Is Taxing Waste a Waste of Time?
Evidence From a Supreme Court Decision

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Abstract

Environmental taxes are often underexploited. This paper analyses the effectiveness of a garbage tax, assessing its effects on multiple outcomes, as well as its acceptability. We study how a Supreme Court decision, mandating the Swiss Canton of Vaud to implement a tax on garbage, affects garbage production and beliefs about the tax. We adopt a difference-in-differences approach exploiting that parts of Vaud already implemented a garbage tax before the mandate. Pricing garbage by the bag (PGB) is highly effective, reducing unsorted garbage by 40 %, increasing recycling of aluminium and organic waste, without causing negative spillovers on adjacent regions. The effects of PGB seem to be very persistent over time, and across specifications. Our assessment of PGB looks very favourable. It is puzzling why we do not use it more often. Hence, we look at the political economy of PGB, and analyse people's perceptions. We find that people are very concerned with PGB *ex ante*. Public opposition seems to be the main obstacle to PGB. However, implementing PGB reduces concerns with effectiveness and fairness substantially. After implementing PGB, people accept 70 % higher garbage taxes compared to before PGB. We argue that environmental taxes could be much more diffused, if people had the chance to experience their functioning and correct their beliefs.

Keywords: Unit pricing; Recycling; Effectiveness; Difference-in-differences; Acceptability; Social perceptions

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1 Introduction

Many countries have aimed to increase the fraction of garbage that is sorted and recycled, and thus reduce the quantity of garbage sent to incineration or landfills. In some cases, ambitious recycling targets have been set. One such example is represented by the European Union, which would like its households to recycle 65 % or more of their garbage, on average a 15 % increase compared to current levels (Dijkgraaf and Gradus 2016). Similarly, in Switzerland household waste recycling targets at the Cantonal level can be at 60 % or more. One may expect these targets to translate into a wide use of economic instruments to foster recycling. However, the use of theoretically ambitious economic policies may not always be aligned with the definition of ambitious policy goals.

From an economic perspective, waste collection represents a private good, since any additional bag of garbage or container generates additional costs to the community. Furthermore, it is possible to attribute the costs of waste collection to the single household causing them, for instance with the use of special bags (Fullerton and Kinnaman 1996). Pricing garbage by the bag allows attributing to households their share of waste management costs, following the polluter pays principle, well-known since Pigou (1920). Pricing garbage by the bag may in principle also account for the external costs related with waste disposal or incineration (cf. e.g. Muller et al. 2011).

The logic of pricing garbabe by the bag (PGB) is compelling. But the real world seems either not to understand it or not to accept it. PGB and other measures of waste taxation are not often used in developed countries (see Halvorsen 2012). Why is this so? First, taxation may not work for household waste. Consumers can find other ways to dispose of their bags, leaking them to areas that do not have pay-per-bag policies, or consumers may not want to reduce waste production. Taxation may also have a short-lived effect on behaviour, with no longlasting impact on recycling. Second, people may think unit pricing is ineffective, or unfair, for instance due to its potentially regressive nature (Fullerton and Kinnaman 1996, Husaini et al. 2007).

We analyse the political economy of unit pricing and study both effectiveness and acceptance of pricing garbage by the bag. On July 4, 2011, the Supreme Court of Switzerland mandated all municipalities in the Canton of Vaud, in Western Switzerland, to apply the polluter pays principle to household waste by January 1, 2013. This ruling created a quasi-experimental situation. Some municipalities had, already before the mandate, implemented PGB and were unaffected; these are the control municipalities. Other municipalities were forced to adopt PGB to comply with the mandate;

these are the treated municipalities. We compare the evolution of outcomes in treated municipalities to control municipalities, before and after 2013, to learn about the effects of PGB.

Our innovative approach couples three sources of information. First, we conducted short telephone interviews with people living in treated and control municipalities. To the same households, in both groups, we asked twice the same questions, in fall 2012 and in spring 2013. We asked questions related to the policy's effectiveness: waste production and recycling behaviour. We also integrated a module designed to assess people's attitudes and beliefs about the policy. We were interested in perceptions concerning the effectiveness of the tax and its fairness. The interviews provide a more complete description of behavioral change at the microeconomic level and consumer sentiment. Second, we collected administrative data on incinerated garbage, at the municipality level, from 2008 to 2015, to compare our survey-based estimates of the effects of PGB to administrative estimates. We also assess whether the evolution of incinerated garbage is comparable across treated and control communities, the key requirement for a difference-in-differences analysis, and analyse the persistence of the observed effects. Third, municipalities adopting PGB often facilitated waste disposal to their citizens. We conducted a telephone survey with municipalities and collected data on additional measures undertaken by municipalities to assess to what extent PGB is a pure price effect as opposed to e.g. ease of access to waste management facilities.

Multiple outcomes need to be examined to determine the success, or failure, of a policy such as PGB. We address the question of the effectiveness of PGB from different angles and, in a single treatment, provide the following empirical findings. First, our results indicate that PGB strongly reduces the volume of incinerated waste. Both survey data and administrative data indicate that the tax reduces the quantity of incinerated garbage by about 40 %. This result is consistent across specifications regardless of how garbage is measured, i.e. in terms of weight or volume. This is a finding *per se*, as it shows limited stomping. Second, we show that PGB increases recycling of aluminium and organic waste. About 20 % new households start sorting aluminium. Similar results apply for organic waste. Third, we show that the effect of PGB is persistent over time. The 40 % drop in garbage takes place within a year from implementation, and lasts over the following years. Hence, PGB seems to be effective beyond the very short run. Fourth, we study leakage by comparing Vaud municipalities, with PGB, to their neighbours in Geneva, without PGB. A key concern with PGB is leakage, people leaving their waste elsewhere to save on the garbage tax. We find no evidence of leakage.

Our findings suggest that PGB is highly effective in reducing incinerated waste. Its effects are not just driven by stomping, or leakage. Its effects are not just driven by short-lived increases in awareness of waste use and policies, either. Why do not we see PGB implemented more often, then? At this point, we need to look at the political aspect of implementing PGB to find a potential explanation. What do inhabitants of the affected communities believe regarding the PGB's effectiveness, fairness, and political acceptability? Our novel approach provides the answer. Before PGB implementation, inhabitants of treated municipalities are concerned that PGB will not work, and believe the tax is unfair. Hence, we identify political opposition as the main barrier to PGB. However, implementing PGB reverses the situation: inhabitants in treated villages believe PGB is more effective and fairer, eventually converging to the beliefs in non-treated municipalities, who had PGB throughout. Is this a good news for PGB, i.e. does better perception of the garbage tax matter for policy? We asked people about the maximum price they would accept in a vote. This maximum price, the garbage tax, is 70 % higher after implementing PGB.

Our original approach contributes to two strands of literature. First, our study complements the literature assessing the effectiveness of unit pricing. Several different types of garbage taxation exist, such as pricing garbage by the bag (or by tags, stickers), weight pricing and subscription programs. Subscription programs tend to under-perform 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). Ideally, unit pricing should incentivise households to sort more, and to look for less voluminous wrapping while shopping Jenkins et al. (2003).

Since the price of incinerating garbage, or disposing in landfills, is usually defined in terms of weight, municipalities should in principle price households in the same unit. When garbage is priced based on its volume, and not weight, households may be tempted to compress waste to reduce volume (the so-called Seattle Stomp). However, operating weight programs is generally much more costly than operating volume programs. It is hence an empirical question whether PGB can be effective both when measuring garbage in litres, and in kilos. According to the review of Kinnaman (2006), PGB and weight programs may perform in a very similar way, in common units. Overall, the estimates for price elasticities that he reports range approximately from -0.08 to -0.39, pointing to incinerated garbage as a relatively, but not completely inelastic good and thus potentially supporting the fee's effectiveness. This reconciles unit-pricing schemes with other types of environmental taxes.

Second, our analysis contributes to the study of the acceptability of environmental taxes. On the question of public acceptability, the literature is much less developed. 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). Environmental taxes may be in general perceived as a constraining instrument, for instance as opposed to subsidies (Steg et al. 2006). A recent strand of literature on the acceptability of carbon taxes emphasises 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 Baranzini and Carattini 2016). Yet, the cross-country comparison of Husaini et al. (2007) suggests that, where implemented, unit pricing enjoys a relative popularity among the general public. This may be a signal that acceptability *ex ante* and *ex post* differ.

Our study contributes to the existing literature on the effectiveness of PGB and the political economy of environmental taxes in at least three important ways. First, we study effectiveness, and beliefs, in a setting that forces municipalities to adopt PGB. This is a unique setting, allowing us to document both what PGB does, and how it affects people's perceptions. Earlier research is based on jurisdictions that voluntarily adopt unit pricing (e.g. Dijkgraaf and Gradus 2004). The decision to implement PGB can be strongly correlated with the outcome variable, garbage per capita. Nonetheless, we are aware of only a few studies dealing with endogeneity in garbage taxation.

Second, our assessment is based on a transparent and plausible empirical design. Our methodology consists in following the same set of households, and municipalities, both before and after adoption of PGB, allowing us to document our findings in a difference-in-differences setting. Our original data sources allow us to provide in a single treatment a full assessment of PGB's effectiveness, comparing evidence from our household panel with administrative data covering a relatively long period. We are able to identify the margin of response in terms of frequency of recycling, the extent of stomping, the persistence of the decrease in garbage per capita and the effect on surrounding municipalities. Thanks to the survey to municipalities we are also able to provide a more complete description of administrative changes around the implementation, and test (and rule out) whether the observed effect of PGB is driven by confounding policies. Thanks to the length of our panel of municipal waste data, we can also test (and rule out) whether the observed effect of PGB is driven by short-lived increases in awareness.

