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When Trash Costs Money: Analyzing the Impact of Pay-As-You-Throw Programs in Massachusetts

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Abstract

This paper evaluates whether municipalities with Pay-As-You-Throw (PAYT) programs dispose of less trash per household than municipalities without them. Given how much trash U.S. residents produce, the negative environmental effects associated with trash disposal, as well as how much the U.S. Environmental Protection Agency advocates for PAYT, it is important to closely analyze whether these programs actually do their job. This paper formally analyzes the effects of PAYT programs using the Massachusetts Department of Environmental Protection's trash disposal data from 2011-2015. After controlling for municipality and time heterogeneity, my analysis shows that PAYT programs reduce trash per household by a statistically significant amount.

Keywords

Pay-As-You-Throw, PAYT, Save-Money-and-Reduce-Trash, SMART, Massachusetts, Municipality, Fixed Effects, Difference-in-Differences

Cover Page Footnote

I would like to thank Professor Nathan Chan for his guidance throughout this research project.

Introduction:

The world is currently facing a "trash crisis," and the United States produces more waste than any other nation. In 2013, the U.S. produced 254 million tons of trash, while China, whose population is four times larger, produced 190 million tons (Simmons, 2016). Throwing out this much trash has serious environmental consequences. This is because the energy used to produce, process, transport, and dispose of goods emits greenhouse gases. In the U.S., 42 percent of greenhouse gas emissions are associated with these activities. Thus, disposing of goods and materials instead of recycling, reusing, or composting them increases the risk of climate change (U.S. Environmental Protection Agency [EPA], 2016a). Since throwing out trash is so harmful for the environment, the U.S. Environmental Protection Agency (EPA) and municipalities across the country are making an effort to reduce household trash disposal. According to the EPA, the most effective way for municipalities to reduce residential solid waste, increase recycling, and decrease waste-related greenhouse gas emissions is by implementing Pay-As-You-Throw programs (U.S. EPA, 2016b).

Pay-As-You-Throw (PAYT) is a solid waste program where residents pay a per-unit fee for disposal of household trash. If a municipality decides to implement this program, the cost of throwing out trash for a resident is determined by the price of the bags or stickers they must purchase in order to dispose of their waste. While some municipalities name their bag or sticker programs Save-Money-and-Reduce-Trash (SMART), both PAYT and SMART are "unit-based pricing" systems that provide residents with a financial incentive to reduce the amount of waste they discard through recycling, composting, and waste reduction. Since PAYT and SMART are synonymous, this paper considers all unit-based-pricing systems as PAYT programs. Many communities that have implemented these programs have experienced decreases in residential trash tonnage, and have been able to use landfills longer. As a result, they have managed to reduce greenhouse gas emissions, and protect natural resources (Massachusetts Department of Environmental Protection [MassDEP], 2016a).

145 municipalities in Massachusetts were implementing PAYT programs as of November 2016 (MassDEP, 2016b). Since municipalities with PAYT programs consistently throw out less trash per household per year, there appears to be a clear correlation between PAYT programs and waste reduction (Quinn, n.d.). However, since PAYT programs are becoming increasingly popular in states like Massachusetts, it is important to accurately assess the impact of PAYT on trash disposal using econometric models. That is why I focus my research on whether implementing a PAYT program decreases trash per household by a statistically significant amount. My assessment of PAYT's effectiveness in Massachusetts will provide another perspective to the Massachusetts Department

of Environmental Protection (MassDEP), as well as municipalities considering whether PAYT systems are worth the time, money and effort to implement.

> **Hypothesis:** After controlling for municipality and time fixed effects, municipalities with PAYT programs will experience larger reductions in trash per household than municipalities without them.

