The Effects of Pay-As-You-Throw Schemes on Economic, Political and Behavioral Outcomes. Evidence from Italian Municipalities

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Abstract

Using a generalized DiD in a staggered rollout design, we estimate the effects of the introduction of "Pay-As-You-Throw" schemes on municipal waste generation and management costs. We find that this policy is effective in reducing the amount of unsorted waste and increasing that of recycled waste. It also contributes to the reduction of municipal waste management costs. The introduction of PAYT has also positive effects on the propensity to vote for green parties, while it has no significant effects on water consumption.

1 Introduction

The European Green Deal has the overarching aim of making Europe climate neutral by 2050. Managing waste in a safe and environmentally sound manner and making use of the secondary materials it contains are key elements in the EU's environmental policy. However, financing solid waste management is a significant challenge for local authorities, even more so for ongoing operational costs than for capital investments. User fees rarely cover full management costs, leading to relevant debates on how effectively design user fee models. In this paper, we evaluate the effectiveness of a specific waste management policy, the "Pay-As-You-Throw" (PAYT) scheme, in improving waste outcomes – reducing the amount of unsorted waste and increasing the amount of recycled waste – and waste management costs. We further investigate spillover effects on political and environmental-related behavioral outcomes. Identification is based on a staggered Difference-in-Differences strategy that exploits variation in the timing of policy adoption.

The world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33% not managed in an environmentally safe manner[1] (World Bank, 2018). Although they only account for 16% of global population, European and Northern American countries generate about 34% of the world's waste. In 2019, 502 Kg of municipal waste per capita were generated in the EU[2]. Recycling rates for municipal waste[3] are slowly increasing in Europe, as Figure A2 in online Appendix shows. The overall recycling rate – the ratio between total waste generated and the quantities that were managed through recycling – stayed below half of the total

[1]Solid waste-related emissions, which nowadays account for 5% of total emission, are expected to increase by around 40% within 30 years if no improvements are made in this sector.

[2]Please refer to Figure A1 in online Appendix

[3]And for packaging waste and Waste Electrical and Electronic Equipment (WEEE).

waste generation, reaching 48% in 2019. Under the revised EU Waste Framework Directive, the recycling and re-use of municipal waste must reach 65% by 2030 (European Regional Development Fund, 2020). Among the measures indicated by the European Environmental Agency to reach higher recycling rates there are "economic instruments, such as waste collection fees, that strongly encourage recycling" (EEA, 2018). PAYT schemes, also known as variable rate, volume-based or unit-based pricing, imply that households pay on the basis of the unsorted waste they produce. The rationale behind such schemes is that when consumers pay for every bag or can of waste they generate, they are motivated to recycle more and look for creative ways to prevent waste in first place. There is substantial evidence on important substitution effects of unsorted waste with recycled waste under PAYT schemes (Fullerton and Kimaman, 2000; Allers and Hoeben, 2010; Huang et al., 2011; Bucciol et al., 2015; Carattini et al., 2018; Valente, 2021). However, whether PAYT yields a net gain in terms of management costs is still debated. Moreover, whether PAYT introduction has spillover effects on other environmental-related behaviors and political outcomes is still an unexplored issue. We investigate the economic, political, and behavioral effects of PAYT introduction In Italian municipalities. Specifically, we attempt to answer the following questions: i) Do PAYT schemes affect the amount of total/unsorted/recycled waste production? ii) Which are the effects of PAYT adoption on waste management costs? iii) Which are the political consequences of PAYT introduction? In particular, are there any effects on turnouts? Are there effects on the propensity to vote for green parties? iv) Are there spillover effects on other environmental-related behaviors?

In our setting, the treatment, PAYT introduction, is implemented for different municipalities at different times. Staggered rollouts are commonly analyzed using methods that extend the simple two-periods difference-in-differences (DiD) estimator to the staggered setting. However, a number of recent alternatives have been proposed to better deal with the peculiarities of such settings (Callaway and Sant'Anna (2020); De Chaisemartin and D'Haultfoeille (2019); Goodman-Bacon (2018)). To estimate the effects of PAYT we focus on PAYT municipalities only and exploit the staggered introduction of the scheme across units applying a generalized DiD design. In our main empirical strategy, we compare the outcomes of municipalities treated earlier – treated units – and municipalities treated later – comparison units – before and after PAYT introduction.

We find that PAYT introduction significantly reduces the amount of municipal unsorted waste by 7.3%, while increases the amount of recycled waste by 12.8%. It also reduces the amount of total waste generated by 7.5%. Two years after policy implementation, we find a reduction in municipal waste management costs, a pattern that stays constant over time. We also find spillover effects on political outcomes: PAYT introduction increases both political participation and the propensity to vote for green parties. We do not find significant effects on other environmental-related behavioral outcomes.

The structure of the paper is as follows. Section 2 describes the institutional context and data. Section 3 presents the empirical strategy. Section 4 shows the main results of the analysis. Section 5 presents additional results on political and environmental-related behavioral outcomes. Section 6 concludes.