Third, and most importantly, our extensive information on people's perceptions of the effectiveness and political acceptability of the tax enable us to assess how these beliefs change when the tax is implemented. Doing so turns out to be important as perceptions change dramatically when the tax is implemented. While the recent literature on the acceptability of environmental taxes has used several methodologies to understand why more often than not economic prescriptions are not followed by local and national authorities, we are not aware of any study analysing the perceptions of the same households before and after the implementation of any environmental tax. Our results on acceptabilty provide considerable implications. First, we document that the main reason for not implementing PGB is people thinking it is ineffective, or unfair, and not PGB being ineffective, or unfair. Second, people update, and correct, their beliefs once the policy is in place, suggesting that PGB, and potentially other environmental policies, could be much more diffused had people the chance to observe them in action. By studying a situation in which vested interest play little role, we can isolate the effect of experiencing environmental policy on acceptability and inform the literature analysing more complex policies, such as carbon taxes, in which popular opposition interacts with lobbying from potential losers.

The next section provides information on waste collection in Switzerland and a literature review. Section 3 provides background on the data sources, and a first descriptive overview. Section 4 presents our empirical strategy, difference-in-differences, and discusses the identifying assumptions. Section 5 provides our evaluation of the effectiveness of pay-per-bag fees. Section 6 shows how introducing PGB changes people's perceptions. Section 7 concludes.

2 Waste Management in Switzerland and the Canton of Vaud

In Switzerland, municipalities manage waste disposal either directly or by joining forces in regional companies that take care of the full process for several shareholder municipalities. Regional companies collect and weigh garbage, which is then incinerated in local plants, also funded by public capital from municipalities or the Canton. Regional companies re-inject recycled materials in the production cycle.

Households are charged for this service by the municipality in which they reside. Absent any pricing, all waste management costs are raised independently of the quantity of garbage that the household produces. Most commonly, waste management costs are covered by lump-sum taxes calculated based on the number of household members in adult age. Municipalities (as well as Cantons and the Federal Government) can raise income taxes, but these are generally not used to pay for waste management.

Households are free to recycle or not, based on the incentives that they face. Drop-off centres are available in all densely populated areas as well as in rural municipalities. Most of them allow the disposal of the following materials: polyethylene terephthalate (PET), carton, paper, clothes, glass, cans, organic waste, batteries, and aluminium. In many apartment buildings, paper and carton are collected within the building's premises.

Unit pricing has existed for two decades in Switzerland, but in a very heterogeneous fashion. Unit pricing is frequent in the Swiss-German, Eastern, parts of Switzerland. In the Western parts of the country it is limited to the Cantons of Fribourg and Neuchâtel (unit pricing introduced in 2012) and to some municipalities of the Cantons of Jura, Vaud and Valais. The Cantons Jura and Geneva, are known to have been historically averse to such policy.

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. A limit to the principle of subsidiarity comes however from a 1997 federal environmental protection legislation imposing the principle of causality in waste collection management, thus forcing the implementation of unit pricing at the municipal level.

In the Canton of Vaud this legislation was nevertheless not enforced until a 2011 lawsuit led to a Federal Supreme Court's ruling. The Federal Supreme Court mandated all municipalities in the Canton of Vaud to implement unit-pricing schemes to finance waste collection. Lump-sum taxes are only allowed as a complementary source of revenue. This decision started a legislative process at the municipal level that generated a large wave of unit pricing implementations in the Canton.

Our analysis focuses on municipalities that switched to a system of pricing by the bag. Pricing for garbage is identical all across the Canton and proportional to volume, e.g. the price for 17-litre bag is 1 CHF or about 1 USD, for a 35 litre bag it is 2 CHF, etc. When switching to PGB, municipalities decreased the lump-sum taxes used to fund waste management costs, as prescribed by the federal institutions overseeing regulated prices in the country.

3 Data

In this Section, we first discuss how we defined treated and control municipalities, how we collected the household survey data, and provide a first descriptive overview of the main variables.

Treatment and control municipalities Before 2013, 86 municipalities had already introduced some form of unit pricing, out of which 58 had implemented using PGB. By November 2013, 162 municipalities had modified their laws in order to introduce unit pricing by January 2013, out of which 158 adopted a PGB scheme. A total of 121 municipalities had not reached a decision on introducing PGB by January 2013.[1]

Our analysis focuses on municipalities that introduced PGB by January 1, 2013. We separate these municipalities in two groups. The 58 municipalities that introduced PGB before January 1, 2013, are 'control' municipalities, as they did not change PGB status. The 158 municipalities that introduced PGB on January 1, 2013, are 'treated' municipalities.

We collected data on control and treated municipalities from three sources: a household survey, municipality level data on waste, and municipality survey on waste management policies, introduced along with PGB.

We designed the household survey study as follows. We randomly selected 48 municipalities from the set of control municipalities, and 22 municipalities from the treated municipalities. We then contacted a professional survey company, which provided us with a random sample of at most 30 addresses of people within each municipality in our sample. Overall we had 1380 addresses for the control group, and 599 for the treatment group.[2]

A team of interviewers then administered two rounds of telephone interviews to households in our sample. The first round of interviews took place between November and December 2012. Due to the limited amount of time available, we contacted only 70 % of the households before January

[1] Among them, a few municipalities introduce PGB later during 2013, and are excluded from the econometric analysis. We further consider the possible implications of this specific situation. Note that due to on-going merging processes, the number of municipalities slightly differs between 2012 and 2013. Note also that a few municipalities implemented PGB in 2012, i.e. after the Supreme Court's ruling but before the formal date of forced implementation. Excluding these municipalities from the control group would not affect our results.

[2] The sampling rates are not the same across treated and control municipalities since not all municipalities that were supposed to introduce PGB on January 1, 2013, did it. Latecomers had not announced the implementation of the tax in November 2012, when we designed the survey, but we could not rule out that some of these municipalities would manage to introduce PGB on time. We exclude latecomers from our analysis as none introduced PGB by January 2013. As shown by Table A.1, the municipalities implementing PGB at a later stage are no different from those implementing it on January 1, 2013, in terms of population size, greenness (measured in terms of votes cast for a green party at the last federal elections) and income tax coefficients, a standard proxy for wealth. Data for 2014 confirm this observation; the effect of PGB is not different on latecomers. Section 5 tests whether heterogeneous treatment effects may exist across municipalities.

1, 2013, the date of the policy change. Since each interviewer contacted a random mix of treated and control households, households we did not contact are similar to households we contacted. We collected data from 228 households in the control group, and for 124 households in the treatment group. The response rate in this first round of interviews is about 20 % for both groups.

The second round of interviews took place between April and June 2013, once the policy was in place. Out of the 352 households that participated in the first round, 193 households participated also to the second round. We will use data on the 193 households participating in both interview rounds in our difference-in-differences analyses. The response rate is higher for treated households. We discuss below potential selection issues and how we pacify any related concern.

Interview data provide rich information on households, but do not cover all individuals living in treated and control municipalities. To address this, we also collected administrative data on incinerated waste, available for all municipalities. These data provide information on the quantity of solid waste produced per capita in a municipality. It is available from 2008 to 2015. The data covers the entire Canton of Vaud, allowing comparing survey data from our sample of households and aggregate data for all municipalities in each group.

Many municipalities introduced measures that made it easier for their citizens to dispose of their waste when they shifted to pricing garbage by the bag. These measures have often been neglected in previous research, although they may confound the main estimates. We collected detailed information on these measures. We contacted the member of the municipality councils in charge of waste management for all municipalities covered by the survey panel data. We administered a supplementary questionnaire capturing changes in the number of kerbside programs, of collection centres, of skips, in the opening hours of existing collection centres and in the frequency of raising-awareness initiatives taking place between the two periods. Of the 82 municipalities for which we observe at least one household, we obtained answers for 34 municipalities. We pay attention to possible selectivity of this sub-sample of 34 municipalities in our estimates below. Assessing the effects of PGB only on the municipalities for which we know that no additional measures were introduced between 2012 and 2013 would provide the same results as in the main estimations.

Finally, implementing PGB may increase household awareness on the importance of recycling. Short-lived awareness may lead to large estimates of PGB, which may disappear in the medium to long run. Some households may also over- (or under-) react in the short run, and realise that they may (not) be better off paying the fee than recycling a given material. We use administrative data for 2014 and 2015 to shed light on the persistence of PGB's effect. This aspect has been generally overlooked in the literature, and we exploit our relatively long panel and the other properties of our context to fill this gap.

Main Variables The survey is structured in three parts. In the first part, we ask households about their behaviour regarding solid waste and recycling of the following 9 materials: PET, carton, paper, textiles, glass, cans, organic waste, batteries, and aluminium. 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 A.2).

Table 1 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. Descriptive statistics are given for the treatment and control groups for 2012 and 2013. Solid waste is measured in litres per week. This value is obtained by multiplying the number of bags used per week with their volume (17 and 35 litres are the most common sizes). Total observations for solid waste are 371. Recycling variables take value 1 if the household sorts a given material and 0 otherwise.[3]

4 Empirical Strategy

In this Section, we explain the empirical strategy and discuss the external validity of the household survey data.

Empirical framework Evaluating the introduction of PGB is challenging because adoption of PGB could be related to environmental preferences of voters, i.e. policy endogeneity (cf. Besley and Case 2000). We describe in this section how we address endogeneity. We assume the level of garbage production absent any treatment to be dependent on time and municipality characteristics and apply

[3] 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 it is desirable to recycle n units of material, then it is likely to be desirable to recycle $n+1$ units. 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 behaviour (Sterner and Bartelings 1999). We use a binary measure also for voluminous wrapping: we ask to households whether they pay attention to wrapping or not.

a standard difference-in-differences approach. The parameter of interest captures the average effect of introducing PGB in municipalities that adopted PGB in compliance to the Supreme Court mandate. The average effect might vary across municipalities for socio-economic reasons, but not because of differences in the garbage tax, as the tax is linear and homogeneous at the cantonal level.

The key identifying assumption requires that the trend in the treated outcome in municipalities that had PGB before the mandate, or control municipalities, is the same as the trend in the non-treated outcome in municipalities that adopted PGB in compliance with the mandate, or treated municipalities.[4] We assess this identifying assumption below using several years of data before the policy change. If the underlying assumptions are verified, an OLS estimate of our key empirical specification provides unbiased estimates of the average causal effect of our treatment. In all estimates, we allow for clustering of the errors at the municipality level. Household characteristics may vary between municipalities and groups, so we will assess sensitivity of our results to control variables.

