0.193) | | | -0.203*** | (0.0712) | | | -0.124* | (0.0728) |
| Self-employed | | | 0.251 | (0.188) | | | -0.225*** | (0.0835) | | | -0.182** | (0.0802) |
| Manager | | | 0.239 | (0.228) | | | -0.238** | (0.0944) | | | -0.125 | (0.0944) |
| Retiree | | | 0.222 | (0.206) | | | -0.240** | (0.0954) | | | -0.160* | (0.0874) |
| Green | | | 0.0431 | (0.0646) | | | -0.00454 | (0.0421) | | | 0.0518 | (0.0509) |
| Distance | | | -0.00205 | (0.00476) | | | 0.0000173 | (0.00316) | | | -0.00520* | (0.00306) |
| Renter | | | 0.0245 | (0.0444) | | | 0.00867 | (0.0296) | | | -0.0228 | (0.0371) |
| Income category 1 | | | 0.110 | (0.119) | | | -0.00924 | (0.0730) | | | 0.108 | (0.103) |
| Income category 2 | | | 0.109 | (0.0942) | | | -0.00115 | (0.0619) | | | 0.119* | (0.0620) |
| Income category 3 | | | 0.0884 | (0.0913) | | | 0.0653 | (0.0665) | | | 0.0629 | (0.0847) |
| Income category 4 | | | 0.0101 | (0.0800) | | | 0.0228 | (0.0493) | | | 0.0181 | (0.0698) |
| Income category 5 | | | -0.0275 | (0.102) | | | -0.0222 | (0.0561) | | | -0.0195 | (0.0615) |
| Income is missing | | | 0.0315 | (0.0723) | | | -0.0124 | (0.0557) | | | 0.0945* | (0.0532) |
| Constant | 0.829*** | (0.0173) | 0.460** | (0.222) | 0.938*** | (0.0133) | 1.117*** | (0.137) | 0.902*** | (0.0159) | 1.055*** | (0.128) |
| Within-$R^2$ | 0.047 | | 0.101 | | 0.009 | | 0.059 | | 0.0258 | | 0.088 | |
| $N$ | 386 | | 368 | | 386 | | 368 | | 386 | | 368 | |

Note: Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

| | Clothes | | | | Glass | | | | Organic waste | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (7) | | (8) | | (9) | | (10) | | (11) | | (12) | |
| Year 2013 | -0.0561 | (0.0487) | -0.00975 | (0.0542) | -0.0187 | (0.0295) | 0.0281 | (0.0180) | -0.00935 | (0.0509) | 0.0369 | (0.0470) |
| Pay-per-bag fee | 0.0910 | (0.0683) | 0.0335 | (0.0766) | 0.0885* | (0.0443) | 0.0206 | (0.0355) | 0.195*** | (0.0695) | 0.144** | (0.0645) |
| Gender (M) | | | 0.0232 | (0.0552) | | | -0.00934 | (0.0192) | | | 0.0818* | (0.0487) |
| Age | | | 0.00223 | (0.00208) | | | 0.000986 | (0.000857) | | | 0.00507** | (0.00218) |
| EU | | | -0.0850 | (0.0611) | | | -0.0218 | (0.0265) | | | -0.0414 | (0.0664) |
| Rest of the world | | | 0.0643 | (0.120) | | | -0.156** | (0.0726) | | | 0.00972 | (0.171) |
| Adults in households | | | -0.0290 | (0.0367) | | | -0.0195 | (0.0218) | | | 0.0160 | (0.0353) |
| Children in households | | | -0.0126 | (0.0271) | | | 0.00483 | (0.0106) | | | -0.00117 | (0.0274) |
| Apprenticeship | | | -0.00251 | (0.0615) | | | 0.0212 | (0.0353) | | | -0.0853 | (0.0525) |
| High school | | | -0.0121 | (0.0737) | | | 0.00932 | (0.0298) | | | -0.137* | (0.0784) |
| University | | | 0.0573 | (0.0584) | | | 0.0303 | (0.0330) | | | 0.0162 | (0.0598) |
| Jobless | | | -0.320*** | (0.115) | | | 0.0649 | (0.111) | | | -0.0926 | (0.282) |
| Homemaker | | | -0.130 | (0.123) | | | 0.158 | (0.117) | | | -0.0111 | (0.316) |
| Employee | | | -0.283*** | (0.0967) | | | 0.0712 | (0.107) | | | 0.0892 | (0.261) |
| Self-employed | | | -0.322*** | (0.0986) | | | 0.0533 | (0.109) | | | -0.00952 | (0.265) |
| Manager | | | -0.352** | (0.160) | | | 0.0574 | (0.109) | | | 0.106 | (0.271) |
| Retiree | | | -0.298** | (0.113) | | | 0.0478 | (0.107) | | | 0.0118 | (0.262) |
| Green | | | -0.0106 | (0.0701) | | | 0.0149 | (0.0228) | | | 0.0143 | (0.0674) |
| Distance | | | -0.00677* | (0.00352) | | | -0.00438** | (0.00212) | | | -0.0208*** | (0.00485) |
| Renter | | | -0.0162 | (0.0486) | | | 0.00813 | (0.0223) | | | 0.0446 | (0.0456) |
| Income category 1 | | | 0.0639 | (0.123) | | | 0.0256 | (0.0489) | | | 0.135 | (0.128) |
| Income category 2 | | | 0.0795 | (0.103) | | | -0.0415 | (0.0616) | | | 0.0748 | (0.0969) |
| Income category 3 | | | 0.147* | (0.0869) | | | 0.00454 | (0.0687) | | | -0.0716 | (0.123) |
| Income category 4 | | | 0.0778 | (0.0946) | | | 0.0534 | (0.0532) | | | 0.00856 | (0.106) |
| Income category 5 | | | 0.0103 | (0.0949) | | | 0.0128 | (0.0511) | | | -0.159 | (0.125) |
| Income is missing | | | 0.0795 | (0.0796) | | | 0.0362 | (0.0516) | | | -0.00912 | (0.102) |
| Constant | 0.886*** | (0.0172) | 1.070*** | (0.206) | 0.948*** | (0.0110) | 0.871*** | (0.152) | 0.782*** | (0.0176) | 0.567 | (0.363) |
| Within-$R^2$ | 0.006 | | 0.069 | | 0.017 | | 0.133 | | 0.032 | | 0.166 | |
| $N$ | 386 | | 368 | | 386 | | 368 | | 386 | | 368 | |