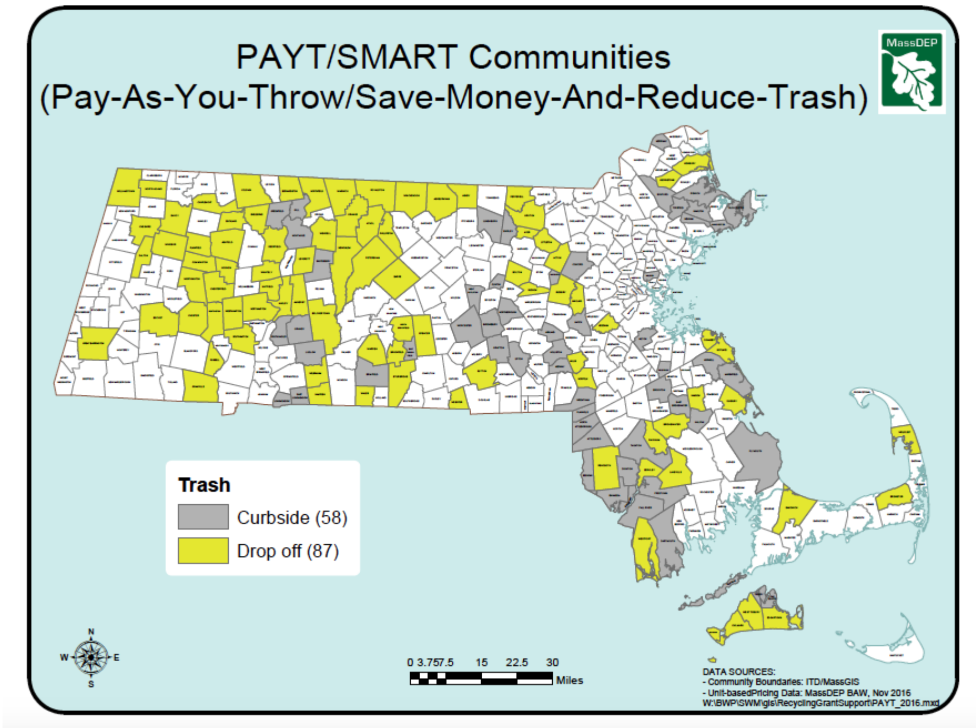

Figure 1. Map of PAYT Communities in Massachusetts. (MassDEP, 2016b)

Literature Review:

I found two articles that use data from prior to 2008 to analyze the impact of PAYT programs on municipal recycling behavior in Massachusetts, as well as one article that assesses the impact of PAYT on residential solid waste production in Southern Maine between 2007 and 2013.

Prior to 2008, the effectiveness of a PAYT program was generally measured by its ability to increase recycling rates at the municipality level. To uncover whether this was the case, researchers at Tufts used panel data on Massachusetts Municipalities' Recycling Rates and each municipality's PAYT program status from 2003 to 2008 to run OLS and random effect regressions. In both the OLS and random effect models, these researchers found that implementing a PAYT program contributed to a higher recycling rate (Tufts, n.d.).

Using demographic and recycling program data for 350 municipalities in Massachusetts from 1997 to 2008, Russell (2011) found that implementing a PAYT program did increase a municipality's recycling rate. Between 1997 and 2008, 8 of the 10 municipalities with the highest average recycling rates in Massachusetts had PAYT programs, as opposed to 1 out of the bottom 10 municipalities. However, this paper does not use econometric analysis to support its claims, and uses recycling rates only to compare programs across municipalities (Russell, 2011).

Blackmer and Criner (2014) analyze the impact of PAYT on residential solid waste disposal in southern Maine. Their statistical models use data from econmaine, a non-profit waste management company in southern Maine. This data includes quantities of materials discarded as trash and materials collected for recycling for 33 municipalities in southern Maine between 2007 through 2013. In both their statistical models (one of which is a fixed effects model), they find that implementing a PAYT program has a positive and statistically significant impact on recycling rates (Blackmer & Criner, 2014).

While these three studies, two of which focus on municipalities in Massachusetts, already evaluate the effectiveness of PAYT, they do leave some questions unanswered. First, the two Massachusetts-focused studies use recycling-rate data from before 2008. However, in 2008, the MassDEP stopped calculating municipal recycling rates. After 2008, the annual waste and recycling data spreadsheets on the MassDEP's webpage (which are discussed in more detail in the **Data** section) note that data collected before 2008 cannot be directly compared to data collected after 2008. As a result, we cannot compare rates calculated before 2008 to rates calculated using more recent data. Due to how difficult and potentially unreliable it would be to calculate and use recycling rates, trash per household is the preferred dependent variable for this PAYT research.

In order to test whether Al Gore's Documentary, *An Inconvenient Truth*, led to an increase in voluntary carbon offset purchases, Jacobsen (2011) uses a differences-in-differences identification strategy like the one I use in this paper. Jacobsen examines whether zip codes that were close to where *An Inconvenient Truth* was shown experienced an increase in offset purchases in the two months after the film was released relative to the change that occurred during the same two months in zip codes that were not close to where the film was shown. This is similar to my equation (1), shown in the **Empirical Approach** section. My equation (2) is similar to the fixed effects model used in Blackmer and Criner (2014), as well as in Wichman et al.'s (2016) study of water conservation policies. In order to estimate whether changes in price or water restriction policy (mandatory or voluntary) influence water demand, Wichman et al. controls for month and household heterogeneity with fixed effects (Wichman et al., 2016). Although econometric techniques have already been used to analyze the effectiveness of PAYT in Massachusetts, the MassDEP is interested in my research since PAYT's effectiveness is currently not being presented using estimates from econometric models.