2 Institutional Background and Data

PAYT schemes can be broadly defined as waste management systems compatible with the "Pay-As-You-Throw" principle. A more precise definition can be found in the Annex IVa of Directive 2018/851 of the European Parliament and of the Council were PAYT schemes are defined as "schemes that charge waste producers on the basis of the actual amount of waste generated and provide incentives for separation at source of recyclable waste and for reduction of mixed waste" (Directive 2018/851, page 31). From this definition it follows that the implementation of a PAYT scheme requires the ability to tax households according to the volume or weight of unsorted waste they generate. This can happen both ex-ante via prepaid bags or ex-post, using electronic keys, tag on bags or bins with chip. In Italy, as in many other parts of the world, municipalities that adopt such a scheme cover the costs of waste management by using both a flat and a variable fee. The flat part of the fee is meant to cover the fixed costs of the service and is computed for each household using as parameters the square footage of the house and the number of inhabitant. The variable part, instead, covers the variable costs of the system and is computed according to the amount of waste generated by the household, i.e. by effectively putting a nonnegative price on waste. It is by virtue of this variable part that the system is consistent with the "pay as you throw principle". Due to their ability of providing incentive for recycling and reducing of unsorted waste, PAYT schemes are strongly championed by the European Union. In the Directive 2018/851 PAYT schemes are explicitly cited among the economic instruments that Member States should use in order to incentive the application of the waste hierarchy[4] (Directive 2018/851). In the last decade Italy has witnessed an increase in the number of municipalities that decided to adopt a PAYT waste management scheme, as Figure 1 shows. In particular, in 2019, PAYT was used in 872 Italian

[4]To know more on the EU's waste hierarchy:https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index_en.htm

municipalities – 11% of the total number of municipalities in the country (Inspra, 2019). Thus, despite the increase in PAYT-adopters among Italian municipalities, it remains the case that the vast majority of Italian municipalities still uses a non-PAYT waste management scheme which relies only on a flat fee computed for each household on the basis of the square footage of the house and the number of inhabitant[5]. This can be viewed as a waste management system were the price of each unit of waste is set to zero. As we have already partially stressed, this kind of system is not compatible with the PAYT principle and it does not generate any incentive for households to reduce the amount of unsorted waste they generate. Under the current legislative framework a municipality willing to implement such reform has more than one option to do so. A complete account of the Italian legislation on the matter is beyond the scope of this paper[6]; for our work it is important to stress that, no matter the route chosen to implement the PAYT system, the final result is the same: the introduction of a waste management scheme with an overall fee determined by a fixed and a variable part that works as already explained at the beginning of this paragraph.

Using different sources of data, we have built a municipal level dataset over the period 2010 − 2019 with information on PAYT adoption, year of introduction, waste amounts, waste managements costs, municipality socio-economic and geographic characteristics. Waste generation and management costs are from the National Environmental Protection Agency (Inspra). Water supply and municipal

[5]It is worth emphasizing that in municipalities with a non-PAYT waste management scheme the fix fee is higher than in municipalities adopting a PAYT scheme. This is simply because in the former the fix fee has to cover the whole costs of the service while in the latter variable costs are covered through the variable fee (Valente, 2021)

[6]For more information on this topic: "Guida alla Tariffazione Puntuale dei Rifiuti Urbani" – IFEL , 2019

characteristics are from the National Institute for Statistics (ISTAT). Information on water supply is available for the years 2012, 2015 and 2018. We collected information on political outcomes (turnouts, share of votes for green parties) at the European political elections in 2009, 2014, and 2019.

Figure 2 shows the year of introduction of the PAYT scheme for the municipalities in our sample – the main source of variation in our empirical strategy. We observe an interesting spike in 2014 when 126 municipalities introduced a PAYT scheme. This sharp increase is likely due to a change in the Italian legislative framework with the approval of law 147/2013 in December $27th$ 2013. This law reformed many aspects of waste taxation, also introducing a relatively easy path for Italian municipalities to reform their waste management system adopting a PAYT scheme. (Guida alla Tariffazione Puntuale dei Rifiuti Urbani – IFEL) Figure A3 in the online Appendix shows the share of municipalities that have implemented a PAYT scheme by Italian macro-region. The graph clearly shows that PAYT adopters are much more likely to be in the Center-North of Italy. Indeed, out of the 872 municipalities that have implemented a PAYT scheme, 869 of them are in the northern and central part of the country, while only 2 in the southern part (Inspra, 2019). Finally, Figure A4 in online Appendix shows PAYT municipalities according to population size. As we can see, municipalities implementing a PAYT scheme are more likely in the middle-lower part of the spectrum in terms of population size.

3 Empirical Strategy

We are interested in how a fee on household unsorted waste production affects waste generation. We want to further explore if the volume-based user fee on unsorted waste generation has spillover effects on other environmental-related behaviors, political participation and voting decisions.

In light of the recent literature underlining the potential problems with standard two-way fixed effects (TWFE) regressions in DiD designs with multiple periods[7] (Borusyak et al. (2021); Callaway and Sant'Anna (2020); De Chaisemartin and D'Haultfoeille (2019); Goodman-Bacon (2018)), our identification strategy exploits the staggered introduction of PAYT across municipalities. In practice, we focus only on PAYT municipalities – the treated – and exploit variation in the timing of policy implementation. We thus need to assume that, in our setting, treatment timing is randomly assigned. We test whether the timing of PAYT introduction appears random by predicting it on the basis of municipality characteristics[8]. Column (1) of Table A.I shows that some factors predict the likelihood of PAYT introduction. However, no observable characteristics consistently predict the timing of PAYT introduction. These results suggest that the timing of PAYT introduction is random, even if the introduction *per se* is not.

Our design compares municipalities that are treated earlier to municipalities

[7] In a DiD setup with multiple time periods, treatment effects estimates based on TWFE regression models can only be interpreted as weighted averages of causal effects and some of these weights can be negative (Roth and Sant'Anna, 2021). Policy evaluation based on TWFE linear regression models can be misleading, especially when treatment effects are dynamic.