Note: Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

| | Paper | | | | PET | | | | Wrapping | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (13) | | (14) | | (15) | | (16) | | (17) | | (18) | |
| Year 2013 | -0.0374 | (0.0321) | 0.00225 | (0.0228) | -0.0374 | (0.0291) | 0.00447 | (0.0183) | 0.0558 | (0.0612) | 0.0577 | (0.0682) |
| Pay-per-bag fee | 0.0955* | (0.0528) | 0.0361 | (0.0531) | 0.0723 | (0.0475) | 0.00896 | (0.0412) | 0.0497 | (0.0914) | 0.0561 | (0.0987) |
| Gender (M) | | | -0.0190 | (0.0223) | | | 0.0128 | (0.0188) | | | -0.129* | (0.0736) |
| Age | | | 0.00377*** | (0.00126) | | | 0.00182* | (0.00100) | | | 0.00367 | (0.00279) |
| EU | | | -0.00865 | (0.0328) | | | -0.0277 | (0.0337) | | | -0.179* | (0.105) |
| Rest of the world | | | 0.0440 | (0.0665) | | | -0.0234 | (0.0853) | | | 0.160 | (0.146) |
| Adults in households | | | 0.0235 | (0.0206) | | | -0.0166 | (0.0169) | | | -0.0868* | (0.0480) |
| Children in households | | | 0.000532 | (0.0120) | | | 0.0217** | (0.0108) | | | -0.0382 | (0.0377) |
| Apprenticeship | | | -0.0179 | (0.0399) | | | -0.00308 | (0.0327) | | | -0.0674 | (0.103) |
| High school | | | 0.0318 | (0.0420) | | | 0.0453 | (0.0291) | | | -0.0892 | (0.116) |
| University | | | 0.0393 | (0.0394) | | | 0.00968 | (0.0327) | | | 0.0428 | (0.0979) |
| Jobless | | | -0.0362 | (0.0465) | | | -0.0661 | (0.0785) | | | 0.0870 | (0.248) |
| Homemaker | | | -0.0443 | (0.0523) | | | -0.0621 | (0.0632) | | | 0.181 | (0.249) |
| Employee | | | -0.120** | (0.0481) | | | -0.108 | (0.0651) | | | 0.166 | (0.149) |
| Self-employed | | | -0.126** | (0.0578) | | | -0.123* | (0.0691) | | | 0.123 | (0.152) |
| Manager | | | -0.114* | (0.0602) | | | -0.0676 | (0.0746) | | | 0.410* | (0.225) |
| Retiree | | | -0.143** | (0.0689) | | | -0.0987 | (0.0727) | | | 0.213 | (0.160) |
| Green | | | 0.0599* | (0.0302) | | | 0.0381 | (0.0274) | | | 0.0697 | (0.0988) |
| Distance | | | -0.00642** | (0.00250) | | | -0.00421* | (0.00250) | | | -0.00541 | (0.00773) |
| Renter | | | 0.00529 | (0.0297) | | | 0.0303 | (0.0255) | | | -0.0363 | (0.0753) |
| Income category 1 | | | 0.0850 | (0.0610) | | | 0.0768 | (0.0829) | | | 0.487*** | (0.182) |
| Income category 2 | | | 0.0550 | (0.0679) | | | 0.0493 | (0.0781) | | | 0.205 | (0.152) |
| Income category 3 | | | 0.0655 | (0.0772) | | | 0.165** | (0.0760) | | | 0.201 | (0.130) |
| Income category 4 | | | 0.0611 | (0.0522) | | | 0.108 | (0.0688) | | | 0.625*** | (0.120) |
| Income category 5 | | | -0.00134 | (0.0627) | | | 0.0657 | (0.0690) | | | 0.00950 | (0.167) |
| Income is missing | | | 0.0192 | (0.0596) | | | 0.111* | (0.0608) | | | 0.330** | (0.126) |
| Constant | 0.938*** | (0.0129) | 0.798*** | (0.106) | 0.953*** | (0.0116) | 0.886*** | (0.130) | 0.514*** | (0.0224) | 0.191 | (0.299) |
| Within-$R^2$ | 0.012 | | 0.112 | | 0.008 | | 0.093 | | 0.008 | | 0.222 | |
| $N$ | 386 | | 368 | | 386 | | 368 | | 378 | | 365 | |