How does this approach compare to those used in the literature? In cross-sectional studies, as in Kinnaman and Fullerton (2000), environmental-friendly communities may be relatively more likely than others to introduce unit-pricing systems. 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 implementing such policy to converge towards a "standard" level of garbage production. Efficiency reasons may also support this second source of endogeneity (Dijkgraaf and Gradus 2009). Cross-sectional comparisons may thus underestimate the policy's effectiveness.[5]

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 trends (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). Other elements,

[4] Our assumption is somewhat different from the standard identifying assumption in difference-in-differences contexts, asking for parallel trends in the outcome without treatment in treated and control municipalities. The control group in our setting is always treated whereas the control group is never treated in the standard setting.

[5] 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. Their finding suggests that the second source of bias may dominate, i.e. simple cross-sectional analysis would underestimate the policy's effectiveness. Dijkgraaf and Gradus (2004) use the decision to adopt unit pricing as signal of 'environmental activism'. Controlling for 'environmental activism', the authors find with panel data a lower estimate for unit pricing. They hence argue that this variable helps correcting for the policy endogeneity. Based on their finding they suggest that the first source seems to dominate, i.e. simple cross-sectional analysis would overestimate the policy's effectiveness. Allers and Hoeben (2010) use the tax rate of unit pricing in neighbouring municipalities as instrument for the likelihood of implementing unit pricing. This approach does not improve the estimates for unsorted waste, but it does for organic waste.

such as citizen's environmental friendliness, may also change over time. Non-tax policies (as the ones we observe in our context) 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 approach addresses both issues. For treated municipalities, waste production changes over time because of the tax but also because of other changes in time. Control municipalities provide information on the time trend. Difference-in-differences isolates the effect of PGB by netting out the time trend.

External validity Our survey provides fascinating and rich information but given the number of households may not be fully representative of the Canton as a whole. How can we verify that our results are not distorted by selection issues? We now discuss several pieces of evidence. First, Tables A.2 and A.3, compare our sample to the population in the Canton. This comparison suggests that, if anything, our sample is slightly older and richer than the underlying population, and includes slightly more Swiss nationals. These minor differences may not be related with selection. Recall that we give equal weight to all municipalities, regardless of their size. We thus cover households living both in urban and rural areas. Second, Table A.2 compares individuals who participate in the first round of interviews but not in the second one to those who participate in both interviews. Results indicate that compliers may be slightly richer and better educated. Statistically speaking, a small difference can be found also for foreign (EU) citizens between the two waves. Third, Table A.2 also compares individuals in the treated group and in the control group. Once again we remark only very slight differences, for e.g. nationality, education, and income. Based on these comparisons we see that the extent of non-randomness, if any, is limited in the selection of our panel. We will introduce control variables in our analyses to account for any possible non-random selection.

Furthermore, we recall that we collected extensive official data measured by municipalities. Using these data, we can estimate the effect of introducing PGB using data on everyone in the municipality. To do so, we proceed as follows. We first compare population estimates with survey estimates to learn about the representativity of our survey estimates. We then exploit the full scope of the administrative data to look at all municipalities starting to price garbage by the bag on January 1, 2013, as (extended) treatment group, with all municipalities already pricing garbage by the bag by the end of 2012 as (extended) control group. These tests should indicate whether our survey results are also relevant for the larger population.

5 Is PGB a Waste of Time?

In this section, we present the main results on the policy effectiveness. We start by studying the evolution of waste over time in treated and control municipalities. We then show effects on waste, and recycling based on survey data. We then present evidence based on administrative data, verifying the external validity and representativity of our survey sample. Administrative yearly data are available since 2008, normalised by the number of inhabitants (i.e. kilos per capita). We discuss how to test for leakage, waste wandering into adjacent municipalities that have no PGB. Finally, we test the persistence of PGB's effect, using data for the most recent years, 2014 and 2015. While doing so, we also test the common trend assumption for difference-in-differences estimates. Refer to Figure 2 for an anticipation.

Results for Garbage We start by assessing the treatment effect on the amount of solid waste produced by households in the survey. 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 differences, which is of about -10 litres and statistically significant, as indicated by the confidence intervals.

Column (1) in Table 2 translates this effect into numbers.[6] We introduce control variables in column (2). The treatment effect amounts to about -10.5 litres 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 composition. 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 substantially improves. We thus point to column (2) as the appropriate specification and discuss the estimates accordingly. Since some missing values affect control variables, in column (2) the number of observations is slightly reduced, from 371 to 359.

[6] OLS is used in all specifications unless otherwise specified. Municipality-specific fixed effects are justified by a $\chi^2(2)$ of 32.08 ($p > \chi^2(2) = 0.0000$) in the Hausman test for column (1) and a $\chi^2(25)$ of 62.53 ($p > \chi^2(25) = 0.0000$) for column (2). Quantitatively equivalent results can be obtained using household-specific fixed effects. 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.

In 2012, the average solid waste volume per capita per week in the treatment group was slightly above 27 litres. This implies that the treatment generates a decline in solid waste of about 40 %. The effect of Table 2 is close to the estimate of Fullerton and Kinnaman (1996), a decrease in volume of about 37 %. However the authors find that in terms of weight this estimate is significantly smaller. We test below whether the magnitude of PGB's effect is the same when measuring garbage in kilos. In computing the price elasticity of demand we follow the strategy outlined by Kinnaman and Fullerton (2000) and find an arc-elasticity of about -0.3.[7]

Results on the control variables indicate that a high level of education as measured by possessing a university degree is related to less solid waste per week per capita (about 8 litres) compared to having completed only the compulsory education (the reference case). It is indeed common in the literature to have pro-environmental behaviour positively associated with education (cf. e.g. Jenkins et al. 2003 for the case of garbage). Income is available in six categories, with the highest income serving as the reference. Consistent with consumer economics, low-income households produce significantly less garbage as they have lower levels of consumption and lower opportunity costs of recycling.[8]

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 2012) and especially to a better allocation of recycling tasks within large households, taking into account the differences in opportunity costs. The statistically significant coefficient for distance from a collecting centre shows the importance of installing collection centres 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 centres and kerbside recycling programs (cf. e.g. Jenkins et al. 2003; Kinnaman 2006; Halvorsen 2008; Hage et al. 2009).

Effects on Recycling How does pricing garbage by the bag affect recycling? Table 3 reproduces the same approach of Table 2 for all recycling materials plus wrapping. The outcomes that we observe here are binary. We may thus want to also estimate a probability model. Since the number of unknown parameters increases with the number of households for a fixed panel length, such specification would face the incidental parameters problem, which implies that the coefficients for

[7]On average bags are priced at 1.5 francs. Absent any tax, the retail price of a bag was slightly above 0, around 0.17. The arc-elasticity resulting from an increase in price from 0.17 to 1.5 is the same as the point-elasticity at a price of 0.665. We hence get -9.67·0.665/((27.4+13.875)/2)=-0.32.

[8]Note that socioeconomic variables may be given for the household's representative answering the questionnaire, whereas waste management is rather a household decision.

municipality-specific fixed effects would be 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 however estimate a non-linear model by “brute force” (cf. Greene 2011), knowing that this technique introduces an upward bias of 100 % when T=2 as in this context, and compare it to linear regression. Since estimates from Logit are very similar to those obtained with OLS, taking into account the brute-force bias, and given the lost observations when success or failure are perfectly predicted, we comment the empirical results based on estimates from OLS. Estimations from Logit models are provided in the Appendix. For the same reason, we do not display Logit models with control variables.[9]

In the top panel we apply the simplest model without control variables to the frequency of recycling. Treatment effects have the expected sign and are the largest in the case of aluminium and organic waste. In the bottom panel we introduce our standard set of controls. Only the treatment effects for aluminium and organic waste are robust to the inclusion of control variables.[10] That is, the most conservative estimates from columns (1) and (6) confirm that there is an increase in the frequency of recycling of organic waste (of about 14 %) and of aluminium (of about 20 %). These effects are not only statistically significant, but also considerably large from an economic perspective. Regarding batteries, cans, carton, glass and paper the coefficients remain positive, but are no longer large enough to reach significance.

Statistically significant control variables include distance from the collection centre and a few income categories. 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. The effect of distance from the collection centre is negative and statistically significant for all materials except for aluminium and batteries, which may be less difficult to transport than other materials. From Table A.4 we can infer that a decrease in distance of about 10 minutes would lead to an increase in the frequency of recycling of paper of about 6 %.

[9] All additional estimations are available by the authors upon request. The statistical significance of the treatment effect on recycling, if any, is robust to the use of false discovery rate q-values for multiple regressions (Anderson 2008).

[10] 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 these practices are related with a lack of experience rather than an attempt to cheat. A telling example is the use of non-organic bags for organic waste. There is also little evidence of diffused illegal practices (see Fullerton and Kinnaman 1995) in the context under observation, which reconciles with the Swedish context of Sterner and Bartelings (1999).

Testing for Confounders Some municipalities facilitated recycling at the time of introducing PGB. Neglecting these policies, we would tend to overstate the effectiveness of unit pricing. We now consider the role of this confound using data from the survey to the municipalities. These data measure whether a municipality increased opening hours, launched a raising-awareness initiative, etc. or not.[11] Table A.6 gives descriptive statistics for the variables considered in this analysis for both the control and the treatment groups. We observe in Table A.6 that non-tax measures increase in both the treatment group and the control group, perhaps due to the salience of the Supreme Court mandate in the entire region.

Estimates from the regressions including potential confounders are presented in Table 4, using survey data. Non-tax variables are not available for the whole sample. Column (1) estimates again the treatment effect as in the respective column of Table 2, but 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 2. Column (2) adds variables that indicate the presence of new measures to facilitate recycling. The coefficient for the treatment effect is somewhat smaller but statistically identical to the baseline effect in column (1). This result suggests that mainly PGB, and only to a much lesser extent the recycling programs, explain the sizeable reduction in garbage in municipalities that introduced PGB.[12]

Most non-tax variables are statistically insignificant and the goodness-of-fit is only slightly affected. The number of materials covered by new skips is negative, and statistically significant.[13] The coefficient for the kerbside program is also negative, but does not reach significance. We also find positive point estimates for better opening hours, new collection centres (statistically significant) and unaddressed mailshots (very small). We suspect this result is driven by reverse causality. PGB may also increase awareness in the short-term, regardless of the other efforts undertaken by municipalities. We analyse with administrative data whether PGB's effects change over time, as if it were driven by short-term increases in awareness eventually vanishing away.