[8] To examine whether municipality characteristics predict the likelihood of PAYT introduction we estimate the following equation:

$$PAYT_{mt} = alpha + \beta_{mt}Recycled + X^{'}_{mt}\gamma + \varepsilon_{it} \tag{3}$$

where X includes the population of municipality m, its area and altitude and an indicator for capital cities. *Recycled* is the share of recycled waste.
To examine whether municipality characteristics predict the timing of PAYT introduction we estimate the following equation:

$$YearIntro_{mt} = alpha + \beta_{mt}Recycled + X^{'}_{mt}\gamma + \varepsilon_{mt} \tag{4}$$

where $YearIntro_{mt}$ is the year in which municipality m introduces PAYT.

that are treated later[9] – treated *vs* not-yet-treated. We build a "rolling control group" by constructing our estimation dataset as follows[10]. First, we create a separate dataset for each of the years of PAYT introduction. In each of these datasets, municipalities that introduce PAYT in that year are considered treated, while municipalities that will experience the treatment in later years serve as comparison units. Second, in every dataset we create event-time indicators relative to the year of PAYT introduction. Municipalities that experience treatment in the last year, 2019, serve only as controls. The resulting dataset consists of a total of $40,517$ municipality-year observations.

Our main estimation equation is:

$$Y_{mt} = \alpha_m + \nu_{pt} + \beta Treated_{mc} + \delta Treated_{mc} \cdot Post_{mt} + \sum_{s \neq -1} \gamma_s \cdot D^s + \varepsilon_{mt} \qquad (1)$$

where $Treated_{mc}$ is a dummy that takes value 1 if the municipality m is a treated municipality in the cohort c. This variable is not collinear with α_m, the municipality fixed-effects, since the same municipality can appear multiple times both as treated and control. $Post_{mt}$ is a dummy equal to 1 for the years in which PAYT is in place. The D^s are a set of relative event-time dummies that take value 1 if year t is s periods before (if negative) or after (if positive) PAYT introduction. The inclusion of the relative event-time dummies allows to control for event-time trends that are not captured by the year-by-province fixed-effects ν_{pt}. Standard errors are clustered at the municipality level. This level of clustering also accounts for the repeated appearance of municipalities as treated and controls.

[9] As already described in Section 2, Figure 2 shows the source of variation we are exploiting.

[10] We replicated all our results using the R package did by Callaway and Sant'Anna (2020). All our findings are consistent with those estimated using this package.

To investigate pre-trends and the dynamic evolution of the treatment effect, we also estimate a non parametric event-study specification:

$$Y_{mt} = \alpha_m + \nu_{pt} + \beta Treated_{mc} + \sum_{k \neq -1} \delta_k \cdot D^k \cdot Treated_{mc} + \sum_{s \neq -1} \gamma_s \cdot D^s + \varepsilon_{mt} \quad (2)$$

In this specification, the coefficients of interest are the δ_k, measuring the change in the outcomes of treated municipalities k years before/after PAYT introduction, relative to pre-treatment year, compared to the change in outcomes of control municipalities, that have yet-to-be treated. We estimate treatment effects up to five periods from treatment onset.

4 Main Results

Table 1 compares key attributes of PAYT municipalities before and after policy implementation. The main waste outcomes are kilograms of per capita unsorted, recycled and total waste. Before PAYT implementation, household already generated more recycled than unsorted waste, on average. This is not surprising as adopting PAYT where households are used to recycle helps preventing policy adverse effects (Valente, 2021). Unconditional differences show that, after PAYT implementation, the generation of unsorted waste further decreased by 52%, while that of recycled waste increased by 6%. The generation of total waste decreased by 17%.

We begin our empirical analysis by estimating municipality-level effects of volume-based user fee introduction on production of unsorted, recycling, and total waste per capita. Table 2 displays the main results for the effect of PAYT introduction on indicators of waste generation estimated through equation 1. Upon policy implementation, treated municipalities reduce the generation of unsorted waste by 7%, while they increase that of recycled waste by 12%. Therefore, the policy leads to a relevant substitution effect of unsorted waste with recycled waste. The production of total waste declines by 7.5%. Valente (2021) finds results which are larger in magnitude: an annual decline in unsorted waste by around 50%, driven by an increase in recycled waste of 32% and a reduction in total waste of 5%. The difference in findings can be explained by differences in the approaches. We focus only on PAYT municipalities and compare early *vs* late treated, while Valente (2021) compares PAYT municipalities vs non-PAYT municipalities using machine learning-inspired matching estimators.

Figure 3 displays the coefficients from the event-study specification in equation 2 and allows us to inspect the presence of differential pre-trends, as well as the dynamic of the treatment effect of PAYT implementation. The first thing to notice is that the graphs do not display any significant evidence of differential pre-trends across the three outcomes. Secondly, the figures highlight a strong reaction to PAYT in the first three years after policy adoption. The patterns show a reduction in Kg p.c. of unsorted and total waste, and an increase in Kg p.c of recycled waste. After the third year, however, all the effects turn not-significant.

Figure 4 displays the dynamic effect of PAYT introduction on costs per Kg of waste. Interestingly, we do observe a slightly significant increase in cost per Kg of waste in the year of PAYT introduction. This raise is associated with the increase in recycled waste induced by PAYT, whose cost is, on average, higher than that of unsorted waste. However, the pattern clearly points out that, two years after PAYT introduction, the cost per Kg of waste significantly decreases. These results are in line with Valente (2021), who shows that short-term costs may increase due to higher recycling, but these costs are outrun by the long-term savings due to reduction in overall waste.