*Note:* Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

TABLE 7: Treatment effect on recycling and wrapping (Probit)

| | (1) Aluminum | (2) Battery | (3) Carton | (4) Clothes | (5) Glass | (6) Organic waste | (7) Paper | (8) PET | (9) Wrapping |
|---|---|---|---|---|---|---|---|---|---|
| Year 2013 | -0.0666 | -0.0823 | -0.0801 | -0.0788 | -0.0636 | -0.00724 | -0.119 | -0.143 | 0.0704 |
| | (0.0778) | (0.0993) | (0.0845) | (0.0733) | (0.108) | (0.0951) | (0.110) | (0.116) | (0.0744) |
| Pay-per-bag fee | 0.271*** | 0.216*** | 0.218*** | 0.116 | 0.205*** | 0.238*** | 0.197** | 0.183** | 0.0538 |
| | (0.0611) | (0.0590) | (0.0489) | (0.0796) | (0.0698) | (0.0784) | (0.0810) | (0.0916) | (0.109) |
| *Pseudo-$R^2$* | 0.118 | 0.076 | 0.096 | 0.055 | 0.096 | 0.099 | 0.064 | 0.072 | 0.084 |
| *N* | 234 | 120 | 184 | 250 | 112 | 246 | 144 | 136 | 343 |

*Note:* Estimates report marginal effects (all discrete changes). Brute force fixed effects.

Individuals bypassed if $Y_{ict}$ always =0 or always =1 (fixed effects cannot be computed).

Clustered standard errors in parentheses (cluster per municipality). Standard errors computed with the Delta method (cf. Greene 2011).

* $p < 0.1$ , ** $p < 0.05$ , ***$p < 0.01$.

TABLE 8: Non-tax waste management policies undertaken between 2012 and 2013: descriptive statistics

| | Treatment group | | Control group | |
|---|---|---|---|---|
| Variable | Mean | Std. Dev. | Mean | Std. Dev. |
| New skip: paper | 0.117 | 0.323 | 0.043 | 0.204 |
| New skip: carton | 0.064 | 0.246 | 0.06 | 0.239 |
| New skip: PET | 0.17 | 0.378 | 0.043 | 0.204 |
| New skip: clothes | 0.117 | 0.323 | 0.06 | 0.239 |
| New skip: glass | 0.17 | 0.378 | 0.043 | 0.204 |
| New skip: cans | 0.117 | 0.323 | 0.043 | 0.204 |
| New skip: batteries | 0.117 | 0.323 | 0.043 | 0.204 |
| New skip: aluminum | 0.064 | 0.246 | 0.043 | 0.204 |
| New skip: plastic | 0.085 | 0.281 | 0 | 0 |
| New skip: wood | 0 | 0 | 0.017 | 0.131 |
| New skip: organic waste | 0.117 | 0.323 | 0.138 | 0.346 |
| New skips: number of materials covered | 1.138 | 2.754 | 0.534 | 1.867 |
| New collection center | 0.064 | 0.246 | 0.043 | 0.204 |
| Collection centers: better opening hours | 0.223 | 0.419 | 0.155 | 0.364 |
| New curbside program | 0.074 | 0.264 | 0.034 | 0.183 |
| Awareness-raising campaign: unaddressed mailshot | 0.5 | 0.503 | 0.345 | 0.477 |
| Awareness-raising campaign: information session | 0.117 | 0.323 | 0 | 0 |
| Awareness-raising campaign: street stand | 0.021 | 0.145 | 0 | 0 |
| Awareness-raising campaign: specific website | 0 | 0 | 0.017 | 0.131 |
| N | 94 | | 116 | |