Data:

The data used for this research project primarily comes from the MassDEP "Waste Reduction & Recycling" webpage. This webpage includes Massachusetts Municipal Solid Waste & Recycling Survey Data spreadsheets for each year between 2003 and 2016 (MassDEP, 2017). However, this paper does not consider the 2016 data since it was published just before this research project was finished. Every year, someone who works for a municipality and is involved in its municipal waste and recycling programs fills out this survey. For each of Massachusetts' 352 municipalities, I observe survey data on the number of households served by the municipal trash program, the amount of trash disposal tonnage produced, and whether the municipality is implementing a PAYT program. Thus, each observation in my data is categorized by municipality and year.

Since the MassDEP's "Pay-As-You-Throw (PAYT)/Save-Money-And-Reduce-Trash (SMART)" webpage advertises the effectiveness of PAYT using maps with data from 2011 through 2015 titled, "How Much Trash Did We Throw Out?" I chose to only use municipal solid waste data starting in 2011 (Quinn, n.d.). My data ranges from 2011 to 2015 since, for most of the research process, the most recent available data was from 2015. My data has fairly high resolution since it provides a detailed picture of trash disposal in Massachusetts over a 5-year period, and allows me to calculate annual trash (in pounds) per household in each municipality. However, my data set is an unbalanced panel since some municipalities in this 5-year period have missing statistics. Since these values are self-reported, there are bound to be some mistakes (such as forgetting to fill out the survey on time, or submitting inaccurate statistics). In order to correct for inaccurate data entries, I replaced Newton's reported 33 households served in 2014 according to the MassDEP's dataset with an average of the municipality's values from 2015 (30,900) and 2013 (27,540). I also eliminated Hudson's 2011 and 2012 observations due to improbable disposal tonnage statistics, and removed all observations that had values for trash per household equal to 0, or that were impossible to calculate.

Summary statistics are reported in Table 1, which can be found in the **Appendix**. Between 2011 and 2015, I have 1,223 total municipality observations of average annual trash per household. The number of observations is lower than it would be if every municipality in Massachusetts were observed during this period since (as mentioned above) some municipalities in certain years reported inaccurate data, or not enough data to accurately calculate average annual trash per household. The average annual amount of trash produced per household across all municipalities and years is 1,554.22 pounds. The average for the 566 observations of municipalities with PAYT programs is 1,229.24 pounds, and the average for the 657 observations of municipalities without PAYT programs is 1,834.18 pounds. Even though the average amount of trash disposed per household is consistently lower in municipalities with PAYT programs, this paper attempts to estimate and uncover whether this difference is due to the program, or municipality and/or time heterogeneity.

Empirical Approach:

I run two different regressions to address my research question.

(1) $TrashPerHousehold_{it} = \gamma * TreatmentGroup + \beta * PAYT + \varepsilon_{it}$

(2) $TrashPerHousehold_{it} = \beta * PAYT + \propto_i + \mu_t + \varepsilon_{it}$

Equation (1) estimates the impact of PAYT on the dependent variable *TrashPerHousehold* in municipality *i* at time *t* using a differences-in-differences identification strategy. The *TreatmentGroup* dummy variable coefficient (γ) will tell us how much trash communities with PAYT programs at any point between 2011 and 2015 (i.e. the treatment group) throw out per household, on average, relative to communities that never have PAYT programs between 2011 and 2015. The *TreatmentGroup* dummy variable labels all observations for a municipality with a "1" if that municipality has a PAYT program at any point between 2011 and 2015, and "0" if it never does. The *PAYT* dummy variable is our differences-in-differences estimator, as it interacts the *TreatmentGroup* dummy variable with treatment year. This dummy variable labels an observation with a "1" during the year a municipality has a PAYT program between 2011 and 2015, and labels an observation with a "0" if it does not have a program in a given year between 2011 and 2015. The *PAYT* coefficient, β, is our coefficient of interest in both equations, and it will estimate how much more or less trash per household, on average, a municipality disposes of in a given year when it implements a PAYT program versus when it does not.

Equation (2) is a fixed effects model that estimates the impact of PAYT on *TrashPerHousehold* while controlling for municipality fixed effects ($\propto_i$) and time fixed effects (μ_t). If a municipality consistently has higher or lower amounts of trash per household, then running a fixed effects regression will allow me to more accurately estimate the impact of implementing a PAYT program on the annual amount of trash per household a municipality produces. I hypothesize that β will be negative and statistically significant in both equations. The variable ε_{it} represents the error term for municipality i at time t.