Robustness checks

Another possible strategy is to use the "never treated" units, municipalities that never introduce PAYT during the observation period, as comparison group. Thus, in this exercise, we use a DiD design in which we estimate changes in waste outcomes for PAYT municipalities as compared to a group of non-PAYT municipalities. Table A.II compares key waste outcomes of never treated and treated municipalities before policy. Treated units before PAYT adoption recycle more, on average.

We estimate the following specification:

$$Y_{mts} = \alpha_m + \alpha_{pt} + \alpha_s + \sum_{s \neq -1} \beta_s \cdot PAYT_i + \varepsilon_{its} \tag{3}$$

where the α_m's, α_{pt}'s, and α_s's are fixed effects for each municipality, year-by-province, and event-time. The coefficients β_s's trace differential changes in waste outcomes Y_{mts} around PAYT implementation compared to the reference year $s = -1$. We cluster standard errors by municipality.

We build the comparison group as follows. We select all municipalities that never introduce PAYT during the observation period and assign them "placebo PAYT" in different years. Never treated municipalities can serve as placebo PAYT at most once a year. We are left with a control group of $58,984$ placebo-year observations. Results are displayed in Figure A.V. They are highly consistent with our main findings.

5 Additional results

While the literature on the effects of PAYT introduction is more established, that on spillover effects of waste prices on other outcomes is much more unexplored. In the second part of our analysis, we assess whether PAYT introduction has spillover effects on political and other environmental-related behavioral outcomes.

We rely on two political outcomes, the share of votes for green parties and turnouts at the European elections of 2014 and 2019. As regards other environmental-related behavior, we have information on water injected into municipal drinking water distribution networks in thousands of cubic meters and water supplied to municipal drinking water distribution networks in thousands of cubic meters in 2012-2015 and 2018.

To capture the PAYT effect on political and behavioral outcomes we estimate the following equation:

$$Y_{mt} = \alpha_m + \nu_{pt} + \delta Treated_{mt} + X'_{it}\zeta + \varepsilon_{it} \tag{4}$$

where Y_{mt} is an outcome of interest, α_m are municipality fixed effects, ν_{pt} are year-by-province fixed effects. X is a set of controls for municipality area in Km^2, altitude, indicators for capital cities, mountain or coastal municipalities. $Treated$ is an indicator for a PAYT municipality after policy introduction. δ is our coefficient of interest.

Results are shown in Tables 3 and 4. We do find some positive effects on turnouts and the propensity to vote for green parties, but we do not find any significant effect on water consumption.

6 Conclusions

EU waste policy aims to protect the environment and human health. It targets to improve waste management, stimulate innovation in recycling and limit landfilling. In this paper, we developed a staggered difference-in-differences design to evaluate the effectiveness of "Pay-As-You-Throw" schemes in improving municipal waste outcomes and management costs. We further addressed spillover effects on political and other environmental-related behavioral outcomes.

We find that PAYT introduction significantly reduces the amount of municipal unsorted waste by 7.3%, while increases the amount of recycled waste by 12.8%. It also reduces the amount of total waste generated by 7.5%. Two years after policy implementation, we observe a reduction in municipal waste management costs, a pattern that stays constant over time. We also find spillover effects on political outcomes: PAYT introduction increases both political participation and the propensity of voting for green parties. We do not find significant effects on municipal water supply.

Based on the EU "polluter pays principle", we believe that PAYT schemes can be effective in reaching the EU targets of increasing the re-use and recycling of municipal waste.

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Table 1: Waste amounts in PAYT municipalities before and after policy

	Before		After	
	Mean	Sd	Mean	Sd
Total waste	528.78	472.27	437.94	197.13
Recycled	319.22	282.93	336.92	145.15
Unsorted	209.56	219.50	101.02	80.05
% recycled	60.21	15.97	75.87	11.52
Observations	1805		4456	

Waste amounts are in kilograms (Kg) per capita (p.c)

Table 2: The Effect of PAYT Introduction on Waste Outcomes

	Unsorted	Recycled	Total
Treated · Post	-0.073***	0.128***	-0.075***
	(0.016)	(0.031)	(0.016)
Observations	18141	18141	18141

This Table presents the estimated coefficients δ from equation 1. All dependent variables (in logs) are in per capita terms. All regressions include municipality fixed-effects, event-time fixed effects and year-by-province fixed-effects. Standard errors clustered at the municipality level in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: The Effect of PAYT on Political Outcomes

	Green Parties	Turnout
Treated	0.002^{***}	0.013^{**}
	(0.00)	(0.00)
Observations	15092	22936

