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Which US municipalities adopt Pay-As-You-Throw and curbside recycling?

Raymond Gradus¹, George C. Homsy,² Lu Liao³ and Mildred E. Warner⁴

Abstract:

This study investigates the drivers of curbside recycling program adoption and Pay as You Throw (PAYT) program adoption in 1,856 US local governments using a 2015 survey. While 50% of municipalities and counties adopt curbside recycling programs, we find that the adoption curbside recycling is limited by capacity constraints; local governments with lower per capita expenditures and more poverty are less likely to implement curbside recycling. PAYT programs are less common overall (10% of municipalities) and less common in richer communities and more common in communities with higher education levels. Local official political affiliation is not significant in either model. Both programs are less likely in rural places. Our results point to the need for local governments adopting such innovations to address equity, capacity constraints, and efficiency concerns.

Keywords: local government, US, curbside collection, unit-based waste pricing

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1 Introduction

Removing material from the municipal waste stream and diverting it to a recycling program have long been understood to be environmentally important. Lifecycle analyses across a variety of materials and from various nations have established that recycling reduces the production of municipal solid waste (MSW) and the consumption of energy, as well as cuts air and water pollution in comparison to either landfilling or incineration (Mehta, Shastri, and Babu 2018; Pressley et al. 2015; Kreiger et al. 2014; Giovanis 2015). However, as of 2014, in the US more than half (52.4%) of all municipal solid waste was landfilled, 12.8% incinerated, and only 34.6% recycled or composted (US EPA 2016). In Europe, in 2014 42% was recycled or composted, although the regional and national variation is large (Dijkgraaf and Gradus, 2017).

Municipal recycling programs have proliferated over the last three decades, and Pay-As-You-Throw (PAYT) policies help increase the effectiveness of curbside recycling (Starr and Nicolson 2015; Reichenbach 2008). However, only half of US localities have curbside recycling and only one-in-ten have adopted PAYT programs (US EPA 2016). Given the goals of these programs, in this paper, we examine an understudied question: what drives US local governments to adopt curbside recycling or the incentive-based PAYT programs? The answer to this enquiry is important for scholars studying service provision as well as policymakers seeking ways to increase recycling.

1.1 Municipal recycling policy adoption

In the US, municipal recycling emerged as an environmental concern in the 1960s and 1970s in response to widespread littering and a growing conservation movement (Cooper 1998). Most early programs used drop-off centers for people to leave their newspapers,

bottles, and cans, but participation lagged. In 1975 only about 100 local governments had adopted curbside pickup programs to boost recycling rates. The proportion of local governments with curbside recycling grew to 57% of communities in 2015 according to a national survey of US municipalities over 2,500 in population (Homsy, Warner, and Liao 2016).

Although the recycling rate is positively influenced by curbside programs, their effect may be marginal. Struk (2017) found only a two percent gain in recycling by moving from a collection center to curbside recycling in the Czech Republic. Sidique, Joshi, and Lupi-(2010) in a study of Minnesota cities, found no significant effect for a curbside program. Kinnaman (2006) reviews empirical studies in the US and finds a positive effect of curbside recycling but stronger effects in communities which implement a Pay-As-You-Throw (PAYT) policy. PAYT programs, often adopted in conjunction with curbside recycling, is an incentive-based program that makes homeowners pay for solid waste disposal by amount of waste produced. It is usually calculated by the bag, barrel, frequency, or weight of solid waste material picked up at the curbside. PAYT programs balance the environmental goal of reducing the amount of MSW going into landfills and increasing recycling, with the economic goal of reducing costs of disposal to the municipality. The programs have been implemented in many parts of the world, including in the United States, the EU, Japan and South Korea. Many studies show that solid waste charges lead to environmental benefits: the significant decrease in per capita production of MSW (Folz and Giles 2002; Huang, Halstead, and Saunders 2011) and an increase in recycling (Sidique, Joshi, and Lupi 2010; Lakhan 2015). For example, Dijkgraaf and Gradus (2017) found a PAYT system in the Netherlands raised recycling rates by five to ten percent depending upon the method of pricing.⁵ Similarly in Minnesota the amount of

⁵ PAYT systems differ across the Netherlands with respect to the basis of pricing. There are systems based on weight, number of bags, frequency of collection and volume collected (Dijkgraaf and Gradus, 2014). The weight system is the most refined, as each kilogram of waste results in a higher bill. As bags in the Netherlands

waste dropped four percent upon the introduction of a PAYT system (Sidique, Joshi, and Lupi 2010). In Massachusetts, there was almost a 20% correlation between PAYT and recycling rates, though other aspects of state solid waste policy likely played a role (Starr and Nicolson 2015). In the Czech Republic, a reverse PAYT program (which discounted waste charges as the amount of MSW decreased) boosted recycling by eight percent (Struk 2017).