TABLE 9: Treatment effect on solid waste per capita in liters per week (non-tax policies)

| | (1) | (2) | (3) |
|---|---|---|---|
| Year 2013 | -1.777 | -2.692 | -2.894 |
| | (1.904) | (3.299) | (3.241) |
| Pay-per-bag fee | -12.20*** | -11.08*** | -10.89*** |
| | (3.129) | (3.762) | (3.763) |
| New skips: number of materials covered | | -1.340** | -1.305** |
| | | (0.606) | (0.615) |
| Collection centers: better opening hours | | 6.104 | 5.970 |
| | | (4.170) | (4.258) |
| New curbside program | | -9.383 | -9.451 |
| | | (6.330) | (6.490) |
| New collection center | | 6.918** | 7.213** |
| | | (2.690) | (2.720) |
| Awareness-raising campaign: unaddressed mailshot | | 0.647 | 0.699 |
| | | (4.462) | (4.456) |
| Constant | 21.71*** | 21.68*** | 30.67*** |
| | (0.765) | (0.748) | (4.912) |
| Socio-economic variables | No | No | Yes |
| Within-$R^2$ | 0.105 | 0.115 | 0.153 |
| $N$ | 205 | 205 | 205 |

*Note:* Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

TABLE 10: Treatment effect on solid waste per capita in kilos per year (official data, survey sample, non-tax policies)

| | (1) | (2) | (3) |
|---|---|---|---|
| Year 2013 | -11.15** | -7.579** | -6.619 |
| | (4.346) | (3.407) | (7.496) |
| Pay-per-bag fee | -86.14*** | -84.80*** | -82.73*** |
| | (12.26) | (16.25) | (19.86) |
| New skips: number of materials covered | | | -0.110 |
| | | | (2.669) |
| Collection centers: better opening hours | | | -16.00 |
| | | | (13.81) |
| New curbside program | | | 17.04 |
| | | | (14.27) |
| New collection center | | | 12.49* |
| | | | (6.282) |
| Awareness-raising campaign: unaddressed mailshot | | | 1.356 |
| | | | (10.01) |
| Constant | 173.6*** | 178.7*** | 178.7*** |
| | (2.380) | (3.012) | (3.062) |
| Within-$R^2$ | 0.715 | 0.724 | 0.737 |
| $N$ | 116 | 68 | 68 |

*Note:* Robust standard errors in parentheses.

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

TABLE 11: Treatment effect on solid waste per capita in kilos per year (official data, extended samples)

| | Standard control group | | Secondary control group |
|---|---|---|---|
| | (1) | (2) | (3) |
| Year 2013 | -8.487*** | -7.969*** | -10.20*** |
| | (3.178) | (2.748) | (3.233) |
| Pay-per-bag fee | -80.03*** | | -78.31*** |
| | (4.380) | | (4.418) |
| Unit pricing | | -79.78*** | |
| | | (4.064) | |
| Constant | 186.6*** | 181.3*** | 201.4*** |
| | (1.179) | (1.117) | (1.109) |
| Within-$R^2$ | 0.828 | 0.822 | 0.804 |
| $N$ | 434 | 470 | 500 |

*Note:* Robust standard errors in parentheses.

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

TABLE 12: Income elasticity: income effect on solid waste per capita (in logs)

| | Solid waste per capita (log) |
|---|---|
| Income (log) | 0.395*** |
| | (0.104) |
| Within-$R^2$ | 0.471 |
| $N$ | 205 |

*Note:* Clustered standard errors in parentheses (cluster per municipality).

Controlling for time, treatment and socio-economic variables.