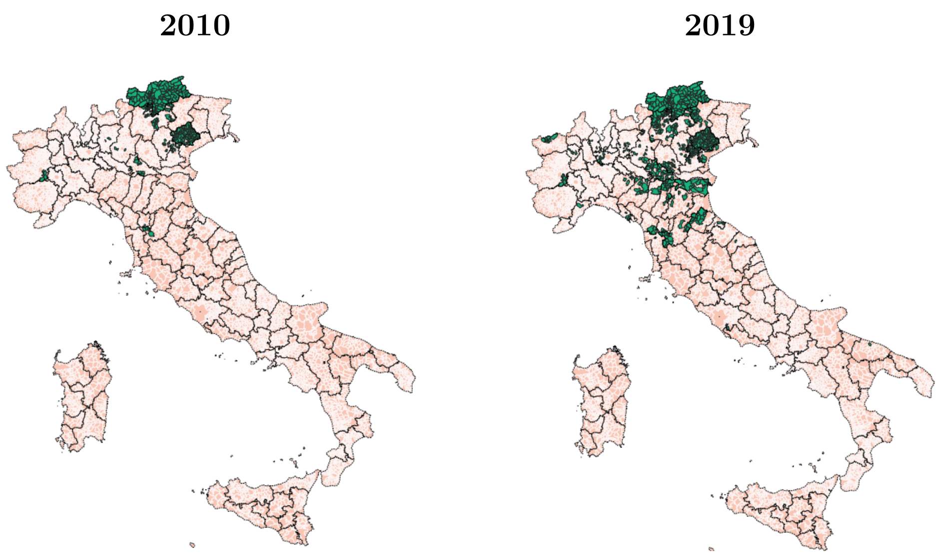
This Table presents the estimated coefficients δ from equation 4. All regressions include municipality fixed-effects, event-time fixed effects, year-by-province fixed-effects, and controls for municipalities' geographical characteristics (area in Km^2, altitude, indicators for capital cities, mountain or coastal municipalities). Standard errors clustered at the municipality level in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: The Effect of PAYT on Environmental-Related Behavioral Outcomes

	Green Parties	Turnout
Treated	0.0194	0.001
	(0.016)	(0.014)
Observations	22878	22878

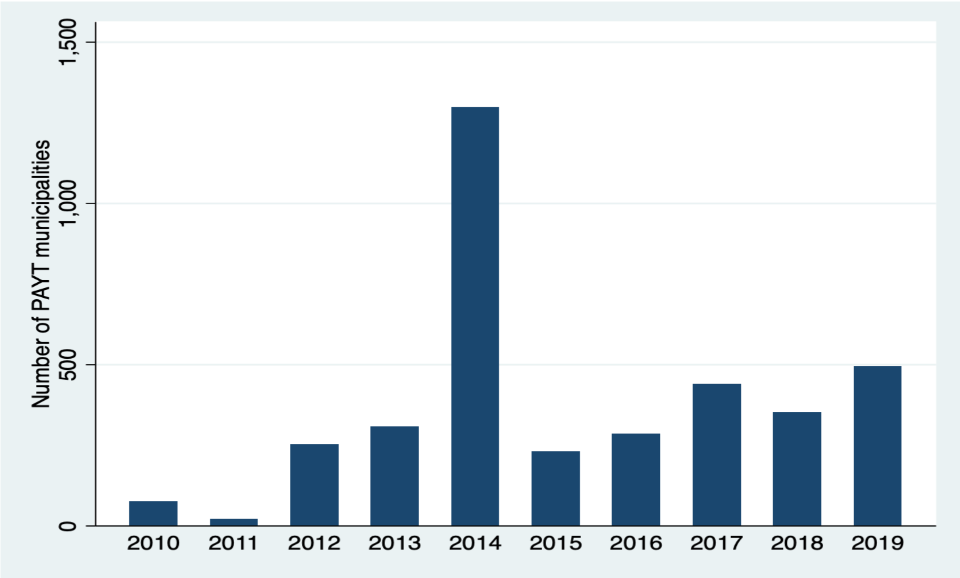
This Table presents the estimated coefficients δ from equation 4. All regressions include municipality fixed-effects, event-time fixed effects, year-by-province fixed-effects, and controls for municipalities' geographical characteristics (area in Km^2, altitude, indicators for capital cities, mountain or coastal municipalities). Standard errors clustered at the municipality level in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1: PAYT Municipalities in 2010 and 2019



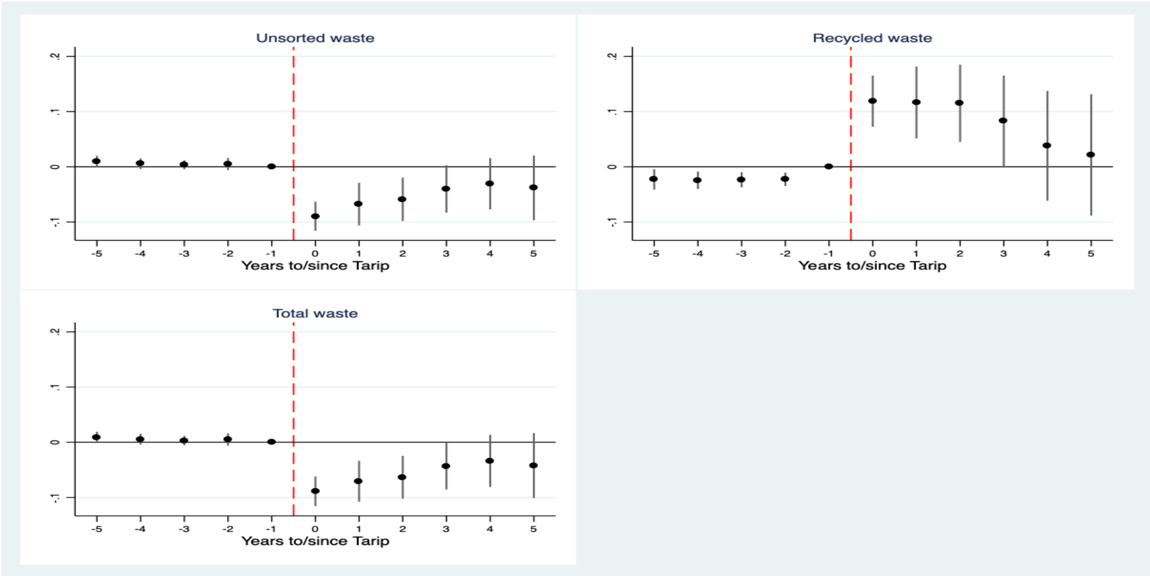
Note: The green dots show PAYT municipalities in 2010 and 2019