[11]We exclude a few measures that affected only a handful of households, i.e. awareness-raising tools such as street stands and specific online websites.

[12]We have replicated results also with administrative data on incinerated waste (see below). Table A.7 shows results that are virtually identical to those obtained with survey data. We have also explored how non-tax variables affect recycling behaviour. Results are not affected. The coefficient for organic waste, for instance, becomes 0.130, statistically undistinguishable from the 0.144 of Table 2 and remains statistically significant.

[13]Note that this variable is counts the number of materials covered by new skips, which allows to avoid including correlated skip dummies for each material.

Administrative Data To estimate the treatment effect, we focus first on the amount of solid waste sent to incineration in 2012 and 2013, from official data, focusing on the subsample of municipalities for which we also have survey data. Estimates are provided in Table 5. The first column shows that the implementation of PGB causes a reduction in the amount of per capita solid waste of about 86 kilos per year. 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 between households. In percentage, with respect to a previous level without treatment of 244 kilos, we find a reduction of about 35 %. Hence, the comparison of estimates from Tables 2 (in litres) and 5 (in kilos) indicates that the two data provide comparable estimates for the effectiveness of PGB.

We obtain a very similar elasticity using weight as unit of measurement (about -0.29 with the estimates from column (1)) as we did based on volume. The slightly smaller elasticity may suggest the presence of some degree of stomping, yet not sufficient to lead to a statistically significant difference in the main effects. As noted by Bel and Gradus (2016), such a difference is likely to exist mainly when volume pricing is represented by containers, as in Fullerton and Kinnaman (1996), instead of smaller units such as bags, as in this case. Considering for instance the case of the Netherlands, no difference between weight and bag pricing is found in Dijkgraaf and Gradus (2004) and Dijkgraaf and Gradus (2009), while some divergence is documented in Dijkgraaf and Gradus (2015), favourable to weight programs, and Dijkgraaf and Gradus (2016), favourable to bag programs.

Administrative data also allow us to test whether the treatment effect found so far applies only to the subset of municipalities covered by the survey data or whether these are representative of the Canton as a whole. As a result, we reproduce in column (2) the same approach of column (1) using all municipalities in the Canton. Estimates from Table 5 provide further evidence on the external validity of the previous results. Based on 434 observations, 217 municipalities, the treatment effect is estimated in column (2) at about 80 kilos per capita per year of reduced solid waste. This figure is quantitatively undistinguishable from the previous estimates and implies a reduction in garbage per capita of about 40 %. The treatment in column (2) is still PGB whereas in (3) we take all unit pricing schemes as treatment. Introducing data also on weight programs does not affect the treatment effect in any statistically perceptible way. However, since only a small fraction of municipalities opts for a weight-based treatment it is difficult to infer from this outcome that effectiveness does not differ across specific pricing schemes.

A central concern with our analysis is the non-random nature of the adoption of PGB. Most of the literature focuses on forerunners. Perhaps treated municipalities, resisting unit based pricing until forced to do so, do not care about the environment and recycling. This might lead in a very large estimate of the effects of PGB on garbage production because of the specific initial conditions. We collect information on the votes cast at the municipal level in favour of green political parties at the national election of 2011. Column (4) of Table 5 adds the green vote share and interacts is with the treatment to assess selectivity of municipalities in our sample. The interaction effect is not statistically significantly different from zero, suggesting that the effect of introducing PGB does not significantly vary with the green vote share. Nonetheless, introducing PGB reduces waste by 109 kg per capita, somewhat stronger than the baseline effect of 80 kg per capita. But note that this main effect refers to municipalities with a zero vote share for green parties. In 2011, the average green vote share in the Canton was 15.90 %. Hence, the effect of introducing PGB for the entire Canton of Vaud, at the average green vote share, is -109.37+0.8556*15.90 = -95.8. This effect is slightly stronger than the effect in column (2), suggesting that, if anything, our difference-in-difference provides an under-estimate of the effects of PGB for the entire region.

Dealing with possible confounders, we extend the specification of column (1) to control for other policies that could potentially drive some of the effect for the treatment, as done with survey data. We do this in Table A.7. Since we possess data on non-tax policies only for some of the municipalities concerned by the household survey, we should 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). This additional estimation also points to relatively little heterogeneity in responses to PGB. Similar to survey analyses, non-tax policies reduce the treatment effect, but neither to a statistically significant nor to a quantitatively important extent. One reason for this is that non-tax policies are not only introduced by some treated municipalities, but also by some control municipalities. A statistically equivalent estimate would be obtained if estimating the effect of PGB only on municipalities for which we know that no other change occurred when PGB was implemented.

Parallel Trends and Persistence Figure 2 shows average garbage from administrative data in the treated municipalities and control municipalities covered by our survey from 2008 to 2015. We focus on municipalities who never changed their PGB status between 2008 and 2012. Dotted lines indicate confidence intervals. The purpose of Figure 2 is twofold. First, we want to understand the trends in incinerated waste, official data, produced by municipalities in the treatment and in the control group. 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.[14] This check provides support for the causal interpretation of the econometric analyses undertaken so far.

Second, we want to assess the effectiveness of PGB beyond the very short run. If the main effect of implementing PGB was to increase awareness for garbage use and recycling, we should probably expect part of the effects discussed so far to vanish over time. Figure 2 provides however evidence in favour of PGB's persisting effects. The average quantity of garbage per capita in the treatment group seems to converge towards the average quantity in the control group, and stabilise afterward.

Table A.8 reproduces the estimations of columns (1) and (2) of Table 5. The estimates are statistically not different across tables (and, again, across specifications). The effectiveness of PGB is the same if measured within the first year after the treatment or within the first three years. If anything, the point estimates are slightly larger after three years.

PGB is effective, and its effectiveness is not related with possible confounders, such as non-price policies. PGB increases recycling of aluminum and organic waste, and its effects are persistent over time. The appraisal is so far very positive. But can PGB lead to perverse effects under the form of leakage to neighbouring regions?

Effect on Surrounding Municipalities We assess whether there is scope for leakage by observing the changes in solid waste per capita across the border between the Canton of Geneva, where solid waste is not priced, and the bordering municipalities of the Canton of Vaud, which implemented unit pricing on January 1, 2013. The policy shock in the Canton of Vaud allows us to exploit a sharp regression discontinuity design, where the threshold between the municipalities in the Canton

[14] We have tested parallel trends by implementing a placebo introduction of PGB for treated municipalities in 2009, 2010, 2011, and 2012, for the different subsamples used in the empirical analyses. The placebo effects are all not statistically significant, and smaller than 10 per cent of the treatment effect, in absolute value.

of Geneva (South) and those in the Canton of Vaud (North) is given by the latitude 46°17N. We thus use the latitude as forcing variable, around the cut-off °17, and an untreated control group. While from a purely theoretical perspective we could be facing some mobility across the border, it is unlikely that households can be tempted to relocate from one side to the other of the border due to unit pricing. We select the optimal bandwidth following Calonico et al. (2014).[15]

Our main focus is on the slope of the regression on both sides of the border. If there is leakage, we would expect the amount of solid waste per capita to increase (decrease) in the Canton of Geneva (Vaud) as we approach the border from South (North). Figure 3 provides the main graphical results. Following the treatment there is a clear jump in solid waste per capita per year, with a difference of slightly more than 100 kilos. This result seems to corroborate the effectiveness of pricing garbage by the bag. However, this exercise also allows us to compare the previous estimates of pricing garbage by the bag's effectiveness with a new set of estimates obtained with an untreated control group. In terms of slope, there is no clear pattern.

Tables 6 and 7 provide quantitative evidence for the results suggested by Figure 3. The jump is estimated at about 107 kilos per capita per year, slightly above but statistically unchanged with respect to the results in the previous paragraphs. In relative terms, the change is again of about 40 %, starting from a level for 2012 of about 273 kilos per capita per year. This figure is clearly consistent with the previous discussion. While graphically there seemed to be some very small leakage, in statistical terms this evidence is not confirmed (cf. Table 6). As shown by Table 7 with simple linear local regressions, the coefficient measuring the slope of the regression is positive (negative) on the left (right) of the threshold, but in both cases it does not reach statistical significance. Hence, we conclude that there is no evidence of leakage (see also the Swedish case of Sterner and Bartelings 1999 and the Dutch case of Dijkgraaf and Gradus 2004 for comparable findings).

If pricing garbage by the bag can be so effective, why do not we see more municipalities adopting it? A possible explanation might be that people do not know about how the tax works, or find it unfair. We analyse perceptions on effectiveness and fairness in the next section.

[15]We implement several bandwidth selectors as proposed in the literature and in all cases the choice of the bandwidth has no implication for the findings of this Section. Note that Figure 3 displays bins, and not single observations. Estimating a difference-in-differences approach across the border would lead to a treatment effect of about -109 kilos of solid waste, statistically indistinguishable from the estimate of the regression discontinuity design. Data for Geneva comes from OCSTAT (yearly garbage per capita in kilos).

6 What do People Think?

In this section, we discuss the effects of PGB on voter perceptions and voting intentions.

Results on Perceptions We address the questions of policy perceptions by applying the same difference-in-differences approach used with respect to the question of effectiveness.

We start our analysis with questions aiming to see whether respondents understand the tax. The variable *perceived effect on the environment* measures whether respondents consider the PGB 'as effective, in the sense that it incentivises the inhabitants of your municipality to recycle more of their garbage and pay more attention to voluminous wrapping' accepting answers 'Yes', 'No', and 'I don't know'. Recall that we ask exactly the same questions to both groups in both periods, before and after PGB is implemented in the treated group. We study the proportion of people answering 'Yes' in columns (1) and (2) of Table 8. Socio-economic controls are included in even columns. Since all variables in this paragraph are binary, we compare again estimates from OLS regressions with a fixed-effect Logit model estimated with Greene's (2011) brute force method (cf. Table A.10, even columns include the standard set of control variables). We find that the treatment is associated with more than one household over ten changing its opinion in favour of the fee's effectiveness.