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

TABLE 13: Acceptability and policy perception: comparison between 2012 and 2013

| | | 2012 | | | | | | 2013 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Treatment group | | | Control group | | | Treatment group | | | Control group | | |
| Variable | Short | Mean | St. Dev. | N | Mean | St. Dev. | N | Mean | St. Dev. | N | Mean | St. Dev. | N |
| Effect on own behavior | Eff. own | 0.419 | 0.496 | 86 | 0.411 | 0.494 | 107 | 0.547** | 0.501 | 86 | 0.383 | 0.488 | 107 |
| Effectiveness | Effectiveness | 0.784 | 0.414 | 74 | 0.839 | 0.37 | 93 | 0.928*** | 0.261 | 69 | 0.878 | 0.329 | 90 |
| Effect on the environment | Eff. env. | 0.581 | 0.496 | 86 | 0.736 | 0.443 | 106 | 0.721** | 0.451 | 86 | 0.71 | 0.456 | 107 |
| Effect on waste management | Eff. waste | 0.221 | 0.417 | 86 | 0.34 | 0.476 | 106 | 0.419*** | 0.496 | 86 | 0.421 | 0.496 | 107 |
| Use of revenues for other purposes | Use rev. | 0.262 | 0.442 | 84 | 0.689 | 0.465 | 106 | 0.709*** | 0.457 | 86 | 0.71 | 0.456 | 107 |
| Polluter-pays: awareness | Pp aware | 0.837 | 0.371 | 86 | 0.85 | 0.358 | 107 | 0.907* | 0.292 | 86 | 0.869 | 0.339 | 107 |
| Polluter-pays: agreement | Pp agree | 0.698 | 0.462 | 86 | 0.916 | 0.279 | 107 | 0.779 | 0.417 | 86 | 0.804*** | 0.399 | 107 |
| Polluter-pays: applied by the fee | Pp applied | 0.674 | 0.471 | 86 | 0.736 | 0.443 | 106 | 0.721 | 0.451 | 86 | 0.692 | 0.464 | 107 |
| Unfair: inequitable | Unfair ineq. | 0.233 | 0.425 | 86 | 0.208 | 0.407 | 106 | 0.07*** | 0.256 | 86 | 0.065*** | 0.248 | 107 |
| Unfair: paying enough taxes | Unfair taxes | 0.547 | 0.501 | 86 | 0.302 | 0.461 | 106 | 0.349*** | 0.479 | 86 | 0.262 | 0.442 | 107 |
| Unfair: paying even if sorting | Unfair sort | 0.558 | 0.5 | 86 | 0.34 | 0.476 | 106 | 0.349*** | 0.479 | 86 | 0.383 | 0.488 | 107 |
| Legitimacy despite regressive effects | Leg. reg. | 0.570 | 0.498 | 86 | 0.308 | 0.464 | 107 | 0.679* | 0.47 | 81 | 0.745*** | 0.438 | 102 |
| Legitimacy provided social cushioning | Leg. cush. | 0.353 | 0.481 | 85 | 0.286 | 0.454 | 105 | 0.558*** | 0.5 | 86 | 0.561*** | 0.499 | 107 |
| More acceptable if base is federal | Federal | 0.488 | 0.503 | 86 | 0.623 | 0.487 | 106 | 0.44 | 0.499 | 84 | 0.535 | 0.501 | 101 |
| Willingness-to-pay | WTP | 0.878 | 1.183 | 86 | 1.491 | 1.478 | 107 | 1.552*** | 1.489 | 86 | 1.574 | 1.297 | 107 |

*Note:* *, ** and *** imply statistically-significant differences in the mean for the same group between years at 10%, 5% and 1%, respectively.

TABLE 14: Policy perception: effect of the pay-per-bag fee's implementation in the treatment group (OLS)

| | (1) Eff. env. | (2) Eff. env. | (3) Use rev. | (4) Use rev. |
|---|---|---|---|---|
| Year 2013 | -0.0251 | -0.0268 | 0.0188 | 0.0155 |
| | (0.0602) | (0.0633) | (0.0519) | (0.0566) |
| Pay-per-bag fee | 0.165* | 0.203** | 0.421*** | 0.458*** |
| | (0.0899) | (0.0968) | (0.0780) | (0.0831) |
| Constant | 0.667*** | 1.225*** | 0.502*** | 0.495* |
| | (0.0224) | (0.378) | (0.0195) | (0.272) |
| Socio-economic variables | No | Yes | No | Yes |
| Within-$R^2$ | 0.013 | 0.119 | 0.116 | 0.214 |
| $N$ | 385 | 368 | 383 | 365 |

| | (5) Unfair taxes | (6) Unfair taxes | (7) Unfair sort | (8) Unfair sort |
|---|---|---|---|---|
| Year 2013 | -0.0376 | -0.00346 | 0.0439 | 0.0925 |
| | (0.0486) | (0.0530) | (0.0583) | (0.0658) |
| Pay-per-bag fee | -0.160* | -0.208** | -0.253*** | -0.312*** |
| | (0.0801) | (0.0838) | (0.0910) | (0.0977) |
| Constant | 0.410*** | 0.617 | 0.437*** | 0.397 |
| | (0.0196) | (0.473) | (0.0225) | (0.423) |
| Socio-economic variables | No | Yes | No | Yes |
| Within-$R^2$ | 0.028 | 0.181 | 0.026 | 0.142 |
| $N$ | 385 | 368 | 385 | 368 |

| | (9) Unfair ineq. | (10) Unfair ineq. | (11) Leg. cush. | (12) Leg. cush. |
|---|---|---|---|---|
| Year 2013 | -0.144*** | -0.118*** | 0.273*** | 0.248*** |
| | (0.0413) | (0.0440) | (0.0557) | (0.0597) |
| Pay-per-bag fee | -0.0186 | -0.0375 | -0.0671 | -0.00935 |
| | (0.0749) | (0.0780) | (0.0896) | (0.0937) |
| Constant | 0.219*** | 0.239 | 0.316*** | 0.479 |
| | (0.0181) | (0.337) | (0.0221) | (0.370) |
| Socio-economic variables | No | Yes | No | Yes |
| Within-$R^2$ | 0.057 | 0.114 | 0.070 | 0.181 |
| $N$ | 385 | 368 | 383 | 365 |

*Note:* Clustered standard errors in parentheses (cluster per municipality). Cluster standard errors in parentheses.