Figure 2: Number of Municipalities Introducing PAYT in a Given Year



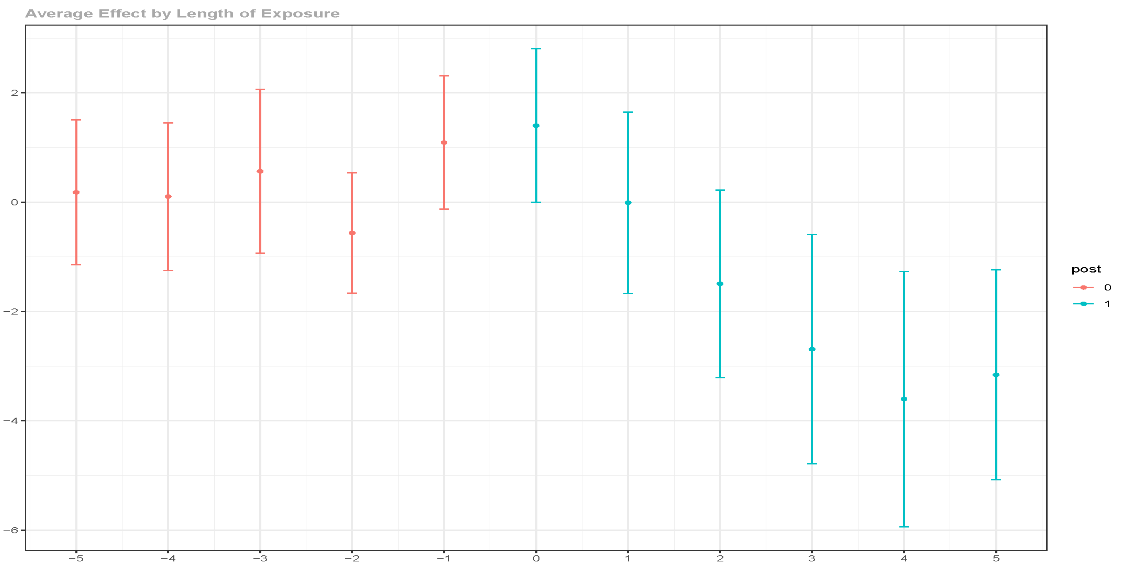
Note: The Figure displays the margins of variations used in the empirical analysis. The bar graphs show the number of municipalities that introduce PAYT in a given year.

Figure 3: Effect of PAYT Introduction on Waste Outcomes



Note: The Figure displays estimates of the changes in waste outcomes around the timing of PAYT introduction (equation 2). The vertical line indicates the timing of introduction.

Figure 4: Waste Cost per Kg



Note: The Figure displays estimates of the changes in waste price (per Kg) around the timing of PAYT introduction (equation 2). The vertical line indicates the timing of introduction.

Online Appendix A: Additional Findings

Table A.I: Factors that Predict Tarip Introduction or Timing of Introduction

	(1)	(2)
Population	-0.025*	0.290
	(0.01)	(0.42)
Area	0.009	0.391
	(0.01)	(0.49)
Altitude	-0.018	-1.061
	(0.01)	(0.75)
Capital city	0.012	2.368
	(0.04)	(1.64)
Recycled	0.001**	0.006
	(0.00)	(0.00)
Observations	72960	6241

Column (1) presents estimates from equation 3 of how observable characteristics predict the likelihood of Tarip introduction. Column (2) presents estimates from equation 4 of how observable characteristics predict the timing of Tarip introduction. Standard errors clustered at the province level in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.II: Key attributes of never-treated *vs* treated municipalities

	Treated		Never Treated	
	mean	sd	mean	sd
Total waste	462.65	967.79	528.78	472.27
Recycled	226.37	513.48	319.22	282.93
Unsorted	236.92	513.87	209.56	219.50
% recycled	49.16	23.38	60.21	15.97
Observations	67043		1805	

Waste amounts are in kilograms (Kg) per capita (p.c). Statistics for treated municipalities refer to pre-policy implementation