1.2 Adoption of PAYT and curbside recycling programs

The number of municipalities with PAYT programs is increasing around the world (Elia, Gnoni, and Tornese 2015), but the drivers of this increased popularity have not been well described in the literature. The politics of municipal leadership might be relevant, though the results are mixed. For example, a 2010 study in the Netherlands found more conservative politicians preferred the market-based PAYT system and more liberal leaders chose to spread the cost of MSW collection across the community (Allers and Hoeben 2010). However, a more recent study in the Netherlands found just the opposite – that conservatives are less likely to adopt PAYT and progressive liberal politicians are more in favor of such unit-based pricing, and municipalities with more political fragmentation were less likely to adopt effective PAYT programs (Gradus and Dijkgraaf 2017). Studies in the United States typically find that political affiliation has little to no influence on innovation in service provision (Warner and Hebdon 2001; Bel and Fageda 2007).

Smaller places in the Netherlands tend to adopt more unit-based pricing for waste (Gradus and Dijkgraaf 2017) in contrast to the United States where smaller municipalities lag across a range of sustainability policy adoption (Homsy and Warner 2015; Homsy 2018). The Netherlands is one of the most densely populated countries in the world and this may explain

are much smaller than bins, the bag system is more refined than the frequency system. With the frequency system the bill depends on the number of times the bin is presented at the curbside.

the higher use of PAYT in that country compared to the US where small communities are more likely to be rural. Fullerton and Kinnaman (Kinnaman and Fullerton 2000) find that education levels are directly correlated to the adoption of curbside recycling and the price of a PAYT user fee, and Callan and Thomas (1999), in a study of Massachusetts municipalities, find both education and household income are significant. Dutch studies find places with larger average household size and larger home ownership rate might be less likely to adopt a PAYT program, because households with these characteristics produce more waste, and thus generate more local opposition for PAYT (Van Houtven and Morris 1999; Allers and Hoeben 2010; Gradus and Dijkgraaf 2017). Administrative costs are an important factor with municipalities settling on the lower cost frequency schemes, even if they are less effective in reducing waste and increasing recycling (Gradus and Dijkgraaf 2017). Increased residential density makes waste collection in general more effective and less costly (Fernández-Aracil, Ortuño-Padilla, and Melgarejo-Moreno 2018).

One issue with PAYT is the possibility of illegal disposal. However, data on illegal dumping are not readily available. Fullerton and Kinnaman (1996) used household questionnaires and observed solid waste quantities to estimate that 38 percent of the reduction in waste attributable to unit-based pricing may have been dumped in Charlottesville, Virginia. Likewise, Hong (Hong 1999) found dumping became substantial after the adoption of a PAYT system in Korea. By contrast, Allers and Hoeben (2010) suggest this is not a serious problem in the Netherlands (based on data to 2006). One would expect that many municipalities would have abolished user fees if this were the case. Gradus and Dijkgraaf (2017) show that illegal disposal may be an issue in the Netherlands as some early innovators, such as the municipality of Oostzaan, moved back to a flat system due to illegal disposal.⁶ By

⁶ Oostzaan was the first Dutch municipality to introduce a weight-based pricing system, and Linderhof et al. (2001) conducted a study based on more than 127,000 observations obtained in a household survey of all the inhabitants of Oostzaan, and found a decrease of 50% in unsorted waste due to pricing. They concluded this reduction was due to illegal disposal, not waste reduction. Remarkably, the number of households with no

contrast, in the Swiss city of Lausanne, Carattini et al. (2018) show that four years after the introduction of a unit-based pricing system, illegal disposal remained a minor issue. The debate on the impact on illegal disposal is still open, but it points to the importance of social norms and education if a municipality implements a PAYT strategy.

In this paper we use a nationwide US sample to examine what drives local government to adopt incentive-based PAYT (usually in conjunction with curbside recycling) or curbside recycling alone. We are able to control for various community characteristics regarding politics, government expenditure, education and demographics, socio economics and the components of the community's solid waste management system.