Generally speaking, environmental taxes need in principle to be set so that they internalise external costs. Remaining revenues should ideally be spent on projects with the highest social return, or refunded to the public. Voters, however, often ask for earmarked environmental taxes since they do not see how improvements in environmental quality can be obtained otherwise. We consider some unrelated municipal expenditures and test understanding of environmental taxes using the variable use of revenues for other purposes, which asks respondents '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?'.

Columns (3) and (4) of Table 8 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 becomes aware of the incentive effect of PGB. Looking at Table A.9, 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 perceived effectiveness.

In terms of fairness, we asked 'In your opinion, is the pay-per-bag fee unfair because you already pay enough taxes?', an item that captures resentment against introducing a new tax. A second item we study considers responses to the question 'In your opinion, does the pay-per-bag fee makes you pay even if you already sort your garbage?'. This item measures resentments against paying a tax on the quantity of garbage that can no longer be sorted. In both cases, we allow for 'Yes', or 'No' answers.

Columns (5) to (8) of Table 8 report the estimates for both unfairness items. Introducing PGB reduces the feeling of unfairness of having one more tax, and of having to pay a tax on unsorted garbage. Implementing PGB reduces both resentments, as people possibly understand the mechanism behind unit pricing better.

We also explore the feeling of inequity, since PGB opposes two different concepts of justice, the polluter pays principle, advocating for higher fiscal burden for bigger polluters, and a social equity principle, stating that the fiscal burden should depend at least proportionally on one's contributive capacity. Given the regressive nature of PGB, the two concepts conflict. The income elasticity of garbage is 0.4 in our sample, so pricing garbage by the bag has indeed a regressive effect. The first item we study is 'In your opinion, a pay-per-bag fee favours high-income households and is thus inequitable', allowing for 'Yes' and 'No' answers. This variable captures resentments against the regressive nature of the tax. The second variable stated 'The pay-per-bag fee could imply a higher expenditure for low-income households'. Respondents were given a choice between three answers: (1) 'I think this is legitimate', (2) 'I think that the fee is legitimate provided that low-income households are compensated', or (3) 'This fact does not influence your opinion on the pay-per-bag fee'. We analyse the proportion of (2) answers.

Columns (9) and (10) of Table 8 present the estimates for the perception of inequitable treatment, while columns (11) and (12) display the estimates for social justice. Introducing PGB does not affect perception of whether the tax is inequitable or legitimate. The point estimates on the treatment effect are not significantly different from zero. But both treatment and control groups consider PGB less inequitable after January 1, 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 offset the possible distributional effects.

Experiencing the treatment seems to positively affect the PGB's perception, in particular concerning its effectiveness and the related sentiments of unfairness. Seeing the tax work, in one's own household as well as in one's social environment, may change some erroneous beliefs that it is not effective. The stigma of social injustice associated to unit pricing is smoothed in the whole Canton, according to the evidence in our sample, perhaps 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.

Voting intentions Individuals become less averse to PGB once they are forced to live with it. But do people become more willing to implement PGB on the political arena? We discuss this using data on voting intentions on the bag's maximum price.

We asked respondents about the maximum bag's price they would vote for in a ballot, if asked to define the tax rate for PGB. Specifically, respondents were asked 'if you were asked to vote on the fee's rate, what is the highest price you would accept to pay for a 35-litres bag?' We accepted responses between 0 and 5 CHF, at increments of 50 cents. Note that this scenario is very realistic as Swiss people regularly vote on local, regional, and national issues.

This survey instrument measures political acceptability of the tax. Note that this is different from willingness to pay. A rich individual, with high willingness to pay to get rid of garbage without time-consuming sorting activities, may well indicate a politically acceptable price of zero in our survey.

Figure 4 shows the distribution of acceptable prices for 2012 and 2013. For both years and groups the distribution is not normal and clusters at 0 and 2 (the official price for a 35 litres bag). In the treated group, 59 per cent of individuals indicated an acceptable price of zero, as opposed to 38 per cent in the control group, before the implementation of PGB. There is a striking difference in the average acceptable price as well. Treated municipalities are willing to vote for a price of 0.89 CHF, whereas control municipalities would vote for 1.49 CHF, or 67 per cent higher than in the not-yet treated group.

In 2013, after PGB has been introduced in treated municipalities, the distributions of acceptable prices overlap. Interestingly, the modal answer in both groups of municipalities is 2 CHF, the actual price of a garbage bag. Hence, it is plausible that the current price provides a reference for voting behaviour. The average acceptable price in the treatment group is 1.55 CHF, and 1.57 CHF in the control group. That is, people increase by 70 % the stated maximum price per garbage bag that they would approve in a ballot. Introducing PGB has removed any differences in the acceptability of the garbage tax.

7 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. The identification strategy relies on the forced implementation on January 1, 2013, of pricing garbage by the bag in many municipalities of the Canton of Vaud, due to a ruling decision by the Federal Supreme Court of Switzerland, creating a difference-in-differences situation.

Both survey and administrative data show that pricing garbage by the bag causes a reduction in the amount of incinerated garbage per capita by about 40 %, implying a price elasticity of demand of about -0.3. Lower incinerated garbage is accompanied by a higher frequency of recycling of e.g. organic waste and aluminium. Our estimates are robust to the presence of simultaneous introduction of other measures that make garbage collection easier. The effects of pricing garbage by the bag are also persistent. Pricing garbage by the bag's effectiveness is the same within one year or three years from the implementation. Applying a regression-discontinuity design we rule out the potential risk of substantial leakage effects on surrounding municipalities.

We also analyse people's beliefs concerning pricing garbage by the bag's effectiveness and fairness. Our key result is a sizable gap between *ex ante* beliefs and *ex post* beliefs. People initially believe the tax is unfair and does not work, but implementing it improves the program's perception of effectiveness and fairness. The environmental tax seems to be better understood once in place.

Biased beliefs can be an obstacle to implementing economic policies. People are pessimistic about a environmental tax before they experience it, and become more optimistic once the tax has been implemented. If people hold pessimistic beliefs at the time of democratic decision-making, many environmental policies will not be implemented. Our setting shows a way out of this stalemate. Outside force, e.g. the Supreme Court mandate, can force people to experience a new economic instrument, thereby updating beliefs, as in the context that we have analysed.

Our context does not allow municipalities to revert the changes forced unto them, but in an ideal world, people could decide on keeping the new policy or returning to the status quo after testing it. Policies forced onto people that remain detested could be abandoned after the trial period. Policies that people embrace after living with them would remain. A mechanism dealing with incorrect beliefs would force people to implement a new environmental tax temporarily but allow them to keep it or abandon it after a trial period.

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Figures

FIGURE 1 – Household survey: treatment effect on solid waste per capita in litres per week

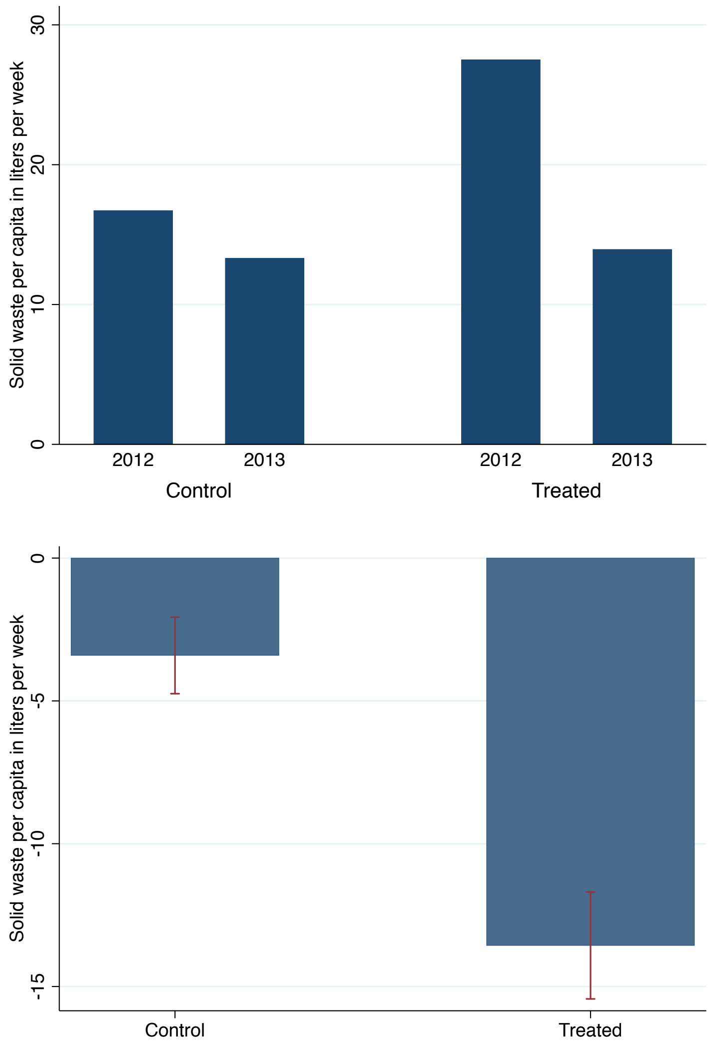


FIGURE 2 – Administrative data: parallel trends and persistence

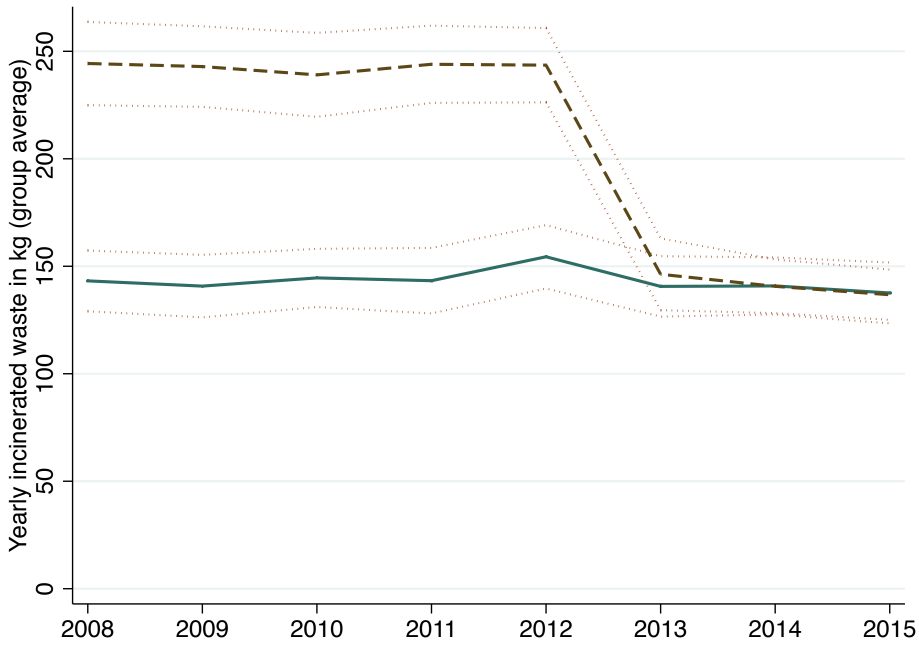


FIGURE 3 – Administrative data: effect on surrounding municipalities, regression discontinuity design