Figure A.I: Municipal Waste per capita in the EU

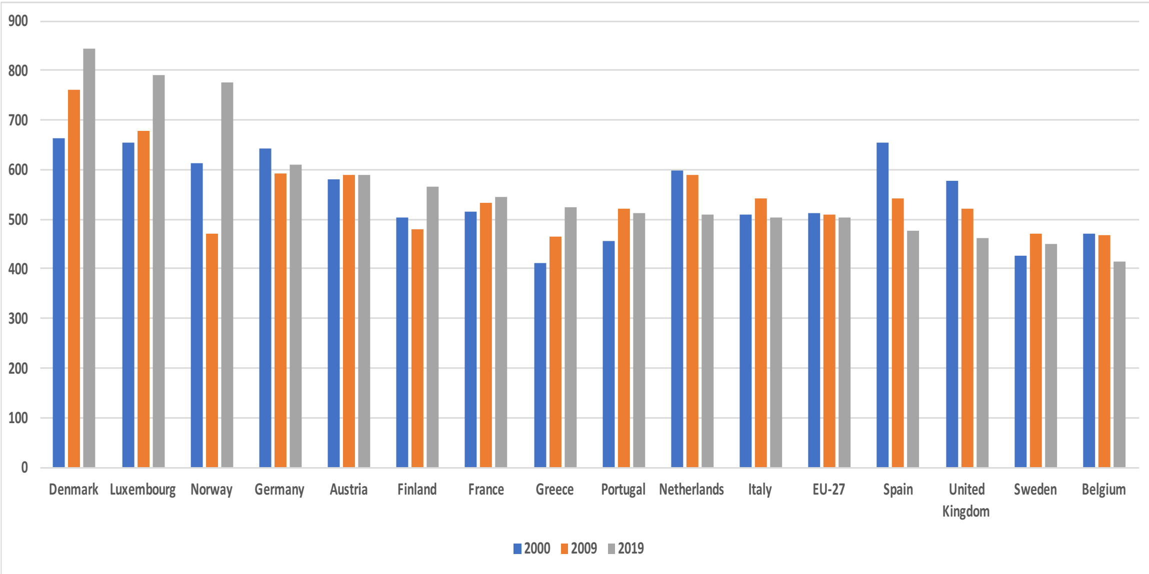


Figure A.II: Share of Recycled Waste in the EU

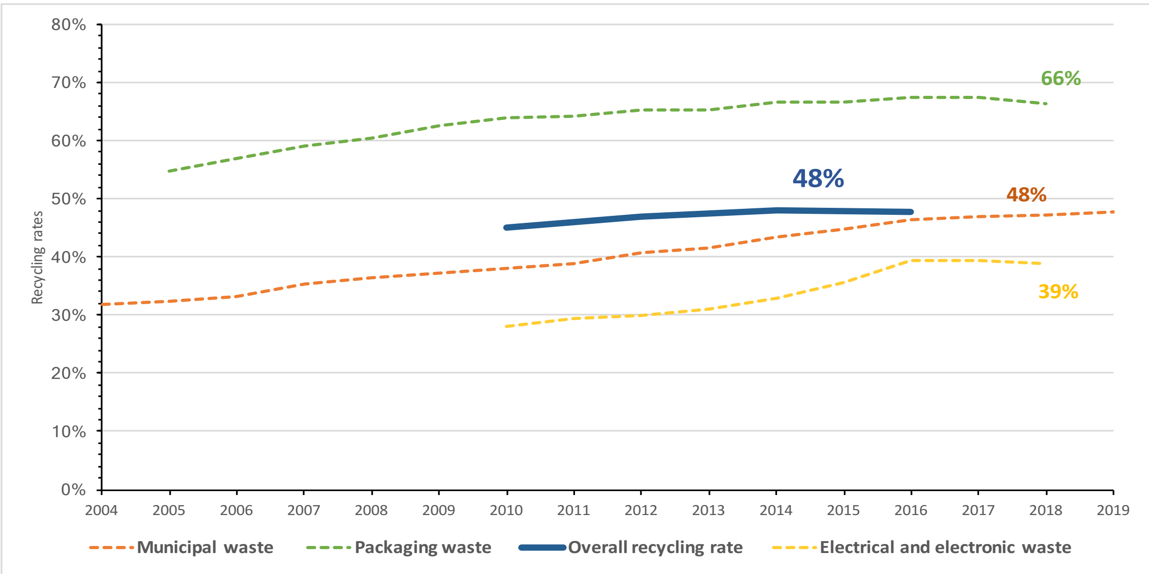
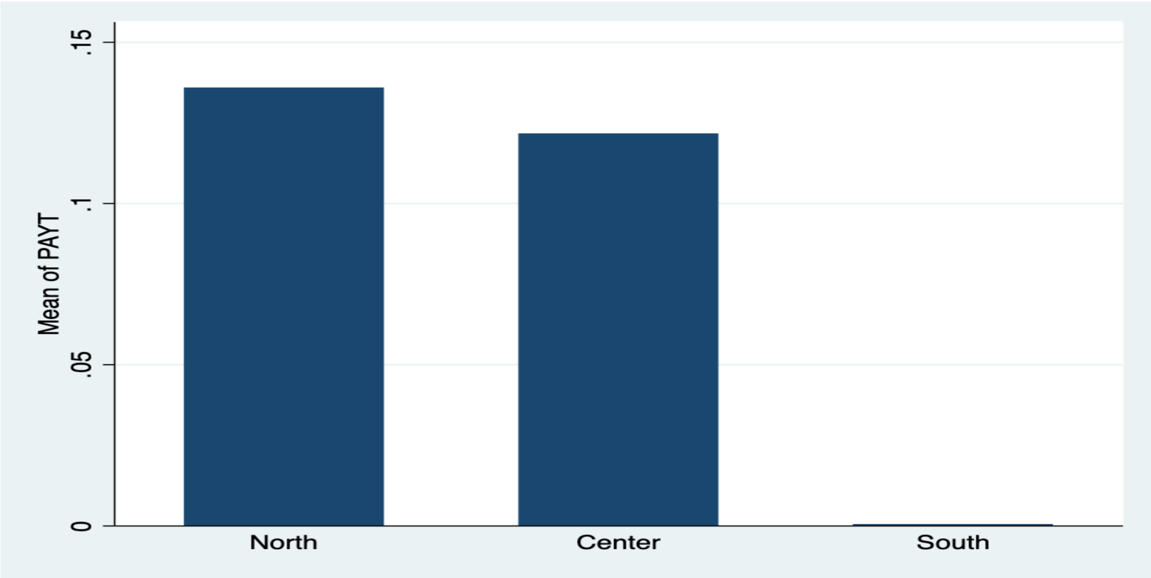
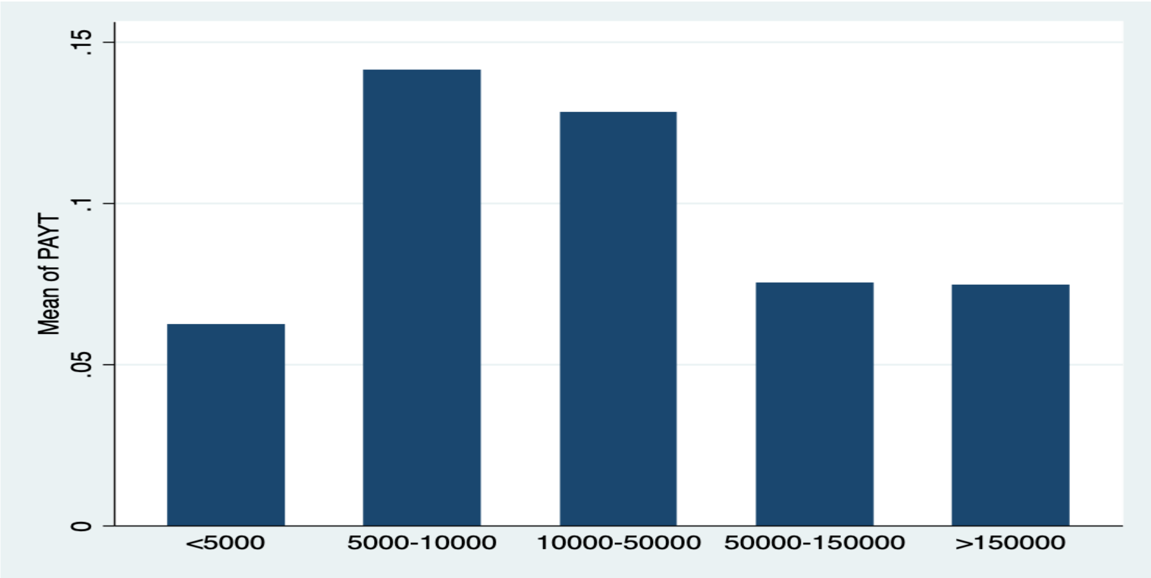