2 The model and the data

2.1 Data sources

The data for this study come from the 2015 Local Government Sustainability Practices Survey, we conducted in 2015 with the International City/County Management Association. The survey measures the adoption of local sustainability policies by municipalities across the US. The survey frame consists of all counties, all municipalities, and townships over 25,000 in population and 40 percent of municipalities between 2500 and 24,999 in population. Since there are so many smaller municipalities in the United States, we could not include all of them in our sample. Therefore we chose to include 40 percent of local governments between 2,500 and 24,999 in population size in our survey sample frame. The chief elected or appointed official in each jurisdiction received a mailed survey. The response rate was 22.2 percent, for a total of 1,899 counties and municipalities. We also draw secondary data from U.S. Census 2014 Five-Year Average American Community Survey, 2010 U.S. Census of Population and Housing, and 2012 U.S. Census of State and Local Government Finances. These U.S. Census

waste at all was much larger than in non-PAYT municipalities, which gives an indication for waste tourism (De Jonge Milieu Advies, 2012).

datasets are closest dates available to the collection of the sustainability survey data in 2015. After matching our survey with other available data, our final sample includes 1,856 counties and municipalities. We examined our sample of respondents, using a chi-square test at the 0.05 confidence level, and found that rural municipalities are underrepresented when compared to our sample frame; urban and suburban ones are somewhat overrepresented. The largest municipalities (with populations of 100,000 or more) and the smallest ones (under 25,000 in population size) are slightly overrepresented, while communities between 25,000 and 99,999 are somewhat underrepresented.

2.2 Model specification

We apply a logit model to reveal the drivers of local government's adoption of curbside recycling or pay-as-you-throw (PAYT) systems. We do this because our dependent variables, as describe below, are both binary. In order to explore different mechanisms that shape local waste management strategies, we construct two dependent variables. The first, *the adoption of curbside waste collection*, is a binomial variable that measures whether localities have implemented a community-wide, curbside recycling collection program for households. The second, *the adoption of Pay-As-You-Throw waste collection*, measures whether places have a PAYT program with charges based on the amount of waste discarded. (In the majority of cases, these programs have been adopted with curbside recycling program. See Table 1.) Both the variables are coded with "1" for the presence of the policy and "0" otherwise. According to Table 1, 57.87% of localities have adopted curbside recycling program, and 9.70% of localities have adopted PAYT, which indicates that we have enough influential observations for our logistic regression. The log likelihood chi-square of both the models show that our models as a whole are statistically significant. As for goodness of fit of the models, the pseudo-R squared for model 1 and model 2 are 0.4247 and 0.1226 respectively.

We expect places that adopt the more common curbside recycling will have different characteristics than those that implement the less common PAYT system – either on its own or in conjunction with curbside recycling. As shown in Table 1, 941 localities have only adopted the curbside collection, while only 180 places have implemented PAYT (including some in conjunction with curbside programs.) The remainder, nearly 40% of local governments, reported not having either program. This finding is in accordance with previous literature, which argues that curbside recycling is a more traditional form of waste management, while PAYT programs are sometimes used concomitant with curbside recycling to enhance implementation (Van Houtven and Morris 1999).

Table 1. Descriptive Statistics of the Two Recycling Collection Programs

	Frequency	Percentage
Neither Curbside or PAYT	735	39.60%
Only Curbside Recycling	941	50.70%
Only PAYT	47	2.53%
Both Curbside and PAYT	133	7.17%

ICMA Sustainability Practices Survey, 2015, n = 1,856 US municipalities

Our independent variables are grouped into five categories: household characteristics, governance factors, recycling policies, geographic characteristics, and other socio-economic characteristics. Across the US, state level policies vary (e.g. some states require recycling and some incentivize PAYT (Kinnaman 2006)), so we include state level fixed effects to control for the variance explained by state-level differences.

Household characteristics. The household characteristics include three measurements- household size, home ownership rate, and percentage of multi-family housing units. All three indicators come from the 2010-2014 American Community Survey (ACS). While the first two variables are drawn from the ACS, the percentage of multi-family units is derived from the Census count of housing units in structure. We expect places with larger

household size, larger home ownership rates, and larger proportion of multi-family housing to be less likely to adopt PAYT, but we expect these variables will not affect adoption of curbside recycling.

Governance factors. As proxies for local government fiscal capacity, we use expenditure per capita and property tax dependence, which are derived from the 2012 Census of Government Finance. Places with higher expenditure per capita might have more incentives to adopt PAYT in order to save money. US municipalities rely primarily on the property tax to fund services. Property tax dependence is the proportion of the total government revenue that comes from property taxes. When curbside recycling programs do not include a unit-based fee for recycling collection, residents will pay for solid waste collection through property tax or through a flat amount of fees to local government or a private waste hauler. We expect places with more property tax dependence to be less likely to use curbside recycling due to budget constraints, but more likely to use a unit-pricing system to gain another source of revenue to cover their solid waste management expenses. We also examine political affiliation. Based on our survey questions, we generate a binary variable indicating whether or not the governing body is Democrat, with the expectation that more liberal governing boards will be less likely to embrace PAYT due to its cost to individual households, but more likely to implement curbside recycling.