* $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$

TABLE 15: Policy perception: effect of the pay-per-bag fee's implementation in the treatment group (Probit)

| | (1) Eff. env. | (2) Eff. env. | (3) Use rev. | (4) Use rev. |
|---|---|---|---|---|
| Year 2013 | -0.0328 | -0.0346 | 0.0304 | 0.0321 |
| | (0.0819) | (0.0851) | (0.0759) | (0.0887) |
| Pay-per-bag fee | 0.174* | 0.221** | 0.440*** | 0.497*** |
| | (0.0945) | (0.0930) | (0.0715) | (0.0662) |
| Socio-economic variables | No | Yes | No | Yes |
| Pseudo-$R^2$ | 0.088 | 0.192 | 0.187 | 0.297 |
| $N$ | 337 | 324 | 333 | 314 |

| | (5) Unfair taxes | (6) Unfair taxes | (7) Unfair sort | (8) Unfair sort |
|---|---|---|---|---|
| Year 2013 | -0.0565 | 0.00372 | 0.0560 | 0.134 |
| | (0.0753) | (0.0885) | (0.0749) | (0.0865) |
| Pay-per-bag fee | -0.190* | -0.295*** | -0.274*** | -0.363*** |
| | (0.102) | (0.0934) | (0.0939) | (0.0929) |
| Socio-economic variables | No | Yes | No | Yes |
| Pseudo-$R^2$ | 0.164 | 0.312 | 0.105 | 0.199 |
| $N$ | 326 | 311 | 355 | 342 |

| | (9) Inequitable | (10) Inequitable | (11) Leg. cush. | (12) Leg. cush. |
|---|---|---|---|---|
| Year 2013 | -0.242*** | -0.188*** | 0.311*** | 0.308*** |
| | (0.0665) | (0.0668) | (0.0629) | (0.0690) |
| Pay-per-bag fee | -0.0179 | -0.0492 | -0.0918 | -0.0202 |
| | (0.119) | (0.0964) | (0.102) | (0.113) |
| Socio-economic variables | No | Yes | No | Yes |
| Pseudo-$R^2$ | 0.167 | 0.263 | 0.127 | 0.217 |
| $N$ | 249 | 236 | 374 | 356 |

*Note:* Estimates report marginal effects (all discrete changes). Brute force fixed effects.

Individuals bypassed if $Y_{ict}$ always =0 or always =1 (fixed effects cannot be computed).

Clustered standard errors in parentheses (cluster per municipality).

Standard errors computed with the Delta method (cf. Greene 2011). * $p < 0.1$ , ** $p < 0.05$ , ***$p < 0.01$.

TABLE 16: Acceptability: willingness-to-pay for a 35-liters bag

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Model | OLS | OLS | OLS | Tobit | Tobit | Tobit |
| Year 2013 | 0.0841 | 0.0552 | 0.139 | 0.153 | 0.136 | -0.680** |
| | (0.173) | (0.186) | (0.391) | (0.278) | (0.279) | (0.289) |
| Pay-per-bag fee | 0.590*** | 0.671*** | 0.892** | 0.944** | 1.059*** | 1.630*** |
| | (0.206) | (0.224) | (0.343) | (0.370) | (0.377) | (0.445) |
| Effect on the environment | | | 0.207 | | | 0.454 |
| | | | (0.164) | | | (0.275) |
| Use of revenues for other purposes | | | -0.285 | | | -0.282 |
| | | | (0.216) | | | (0.334) |
| Unfair: inequitable | | | 0.0204 | | | 0.0734 |
| | | | (0.177) | | | (0.310) |
| Unfair: paying enough taxes | | | -0.452*** | | | -0.862*** |
| | | | (0.148) | | | (0.263) |
| Unfair: paying even if sorting | | | -0.263 | | | -0.371 |
| | | | (0.165) | | | (0.271) |
| Legitimacy provided social cushioning | | | 0.107 | | | 0.240 |
| | | | (0.154) | | | (0.223) |
| Constant | 1.218*** | 2.456*** | 1.460 | 0.0806 | 1.799 | 0.472 |
| | (0.0541) | (0.734) | (0.902) | (0.151) | (1.098) | (1.105) |
| Socio-economic variables | No | Yes | Yes | No | Yes | Yes |
| Within-$R^2$ | 0.033 | 0.177 | 0.320 | | | |
| Pseudo-$R^2$ | | | | 0.076 | 0.125 | 0.178 |
| $N$ | 386 | 368 | 205 | 386 | 368 | 353 |

*Note:* Clustered standard errors in parentheses (cluster per municipality). * $p < 0.1$ , ** $p < 0.05$ , *** $p < 0.01$.