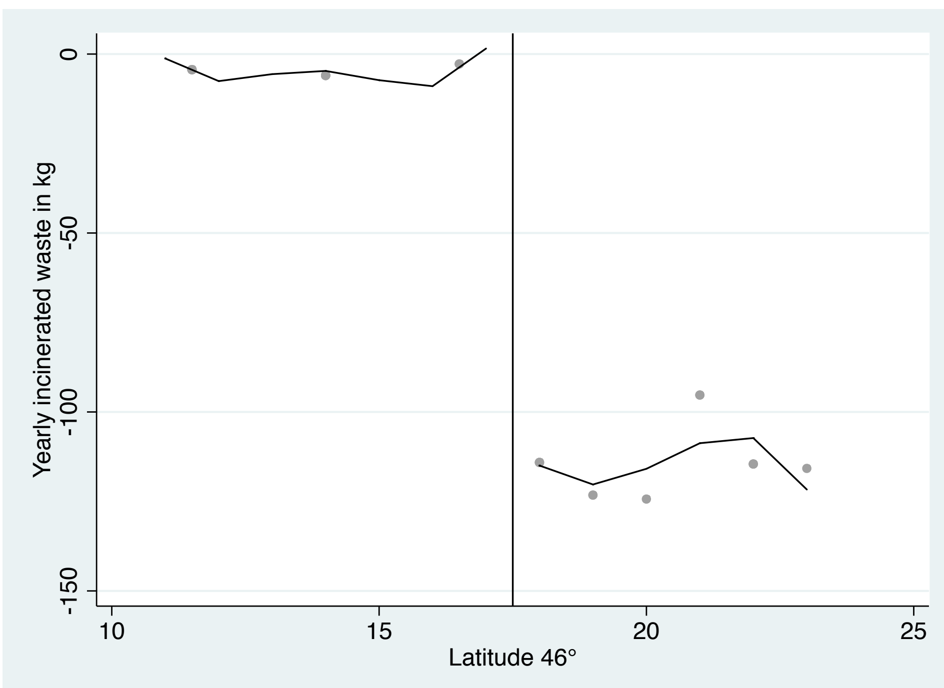
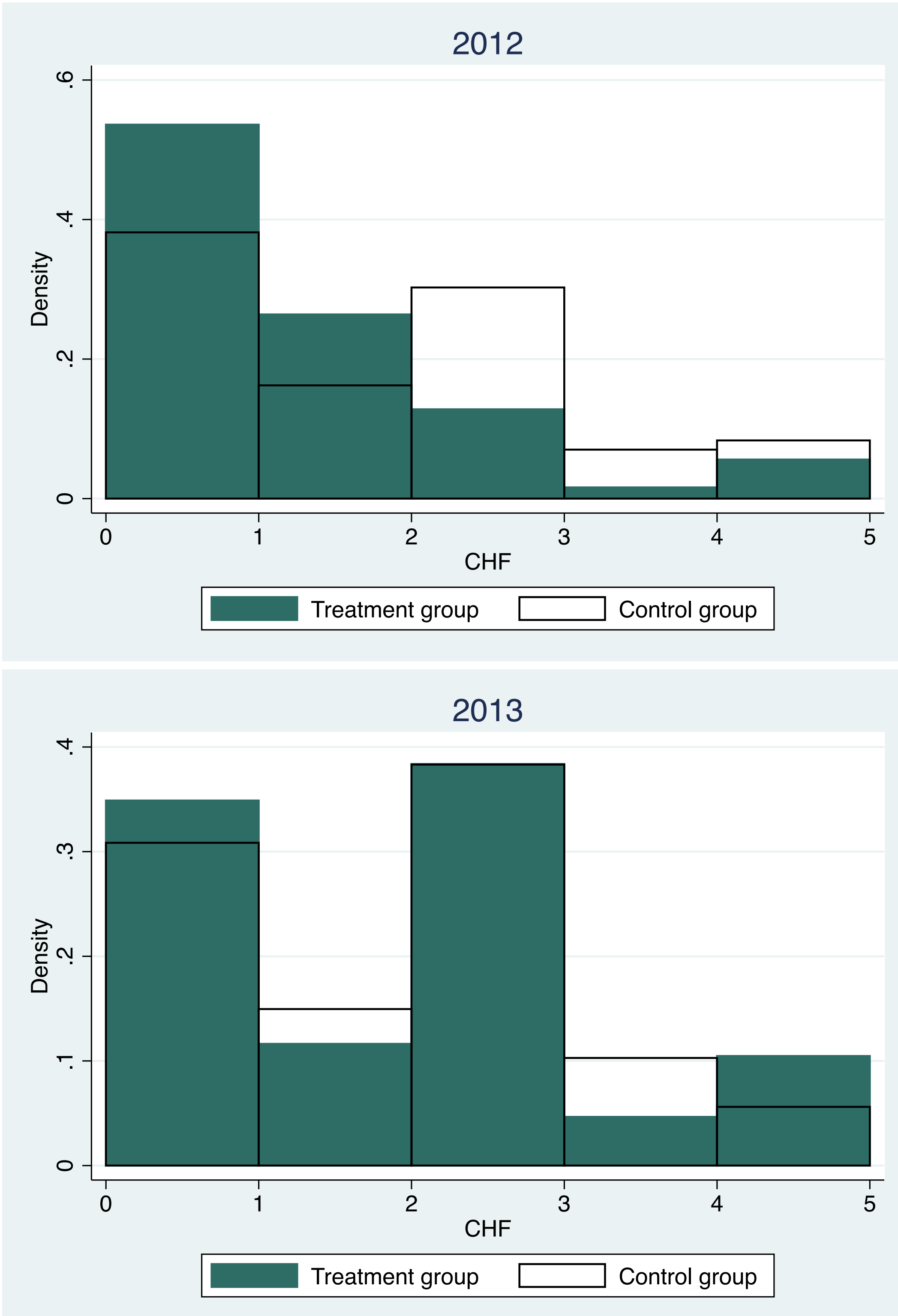


Figure 4 – Household survey: voting intentions, histogram



Tables

Table 1 – Household survey: solid waste, recycling and voluminous wrapping, mean comparison between 2012 and 2013

	2012		2013	
Variable	Treatment	Control	Treatment	Control
Per capita	27.385	16.187	13.875	13.153
Per household	65.906	39.728	33.647	35.061
	N=85	N=103	N=85	N=98
PET	0.919	0.981	0.953	0.944
Carton	0.849	0.944	0.965	0.907
Paper	0.895	0.972	0.953	0.935
Textiles	0.872	0.897	0.907	0.841
Cans	0.733	0.925	0.756	0.738
Organic waste	0.698	0.85	0.884	0.841
Batteries	0.942	0.935	0.988	0.897
Aluminium	0.733	0.907	0.93	0.869
	N=86	N=107	N=86	N=107
Attention to wrapping	0.471	0.551	0.571	0.608
	N=85	N=107	N=84	N=102

TABLE 2 – Household survey: treatment effect on solid waste per capita in litres per week

	(1)		(2)	
PGB	-10.51***	(1.921)	-9.668***	(2.009)
Year 2013	-2.847**	(1.184)	-2.845**	(1.360)
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 3 – Household survey: treatment effect on recycling and wrapping

	(1) Aluminium	(2) Battery	(3) Cans	(4) Carton	(5) Textiles	(6) Glass	(7) Organic waste	(8) Paper	(9) PET	(10) Wrapping
					OLS					
PGB	0.235***	0.0839	0.210**	0.154**	0.0910	0.0885*	0.195***	0.0955*	0.0723	0.0497
	(0.0718)	(0.0519)	(0.0877)	(0.0652)	(0.0683)	(0.0443)	(0.0695)	(0.0528)	(0.0475)	(0.0914)
Year 2013	-0.0374	-0.0374	-0.187***	-0.0374	-0.0561	-0.0187	-0.00935	-0.0374	-0.0374	0.0558
	(0.0401)	(0.0403)	(0.054)	(0.0391)	(0.0487)	(0.0295)	(0.0509)	(0.0321)	(0.0291)	(0.0612)
Within-R^2	0.047	0.009	0.037	0.026	0.006	0.017	0.032	0.012	0.008	0.008
N	386	386	386	386	386	386	386	386	386	378
					OLS (with control variables)					
PGB	0.195**	0.0288	0.149	0.107	0.0335	0.0206	0.144**	0.0361	0.00896	0.0561
	(0.0745)	(0.0511)	(0.0940)	(0.0656)	(0.0766)	(0.0355)	(0.0645)	(0.0531)	(0.0412)	(0.0987)
Year 2013	-0.00107	0.0192	-0.135**	0.00331	-0.00975	0.0281	0.0369	0.00225	0.00447	0.0577
	(0.0423)	(0.0373)	(0.0587)	(0.0360)	(0.0542)	(0.0180)	(0.0470)	(0.0228)	(0.0183)	(0.0682)
Within-R^2	0.101	0.059	0.130	0.088	0.069	0.133	0.166	0.112	0.093	0.222
N	368	368	368	368	368	368	368	368	368	365

Note: Marginal effects are reported for Logit (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). * $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$.