Recycling Policies. Compared to curbside recycling, PAYT is more effective in reducing waste set-outs (Van Houtven and Morris 1999; Sidique, Joshi, and Lupi 2010; Dijkgraaf and Gradus 2017), and thus more likely to be accepted by places that pay more attention to environmental issues. Through two binomial variables we indicate whether a locality generates electricity from a landfill and whether it engages in internal government recycling. We hypothesize that governments that engage in internal recycling programs are more likely to promote recycling at the community level and also might be more likely to

adopt PAYT. Places that produce power from a waste to energy generation facility may be less likely to offer curbside recycling or use a PAYT system since they would have less incentive to reduce their waste stream.

Geographic Characteristics. We distinguished communities by their metro status: metro core, suburbs, and rural areas. The metro cores are the principal cities in metropolitan areas. The suburbs are the portion of metropolitan areas that lie outside the boundaries of the primary cities. The rural areas are non metropolitan. Implementing curbside recycling is especially difficult in rural areas due to low density. Kinnaman and Fullerton (2000) expected communities with lower population density to be less likely to use PAYT. They argued that with lower population density, the opportunities to dump municipal solid waste might be larger, although their empirical results did not substantiate this hypothesis. Similarly, implementing a PAYT program requires additional administration and staffing (Elia, Gnoni, and Tornese 2015), which might be more difficult for the rural areas due to their limitations in administrative capacity (Homsy and Warner 2015). We also control for the geographical region because the Northeast and West Coast of the US generally have more environmental policies than the North Central and the South.

Other Social-economic Characteristics. Population, income, poverty and education are social-economic characteristics which may affect local waste management policy. We use income per capita, percentage of population with bachelor degree and above, population, population density and poverty rate. These data are based on five year averages (2010-2014) drawn from the American Community Survey. In line with previous studies on drivers of local environment policy, we would expect larger places as well as those with higher income per capita (Lubell, Feiock, and Handy 2009), larger proportion of bachelor degree and above (Kinnaman and Fullerton 2000), higher population density (Fullerton and Kinnaman 1996),

and lower poverty rate (Homsy and Warner 2015) to be more likely to adopt innovations such as curbside recycling and PAYT.

Table 2 Descriptive Statistics of Independent Variables (n=1,856 US Cities and Counties)

	Mean ¹	S.D.	Min	Max
Household characteristics				
Household size ²	2.57	0.34	1.65	4.44
Home Ownership Rate ² , %	67.67	13.35	11.88	100.00
% of Multi Family Dwelling ²	21.85	14.42	0.00	95.62
Government Variables				
Property Tax Dependence ³	29.99	19.96	0.07	100.00
Expenditure Per Capita (1,000 dollars) ³	1.74	1.51	0.01	19.31
Major Governing Body (1-Democrat, 0-Other) ⁴ , %	17.08	NA	0	1
Other Waste Management Policies				
Internal Recycling in Govt ⁴ , %	66.06	NA	0	1
Generated Electricity from Waste, %	7.65	NA	0	1
Geographic Characteristics				
Metro Status ⁴				
Metro Core (n= 287), %	15.46	NA	0	1
Suburb (n=1,010), %	54.42	NA	0	1
Rural (n=559), %	30.12	NA	0	1
Region (1=Northeast and West, 0=North Central and South) ⁴ , %	37.50	NA	0	1
Social-economic Characteristics.				
Income Per Capita ² , \$	28,824	12,231	5235	152,128
Bachelor Degree and Above ² , %	28.71	15.78	1.90	89.92
Population Density (Per Square Mile) ⁵	1664	2008	0.22	20,519
Population Size ⁵	62,043	282,033	641	9,818,605
Poverty rate ² , %	14.40	8.02	0.34	54.37

1. For dichotomous variables, the percent with a value of 1 is presented.

2. Source: 2010-2014 American Community Survey (ACS).

3. 2012 Census of Government Finance.

4. 2015 ICMA Sustainability Survey.