## C Questionnaires[10]

**Survey of 2012**

1. Does your households sort the following materials?
   (multiple answers)

   - PET bottles
   - Carton
   - Paper
   - Clothes
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum

2. Do you pay attention to wrapping while shopping?

   - Yes
   - No

3. Would you generate less incinerated garbage if:
   (multiple answers)

   - Collection centers were closer to you
   - Collection centers were better developed
   - You were imposed a fee on all non-sorted garbage
   - You could not do better, you already sort all what can be sorted

4. a. How many bags does your household fill with garbage every week?

   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10

4. b. Bags volume

   - 17 liters
   - 35 liters

[10]The original questionnaires were in French. They are available by the authors upon request.

5. Pricing garbage by the bag is implemented in your municipality. Can you indicate the price for a 17-/35-liters bag?
(if applicable)

5. Pricing garbage by the bag is not implemented in your municipality. Do you know whether its implementation is planned in the foreseeable future?
(if applicable)

   - Yes
   - No

6. If you would be asked to vote on the fee's rate, what is the highest price you would accept to pay for a 35-liters bag?
(please select the value that is closer to your preferences, in CHF)

   - 0
   - 0.50
   - 1
   - 1.50
   - 2
   - 2.50
   - 3
   - 3.50
   - 4
   - 4.50
   - 5

7. a. Does the pay-per-bag fee incite you to sort more?
(if applicable)

   - Yes, you sort more
   - No, you already sorted all what can be sorted
   - No, the fee does not affect your behavior
   - No, you sort less, since you pay the fee you can generate so much garbage as you want

7. a. Would a pay-per-bag fee incite you to sort more than what you currently sort?
(if applicable)

   - Yes, you would sort more
   - No, you already sort all what can be sorted
   - No, the fee would not affect your behavior
   - No, you would sort less, since you would pay the fee you could generate so much garbage as you want

7. b. Would a higher fee incite you to sort more?
   (if applicable, if the third answer is selected)

   - Yes
   - No

8. Does the pay-per-bag fee incite you to pay more attention to volominuous wrapping while shopping?
   (if applicable)

   - Yes
   - No

8. Would the pay-per-bag fee incite you to pay more attention to volominuous wrapping while shopping?
   (if applicable)

   - Yes
   - No

9. Do you consider the pay-per-bag fee as legitimate?

   - Yes
   - No, I am against taxing garbage
   - No, I am against all new taxes
   - I do not know

10. In your opinion, the pay-per-bag fee:
    (multiple answers)

    - Allows for the application of the polluter-pays principle
    - Contributes to the quality of the environment
    - Lowers the waste management costs
    - Favors high-income households and is thus inequitable
    - Makes you paying even if you already sort your garbage
    - Is unfair because you already pay enough taxes
    - Is useless, since it does not change people's behavior

11. The pay-per-bag fee could imply a higher expenditure for low-income households:
    - In spite of this, you think that the fee is legitimate
    - You think that the fee is legitimate provided that low-income households are compensated
    - This fact does not influence your opinion on the pay-per-bag fee
12. Do you consider the pay-per-bag fee as effective, in the sense that it incites the inhabitants of your municipality to recycle more of their garbage and pay more attention to voluminous wrapping?
    - Yes
    - No
    - You do not know
13. Would you accept a pay-per-bag fee whose revenues would be used to fund some public expenditures other than waste management, such as education, safety?
    - Yes, what is important is that what is paid depends on the amount of garbage incinerated and that the polluter-pays principle is applied
    - Yes, so that your municipality can afford to finance other projects thanks to the fee's revenues
    - No, I think that the pay-per-bag fee's must be used to finance the management of waste only
    - No, I am against the fee anyway
14. The pay-per-bag fees applies the polluter-pays principle, in the sense that the costs of waste management are paid by those responsible for those costs in a proportion corresponding to the amount of garbage generated, and not passed to the community as a whole. In your case:
    (one element at the time, start with knowledge of the principle)
    - You knew this principle
    - You did not know this principle
    - You agree with this principle
    - You do not agree with this principle
    - You do not have any opinion on this principle

15. Would you accept more easily a pay-per-bag fee if it would be adopted everywhere in Switzerland?

    - Yes
    - No

Socio-economic characteristics

16. Gender

    - Female
    - Male

17. Municipality

18. Age

19. Of how many people is your household composed? Adults?

20. Children?

21. Nationality

    - Switzerland (specify canton of birth)
    - European Union (specify country)
    - Other (specify country)

22. What is the highest level of education that you attained?

    - Compulsory schooling
    - Apprenticeship
    - Post-compulsory schooling
    - Tertiary education

23. What is your current professional profile?

    - Homemaker
    - Student
    - Employee
    - Manager
    - Self-employed
    - International civil servant
    - Jobless
    - Retired

24. In your opinion, protecting the environment is...

    - A urgent issue
    - An important issue but there are other priorities
    - Not an issue
    - An issue that does not concern me

25. Are you a member of an environmental organization?
    (participating financially is a sufficient condition)

    - Yes
    - No

26. a. Could you estimate the distance between your residence and the closest collection center?
    (in minutes, with the usual transportation mode)