Table 4 – Household survey: treatment effect on solid waste per capita in litres per week, non-tax waste management policies

	(1)	(2)
PGB	-12.20***	-11.08***
	(3.129)	(3.762)
Year 2013	-1.777	-2.692
	(1.904)	(3.299)
Additional skips: number of materials covered		-1.340**
		(0.606)
Collection centres: better opening hours		6.104
		(4.170)
New kerbside program		-9.383
		(6.330)
New collection centre		6.918**
		(2.690)
Awareness-raising campaign: unaddressed mailshot		0.647
		(4.462)
Constant	21.71***	21.68***
	(0.765)	(0.748)
Within-R^2	0.105	0.115
N	205	205

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

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

Table 5 – Administrative data: treatment effect on solid waste per capita in kilos per year

	Survey	Volume	+Weight	Heterogeneous
	(1)	(2)	(3)	(4)
PGB	-86.14***	-79.72***		-109.37**
	(12.26)	(4.386)		(31.56)
PGB · Green votes				0.8559
				(1.85)
Year 2013	-11.15**	-9.084***	-8.461***	-11.15**
	(4.346)	(3.182)	(2.748)	(4.367)
Unit pricing			-79.56***	
			(4.073)	
Constant	173.6***	186.6***	181.3***	172.2***
	(2.380)	(1.177)	(1.116)	(1.835)
Within-R^2	0.715	0.828	0.822	0.834
N	116	434	470	114

Note: Robust standard errors in parentheses.

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

Table 6 – Administrative data: effect on surrounding municipalities, sharp regression discontinuity estimates using local polynomial regression

	(1)
Regression discontinuity estimate	-106.7***
	(37.60)
Total observations	11
Observations (left)	5
Observations (right)	6
Order local polynomial (p)	1
Order bias (q)	2
Available observations	28

Note: Standard errors in parentheses.

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

Table 7 – Administrative data: effect on surrounding municipalities: linear regression on both sides of the cut-off

	Left of the cut-off (1)	Right of the cut-off (2)
Latitude	4.139	-9.124
	(2.217)	(30.48)
Constant	-70.55	50.12
	(36.61)	(573.4)
R^2	0.402	0.013
N	5	6

Note: Robust standard errors in parentheses.

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

Table 8 – Household survey: policy perceptions

	(1) Eff. env.	(2) Eff. env.	(3) Use rev.	(4) Use rev.
PGB	0.165*	0.203**	0.421***	0.458***
	(0.0899)	(0.0968)	(0.0780)	(0.0831)
Year 2013	-0.0251	-0.0268	0.0188	0.0155
	(0.0602)	(0.0633)	(0.0519)	(0.0566)
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
PGB	-0.160*	-0.208**	-0.253***	-0.312***
	(0.0801)	(0.0838)	(0.0910)	(0.0977)
Year 2013	-0.0376	-0.00346	0.0439	0.0925
	(0.0486)	(0.0530)	(0.0583)	(0.0658)
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.
PGB	-0.0186	-0.0375	-0.0671	-0.00935
	(0.0749)	(0.0780)	(0.0896)	(0.0937)
Year 2013	-0.144***	-0.118***	0.273***	0.248***
	(0.0413)	(0.0440)	(0.0557)	(0.0597)
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.

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

Appendix

A Appendix tables

Table A.1 – Administrative data: comparison between villages implementing PGB on schedule, and 'latecomers'

	PGB from January 1, 2013			PGB from later in 2013, 2014		
Variable	Mean	Std. Dev.	N	Mean	Std. Dev.	N
Population	2509.27	10564.87	161	2435.34	4659.38	70
Income tax coefficient	69.29	8.33	161	69.38	7.71	70
Green vote share	16.46	4.00	161	16.88	4.34	70

	p-value for two-sided t-test		
	<0	$\neq 0$	>0
Population	0.5294	0.9412	0.4706
Income tax coefficient	0.4676	0.9352	0.5324
Green vote share	0.2454	0.4907	0.7546

Note: No difference is statistically significant at 10%. Population is the resident population in the municipality as of 2012. The income tax coefficient measures the tax paid to the municipality, as a fraction of the tax paid to the canton. Wealthy municipalities tend to have a low income tax coefficient. Green vote share is the proportion of the electorate voting for a green party (either the Green Party of Switzerland or the Green Liberal Party of Switzerland) at the last federal elections.

Table A.2 – Household survey: sample's socioeconomic characteristics

	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*
International civil servant	0	0	0	0
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
Distance from collecting centre (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 centre (in kilometres 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 A.3 – Administrative data: 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 A.4 – Household survey: treatment effect on recycling and wrapping, control variables

	(1)		(2)		(3)	
	Aluminium		Battery		Cans	
PGB	0.195**	(0.0745)	0.0288	(0.0511)	0.149	(0.0940)
Year 2013	-0.00107	(0.0423)	0.0192	(0.0373)	-0.135**	(0.0587)
Gender (M)	-0.0174	(0.0545)	0.0110	(0.0330)	0.0685*	(0.0402)
Age	0.00130	(0.00184)	0.00143	(0.00145)	0.00024	(0.00183)
EU	-0.0716	(0.0541)	-0.0823**	(0.0371)	-0.200***	(0.0712)
Rest of the world	0.109	(0.0892)	-0.0256	(0.0877)	-0.0013	(0.115)
Adults in households	0.0186	(0.0240)	-0.0267	(0.0268)	0.0404	(0.0394)
Children in households	-0.0293	(0.0261)	-0.00880	(0.0146)	0.0101	(0.0260)
Apprenticeship	-0.0120	(0.0644)	0.00162	(0.0546)	-0.159	(0.0963)
High school	-0.0479	(0.0685)	-0.00507	(0.0560)	-0.134	(0.0915)
University	0.0853	(0.0621)	0.0345	(0.0543)	-0.0654	(0.0904)
Jobless	0.330	(0.222)	-0.232**	(0.0928)	0.0112	(0.299)
Homemaker	0.278	(0.217)	-0.128	(0.0905)	0.599**	(0.269)
Employee	0.235	(0.193)	-0.203***	(0.0712)	0.293	(0.242)
Self-employed	0.251	(0.188)	-0.225***	(0.0835)	0.232	(0.253)
Manager	0.239	(0.228)	-0.238**	(0.0944)	0.468*	(0.265)
Retiree	0.222	(0.206)	-0.240**	(0.0954)	0.366	(0.243)
Green	0.0431	(0.0646)	-0.00454	(0.0421)	0.0396	(0.0701)
Distance	-0.00205	(0.00476)	0.0000173	(0.00316)	-0.0101*	(0.0053)
Renter	0.0245	(0.0444)	0.00867	(0.0296)	0.0853	(0.0521)
Income category 1	0.110	(0.119)	-0.00924	(0.0730)	0.114	(0.136)
Income category 2	0.109	(0.0942)	-0.00115	(0.0619)	0.0223	(0.0954)
Income category 3	0.0884	(0.0913)	0.0653	(0.0665)	0.0972	(0.105)
Income category 4	0.0101	(0.0800)	0.0228	(0.0493)	0.0580	(0.0764)
Income category 5	-0.0275	(0.102)	-0.0222	(0.0561)	-0.0561	(0.0909)
Income is missing	0.0315	(0.0723)	-0.0124	(0.0557)	-.0313	(0.0789)
Constant	0.460**	(0.222)	1.117***	(0.137)	0.529	(0.322)
Within-R^2	0.101		0.059		0.130	
N	368		368		368	

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

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

	(4)		(5)		(6)	
	Carton		Clothes		Glass	
PGB	0.107	(0.0656)	0.0335	(0.0766)	0.0206	(0.0355)
Year 2013	0.00331	(0.0360)	-0.00975	(0.0542)	0.0281	(0.0180)
Gender (M)	0.0176	(0.0298)	0.0232	(0.0552)	-0.00934	(0.0192)
Age	0.0000438	(0.00130)	0.00223	(0.00208)	0.000986	(0.000857)
EU	-0.00425	(0.0376)	-0.0850	(0.0611)	-0.0218	(0.0265)
Rest of the world	0.0846	(0.0591)	0.0643	(0.120)	-0.156**	(0.0726)
Adults in households	-0.0140	(0.0247)	-0.0290	(0.0367)	-0.0195	(0.0218)
Children in households	-0.0279	(0.0186)	-0.0126	(0.0271)	0.00483	(0.0106)
Apprenticeship	-0.00998	(0.0492)	-0.00251	(0.0615)	0.0212	(0.0353)
High school	-0.00834	(0.0436)	-0.0121	(0.0737)	0.00932	(0.0298)
University	-0.00229	(0.0510)	0.0573	(0.0584)	0.0303	(0.0330)
Jobless	-0.102	(0.113)	-0.320***	(0.115)	0.0649	(0.111)
Homemaker	-0.0445	(0.102)	-0.130	(0.123)	0.158	(0.117)
Employee	-0.124*	(0.0728)	-0.283***	(0.0967)	0.0712	(0.107)
Self-employed	-0.182**	(0.0802)	-0.322***	(0.0986)	0.0533	(0.109)
Manager	-0.125	(0.0944)	-0.352**	(0.160)	0.0574	(0.109)
Retiree	-0.160*	(0.0874)	-0.298**	(0.113)	0.0478	(0.107)
Green	0.0518	(0.0509)	-0.0106	(0.0701)	0.0149	(0.0228)
Distance	-0.00520*	(0.00306)	-0.00677*	(0.00352)	-0.00438**	(0.00212)
Renter	-0.0228	(0.0371)	-0.0162	(0.0486)	0.00813	(0.0223)
Income category 1	0.108	(0.103)	0.0639	(0.123)	0.0256	(0.0489)
Income category 2	0.119*	(0.0620)	0.0795	(0.103)	-0.0415	(0.0616)
Income category 3	0.0629	(0.0847)	0.147*	(0.0869)	0.00454	(0.0687)
Income category 4	0.0181	(0.0698)	0.0778	(0.0946)	0.0534	(0.0532)
Income category 5	-0.0195	(0.0615)	0.0103	(0.0949)	0.0128	(0.0511)
Income is missing	0.0945*	(0.0532)	0.0795	(0.0796)	0.0362	(0.0516)
Constant	1.055***	(0.128)	1.070***	(0.206)	0.871***	(0.152)
Within-R^2	0.088		0.069		0.133	
N	368		368		368	