Figure A.III: Share of PAYT Municipalities by Italian Macro-Region



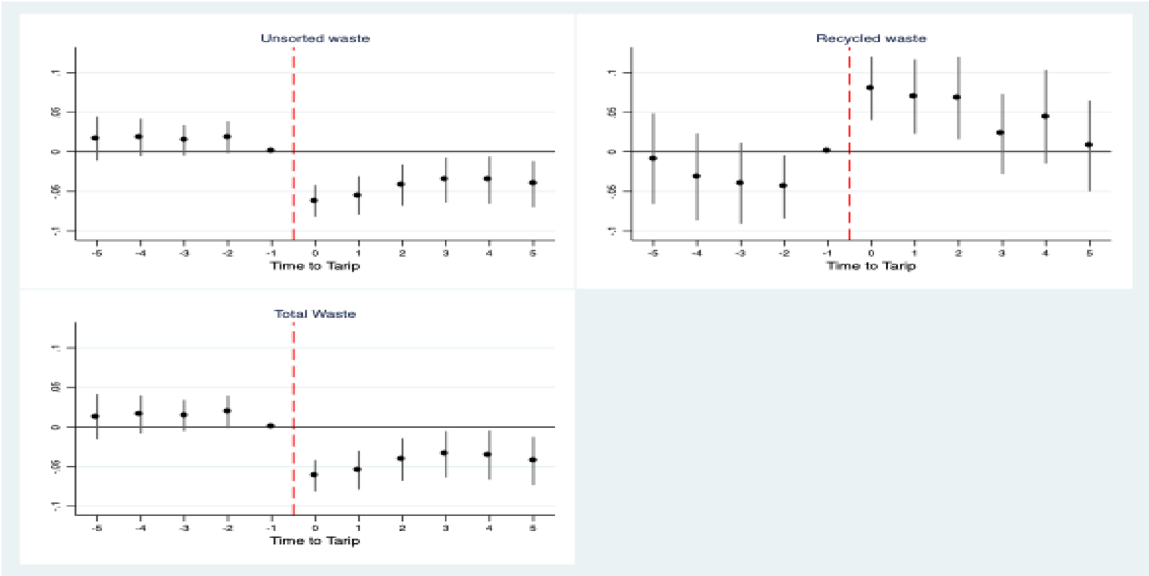
Note: The Figure displays the share of municipalities that introduced PAYT schemes by Italian Macro-Region.

Figure A.IV: Share of PAYT Municipalities by Population Size



Note: The Figure displays the share of municipalities that introduced PAYT schemes by population size.

Figure A.V: Effect of PAYT Introduction on Waste Outcomes using Never Treated Municipalities as Comparison Group



Note: The Figure displays estimates of the changes in waste outcomes around the timing of PAYT introduction (equation 3). The vertical line indicates the timing of introduction.