27. b. Could you estimate the distance between your residence and the closest collection center?
    (in kilometers, approximating)

28. What is the monthly gross income of your household?

- $<$ 3'000 CHF
- 3'001-5'000 CHF
- 5'001-7'000 CHF
- 7'001-9'000 CHF
- 9'001-15'000 CHF
- $>$ 15'001 CHF
- No answer

**Survey of 2013**

1. Does your households sort the following materials?
   (multiple answers)

   - PET bottles
   - Carton
   - Paper
   - Clothes
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum

2. Do you pay attention to wrapping while shopping?

   - Yes
   - No

3. Would you generate less incinerated garbage if:
   (multiple answers)

   - Collection centers were closer to you
   - Collection centers were better developed
   - You were imposed a fee on all non-sorted garbage
   - You could not do better, you already sort all what can be sorted

4. a. How many bags does your household fill with garbage every week?

   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10

4. b. Bags volume

   - 17 liters
   - 35 liters

5. Pricing garbage by the bag is implemented in your municipality. Can you indicate the price for a 17-/35-liters bag?

6. If you would be asked to vote on the fee's rate, what is the highest price you would accept to pay for a 35-liters bag?
   (please select the value that is closer to your preferences, in CHF)

   - 0
   - 0.50
   - 1
   - 1.50
   - 2
   - 2.50
   - 3
   - 3.50
   - 4
   - 4.50
   - 5

7. Does the pay-per-bag fee incite you to sort more?

   - Yes, you sort more
   - No, you already sorted all what can be sorted
   - No, the fee does not affect your behavior
   - No, you sort less, since you pay the fee you can generate so much garbage as you want

8. Do you consider the pay-per-bag fee as legitimate?

   - Yes
   - No, I am against taxing garbage
   - No, I am against all new taxes
   - I do not know

9. In your opinion, the pay-per-bag fee:
   (multiple answers)

   - Allows for the application of the polluter-pays principle
   - Contributes to the quality of the environment
   - Lowers the waste management costs
   - Favors high-income households and is thus inequitable
   - Makes you paying even if you already sort your garbage
   - Is unfair because you already pay enough taxes
   - Is useless, since it does not change people's behavior

10. The pay-per-bag fee could imply a higher expenditure for low-income households:
    - In spite of this, you think that the fee is legitimate
    - You think that the fee is legitimate provided that low-income households are compensated
    - This fact does not influence your opinion on the pay-per-bag fee
11. Do you consider the pay-per-bag fee as effective, in the sense that it incites the inhabitants of your municipality to recycle more of their garbage and pay more attention to voluminous wrapping?
    - Yes
    - No
    - You do not know
12. Would you accept a pay-per-bag fee whose revenues would be used to fund some public expenditures other than waste management, such as education, safety?
    - Yes, what is important is that what is paid depends on the amount of garbage incinerated and that the polluter-pays principle is applied
    - Yes, so that your municipality can afford to finance other projects thanks to the fee's revenues
    - No, I think that the pay-per-bag fee's must be used to finance the management of waste only
    - No, I am against the fee anyway
13. The pay-per-bag fees applies the polluter-pays principle, in the sense that the costs of waste management are paid by those responsible for those costs in a proportion corresponding to the amount of garbage generated, and not passed to the community as a whole. In your case:
    (one element at the time, start with knowledge of the principle)
    - You knew this principle
    - You did not know this principle
    - You agree with this principle
    - You do not agree with this principle
    - You do not have any opinion on this principle

14. Would you accept more easily a pay-per-bag fee if it would be adopted everywhere in Switzerland?

    - Yes
    - No

Socio-economic characteristics

15. Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?

    - Most people can be trusted
    - You can never be too careful when dealing with others

16. Municipality

17. Are you:

    - Renter
    - Homeowner

18. In your opinion, protecting the environment is...

    - A urgent issue
    - An important issue but there are other priorities
    - Not an issue
    - An issue that does not concern

19. Are you a member of an environmental organization?
    (participating financially is a sufficient condition)

    - Yes
    - No

**Survey to the municipalities**

1. Municipality
2. Between 2012 and 2013, how many (if any) new collection centers were introduced in your municipality?
3. Between 2012 and 2013, did your municipality introduce new skips for the following materials?

   - PET bottles
   - Carton
   - Paper
   - Clothes
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum
   - Plastics
   - Other (specify)

4. Between 2012 and 2013, were the opening hours of the collection centers in your municipality prolonged?

   - Yes
   - No

5. Between 2012 and 2013, did your municipality implement a system of curbside collection for the following materials?

   - PET bottles
   - Carton
   - Paper
   - Clothes
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum
   - Plastics
   - Other (specify)

6. Between 2012 and 2013, did your municipality launch any awareness-raising campaign with the aim of spurring recycling such as:

   - Information sessions
   - Street stands
   - Advertising
   - Other (specify)