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

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

	(7)		(8)		(9)	
	Organic waste		Paper		PET	
PGB	0.144**	(0.0645)	0.0361	(0.0531)	0.00896	(0.0412)
Year 2013	0.0369	(0.0470)	0.00225	(0.0228)	0.00447	(0.0183)
Gender (M)	0.0818*	(0.0487)	-0.0190	(0.0223)	0.0128	(0.0188)
Age	0.00507**	(0.00218)	0.00377***	(0.00126)	0.00182*	(0.00100)
EU	-0.0414	(0.0664)	-0.00865	(0.0328)	-0.0277	(0.0337)
Rest of the world	0.00972	(0.171)	0.0440	(0.0665)	-0.0234	(0.0853)
Adults in households	0.0160	(0.0353)	0.0235	(0.0206)	-0.0166	(0.0169)
Children in households	-0.00117	(0.0274)	0.000532	(0.0120)	0.0217**	(0.0108)
Apprenticeship	-0.0853	(0.0525)	-0.0179	(0.0399)	-0.00308	(0.0327)
High school	-0.137*	(0.0784)	0.0318	(0.0420)	0.0453	(0.0291)
University	0.0162	(0.0598)	0.0393	(0.0394)	0.00968	(0.0327)
Jobless	-0.0926	(0.282)	-0.0362	(0.0465)	-0.0661	(0.0785)
Homemaker	-0.0111	(0.316)	-0.0443	(0.0523)	-0.0621	(0.0632)
Employee	0.0892	(0.261)	-0.120**	(0.0481)	-0.108	(0.0651)
Self-employed	-0.00952	(0.265)	-0.126**	(0.0578)	-0.123*	(0.0691)
Manager	0.106	(0.271)	-0.114*	(0.0602)	-0.0676	(0.0746)
Retiree	0.0118	(0.262)	-0.143**	(0.0689)	-0.0987	(0.0727)
Green	0.0143	(0.0674)	0.0599*	(0.0302)	0.0381	(0.0274)
Distance	-0.0208***	(0.00485)	-0.00642**	(0.00250)	-0.00421*	(0.00250)
Renter	0.0446	(0.0456)	0.00529	(0.0297)	0.0303	(0.0255)
Income category 1	0.135	(0.128)	0.0850	(0.0610)	0.0768	(0.0829)
Income category 2	0.0748	(0.0969)	0.0550	(0.0679)	0.0493	(0.0781)
Income category 3	-0.0716	(0.123)	0.0655	(0.0772)	0.165**	(0.0760)
Income category 4	0.00856	(0.106)	0.0611	(0.0522)	0.108	(0.0688)
Income category 5	-0.159	(0.125)	-0.00134	(0.0627)	0.0657	(0.0690)
Income is missing	-0.00912	(0.102)	0.0192	(0.0596)	0.111*	(0.0608)
Constant	0.567	(0.363)	0.798***	(0.106)	0.886***	(0.130)
Within-R^2	0.166		0.112		0.093	
N	368		368		368	

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

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

	(10)	
	Wrapping	
PGB	0.0561	(0.0987)
Year 2013	0.0577	(0.0682)
Gender (M)	-0.129*	(0.0736)
Age	0.00367	(0.00279)
EU	-0.179*	(0.105)
Rest of the world	0.160	(0.146)
Adults in households	-0.0868*	(0.0480)
Children in households	-0.0382	(0.0377)
Apprenticeship	-0.0674	(0.103)
High school	-0.0892	(0.116)
University	0.0428	(0.0979)
Jobless	0.0870	(0.248)
Homemaker	0.181	(0.249)
Employee	0.166	(0.149)
Self-employed	0.123	(0.152)
Manager	0.410*	(0.225)
Retiree	0.213	(0.160)
Green	0.0697	(0.0988)
Distance	-0.00541	(0.00773)
Renter	-0.0363	(0.0753)
Income category 1	0.487***	(0.182)
Income category 2	0.205	(0.152)
Income category 3	0.201	(0.130)
Income category 4	0.625***	(0.120)
Income category 5	0.00950	(0.167)
Income is missing	0.330**	(0.126)
Constant	0.191	(0.299)
Within-R^2	0.222	
N	365	

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

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

Table A.5 – Household survey: treatment effect on recycling and wrapping, Logit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Aluminium	Battery	Cans	Carton	Textiles	Glass	Organic waste	Paper	PET	Wrapping
					OLS					
PGB	0.264***	0.209***	0.293***	0.207***	0.116	0.200***	0.232***	0.191**	0.177**	0.0692
	(0.0576)	(0.0493)	(0.0733)	(0.0468)	(0.0710)	(0.0653)	(0.0724)	(0.0762)	(0.0879)	(0.0757)
Year 2013	-0.0683	-0.0857	-0.346	-0.0773	-0.0812	-0.0606	-0.0174	-0.126	-0.146	0.0582
	(0.0736)	(0.0940)	(0.0999)	(0.0810)	(0.0689)	(0.0962)	(0.0944)	(0.107)	(0.113)	(0.110)
Pseudo-R^2	0.119	0.079	0.131	0.096	0.056	0.096	0.097	0.064	0.072	0.084
N	234	120	282	184	250	112	246	144	136	343

Note: Marginal effects are reported for Logit (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). * $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$.

Table A.6 – Municipality survey: non-tax waste management policies undertaken between 2012 and 2013, descriptive statistics

	Treatment group	Control group
Variable	Mean	
Did the municipality introduce a new kerbside program	0.074	0.034
Did the municipality introduce a new collection centre	0.064	0.043
Did the municipality extend the opening hours of its centres	0.223	0.155
Did the municipality add a new skip for		
Paper	0.117	0.043
Carton	0.064	0.06
PET	0.17	0.043
Textiles	0.117	0.06
Glass	0.17	0.043
Cans	0.117	0.043
Batteries	0.117	0.043
Aluminium	0.064	0.043
Plastic	0.085	0
Wood	0	0.017
Organic waste	0.117	0.138
Overall number of materials covered by the new skips	1.138	0.534
Did the municipality implement any awareness-raising initiative		
Unaddressed mailshot	0.5	0.345
Information session	0.117	0
Street stand	0.021	0
Specific websites	0	0.017
N	94	116

Table A.7 – Administrative data: treatment effect on solid waste per capita in kilos per year, non-tax waste management policies

	(1)	(2)	(3)
PGB	-86.14***	-84.80***	-82.73***
	(12.26)	(16.25)	(19.86)
Year 2013	-11.15**	-7.579**	-6.619
	(4.346)	(3.407)	(7.496)
Additional skips: number of materials covered			-0.110
			(2.669)
Collection centres: better opening hours			-16.00
			(13.81)
New kerbside program			17.04
			(14.27)
New collection centre			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 A.8 – Administrative data: treatment effect on solid waste per capita in kilos per year, 2012-2015

	Survey (1)	Volume (2)
PGB	-90.47***	-80.82***
	(8.942)	(4.226)
Constant	173.6***	186.9***
	(2.946)	(1.591)
Within-R^2	0.674	0.792
N	232	867

Note: Robust standard errors in parentheses. Time dummies for 2013, 2014 and 2015 included in the estimation.

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

Table A.9 – Household survey: policy perceptions, mean comparison between 2012 and 2013

		2012		2013	
		Treatment group	Control group	Treatment group	Control group
Variable	Short	Mean	Mean	Mean	Mean
Perceived effectiveness on own behaviour	Eff. own	0.419	0.411	0.547	0.383
		N=86	N=107	N=86	N=107
Perceived effectiveness	Effectiveness	0.784	0.839	0.928	0.878
		N=74	N=93	N=69	N=90
Perceived effect on the environment	Eff. env.	0.581	0.736	0.721	0.71
Use of revenues for other purposes	Use rev.	0.262	0.689	0.709	0.71
Unfair: inequitable	Unfair ineq.	0.233	0.208	0.07	0.065
Unfair: paying enough taxes	Unfair taxes	0.547	0.302	0.349	0.262
Unfair: paying even if sorting	Unfair sort	0.558	0.34	0.349	0.383
		N=86	N=106	N=86	N=107
Legitimacy provided social cushioning	Leg. cush.	0.353	0.286	0.558	0.561
		N=85	N=105	N=86	N=107

Table A.10 – Household survey: policy perceptions, Logit

	(1) Eff. env.	(2) Eff. env.	(3) Use rev.	(4) Use rev.
PGB	0.174*	0.220**	0.439***	0.499***
	(0.0909)	(0.0879)	(0.0696)	(0.0708)
Year 2013	-0.0340	-0.0358	0.0277	0.0324
	(0.0813)	(0.0862)	(0.0767)	(0.0922)
Socio-economic variables	No	Yes	No	Yes
Pseudo-R^2	0.089	0.193	0.186	0.293
N	337	324	333	314

	(5) Unfair taxes	(6) Unfair taxes	(7) Unfair sort	(8) Unfair sort
PGB	-0.188*	-0.286***	-0.271***	-0.358***
	(0.102)	(0.0957)	(0.0919)	(0.0917)
Year 2013	-0.0590	-0.0031	0.0576	0.132
	(0.0761)	(0.0907)	(0.0763)	(0.0904)
Socio-economic variables	No	Yes	No	Yes
Pseudo-R^2	0.163	0.312	0.104	0.198
N	326	311	355	342

	(9) Unfair ineq.	(10) Unfair ineq.	(11) Leg. cush.	(12) Leg. cush.
PGB	-0.0190	-0.0411	-0.0961	-0.0269
	(0.117)	(0.0941)	(0.102)	(0.121)
Year 2013	-0.229***	-0.166***	0.317***	0.321***
	(0.0675)	(0.0678)	(0.0631)	(0.0734)
Socio-economic variables	No	Yes	No	Yes
Pseudo-R^2	0.167	0.259	0.127	0.218
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).
* $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$.