Results:

The results from the estimation of (1) are reported in Table 2, and the results from the estimation of (2) are reported in Table 3. In Table 2, the *TreatmentGroup* variable estimates that having a PAYT program at any point between 2011 and 2015 will decrease annual trash per household in a municipality by 222 pounds. However, since this is only a simple cross-sectional comparison of municipalities, it does not show the causal impact of implementing PAYT. However, our variable of interest, *PAYT*, does estimate the causal effect of implementing PAYT. The coefficient estimate for *PAYT* says that implementing a PAYT program in Massachusetts, on average, will reduce the annual amount of trash thrown out per household in a municipality by 408 pounds. This would be a 26.25 percent reduction for the average household in my sample. While this estimate is statistically significant at the 1 percent level, the regression explains only 17.28 percent of the variation in my data. Although this result confirms my hypothesis, the results in table 3 provide more accurate results.

Table 2

Average PAYT effect on Trash Per Household in a Municipality

Variables	Model 1
Treatment Group	-221.55*** (83.70)
PAYT	-407.66*** (83.85)
Constant	1,858.46*** (27.71)
Observations	1,223
R-squared	0.1728

Standard errors in parentheses
*** p < 0.01, ** p< 0.05, * p < 0.1

According to Table 3, when controlling for municipality and time fixed effects, implementing PAYT reduces the annual amount of trash produced per household in a municipality by 177 pounds. This would be an 11.39 percent reduction for the average household in my sample. This result is statistically significant at the 6 percent level, and the regression explains 65.35 percent of the variation in my data – a significantly larger percentage than equation (1). These results suggest there is trash disposal heterogeneity across municipalities and time. After controlling for this heterogeneity in a fixed effects regression, I am able to more accurately estimate the causal effect of implementing a PAYT program on the amount of trash per household a municipality produces.

Table 3
Average PAYT effect on Trash Per Household in
a Municipality (including fixed effects)

Variables	Model 2
PAYT	-176.97* (92.28)
Constant	1,707.88*** (223.82)
Observations	1,223
R-squared	0.6535

Standard errors in parentheses
*** p < 0.01, ** p< 0.05, * p < 0.1

These results suggest PAYT programs have a relatively large, statistically significant negative effect on trash per household. PAYT programs appear to provide a strong enough financial incentive to encourage residents to reduce the amount of trash they dispose of through their municipal trash programs. However, my regressions do not capture changes in recycling behavior, since the MassDEP's recycling data is not as accurate and easy to organize as their trash disposal data. Thus, it is difficult to say whether this decrease in trash per household is because residents are putting more effort into recycling, or because more people are using illegal methods such as illegal dumping to dispose of their trash.

Conclusion and Summary:

Overall, these results suggest implementing a PAYT program in a Massachusetts municipality will decrease trash per household by a statistically significant amount and positively impact the environment. PAYT programs are becoming increasingly popular, and my findings could have serious policy implications. My study uses current data to reinforce the findings of past PAYT research, and supports the EPA's assertion that implementing PAYT is an effective way for municipalities to reduce residential trash disposal. Future research should consider whether reductions in trash per household experienced by municipalities after implementing PAYT are due to increases in recycling, decreases in consumption and disposal, or because more people are using illegal methods to dispose of their trash. Since the number of people in a municipality that illegally dispose of their trash may depend upon how strictly the municipal police department treats this issue, the frequency and severity of punishments for illegally disposing trash should be considered. There are also different variations of PAYT, and this study only considers their effectiveness as a whole. Future research should consider whether the effectiveness of PAYT programs depends on the size and price of bags, whether bags or stickers are used, whether trash and recycling must be dropped off or picked up curbside, and whether the program is referred to as PAYT or Save-Money-and-Reduce-Trash (SMART). This research project also only estimates the effectiveness of PAYT in one state of one nation. Future research should consider whether PAYT is more effective in certain communities, municipalities, states, and nations. Other econometric techniques and strategies could also be used in the future to try to answer my research question in a different way.

Appendix:
Table 1
Summary statistics.

Year: 2015	Total Trash in Pounds Per Household	Trash in Pounds Per Household in PAYT Communities	Trash in Pounds Per Household in No PAYT Communities
# of Observations	254	124	130
Mean	1469.488	1237.406	1690.858
Standard Deviation	608.4358	621.2152	506.8742
Year: 2014			
# of Observations	264	126	138
Mean	1467.23	1183.482	1726.304
Standard Deviation	599.8158	604.5767	464.2367
Year: 2013			
# of Observations	218	97	121
Mean	1592.4	1246.402	1869.771
Standard Deviation	965.2807	972.3985	868.4196
Year: 2012			
# of Observations	240	111	129
Mean	1582.484	1168.962	1938.305
Standard Deviation	807.87	396.6824	898.6161
Year: 2011			
# of Observations	247	108	139
Mean	1673.168	1319.81	1947.719
Standard Deviation	662.6489	658.4969	522.3946
Year: All			
# of Observations	1223	566	657
Mean	1554.22	1229.244	1834.183
Standard Deviation	736.1952	664.1593	678.2869

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