5. US Census of Population and Housing 2010.

2.3 Study Limitations

The study has important limitations. First, our research maps associations between particular sociodemographic characteristics and the adoption of PAYT; it was not designed to provide definitive causal mechanisms, though it does give clues about such paths that can be used as a starting point for future research. Second, as a sustainability survey, there is likely a self-selection response bias towards places that undertake more innovative policies. Finally, as previously described, despite the large sample size, our data overrepresents mid sized and urban and suburban municipalities.

3 Results

Model results are shown in Table 3 as an odds ratio, which describes the likelihood that a one-unit change in a particular independent variable will have on the likelihood of the municipality adopting either curbside recycling alone or PAYT.⁷ Each model controls for state fixed effects. As shown in Table 3, Model 1 uses the full sample size while Model 2 uses slightly fewer observations to eliminate collinearity problems among the variables.

⁷ Variance inflation factors (VIFs) between income, poverty and education indicate that multicollinearity is not a problem in this analysis (average VIF is 2.7; range between 1.6 (for poverty) and 3.7 (for income)).

Table 3. Model Results

	Model 1: Logit		Model 2: Logit	
	Curbside		PAYT	
	Odds Ratio	S.E.	Odds Ratio	S.E.
Household characteristics				
Household size	1.158	(0.327)	0.232***	(0.088)
Home Ownership Rate	0.975	(0.013)	0.996	(0.017)
% of Multi Family	0.991	(0.011)	0.983	(0.014)
Government Variables				
Property Tax Dependence	0.994	(0.005)	0.992	(0.007)
Expenditure Per Capita (1,000 dollars)	1.172*	(0.073)	1.070	(0.071)
Major Governing Body (1-Democrat, 0-Others)	1.223	(0.252)	0.872	(0.212)
Other Waste Management Policies				
Internal Recycling in Government (1-Yes)	6.457***	(0.974)	2.672***	(0.614)
Generated Electricity from waste (1-Yes)	2.132*	(0.629)	1.538	(0.456)
Geographic Characteristics				
Metro Status (ref: suburb)				
Metro Core (1-Yes)	1.044	(1.044)	0.934	(0.934)
Rural (1-Yes)	0.613*	(0.117)	0.531*	(0.144)
Region (1-Northeast and West, 0- North Central and South)	0.185	(0.230)	1.522	(1.848)
Social-economic Characteristics.				
Income Per Capita (ln)	1.932	(2.437)	0.031*	(0.047)
Education (% of Bachelor Degree and Above)	1.017	(0.009)	1.034***	(0.011)
Population Density (Per Square Mile) (ln)	4.354***	(0.667)	0.893	(0.152)
Poverty rate (%)	0.955**	(0.015)	0.974	(0.021)
Population (ln)	0.907	(0.063)	1.093	(0.097)
State Fixed Effect		Y		Y
No. of Observations		1856		1689
LR chi2		1073.16***		140.55***
Pseudo R2		0.4247		0.1226

* < 0.05, ** < 0.01, *** < 0.001

Standard error in parenthesis

Data: US Cities and Counties, ICMA Sustainability Policies Survey, 2015

None of the household characteristic variables were significant predictors of curbside recycling, as expected. However, regarding PAYT programs, household size has a negative influence. This result is similar for implementation of PAYT schemes in the Netherlands (Gradus and Dijkgraaf 2017). The odds of adopting PAYT drops by 78% for each additional

person per household. These results are in accordance with our assumption that places with larger average household size will be less likely to implement PAYT due to equity concerns. Homeownership rate and multi-family housing are not significant predictors of PAYT programs.

Contrary to expectations, property tax dependence had no effect in either model. Government expenditure per capita is the only government variable that has a significant effect on the adoption of waste management policies. An increase of 1,000 dollars in expenditure raises the odds of adopting curbside recycling by 17%, which makes sense as curbside recycling is more expensive than other waste collection programs (Bohm et al. 2010). Government expenditure is not significant in the PAYT model, which runs contrary to our hypothesis that cost-saving is a benefit that attracts local governments to adopt PAYT programs (Dijkgraaf and Gradus 2015). Our results also show no evidence that political ideology influences the adoption of either curbside recycling or PAYT.

Regarding government environmental policy, however, we find governments that have implemented an internal recycling program are 6.5 times more likely to adopt curbside recycling program and 2.7 times more likely to adopt PAYT. This is in accordance with our expectations. We had expected that places generating electricity through a waste to energy facility might have less incentive to adopt recycling and PAYT programs. But our models show these places are 2.2 times more likely to adopt curbside recycling and there is no difference in the adoption of PAYT. Thus waste to energy facilities can be understood as a complementary part of a broader waste management strategy, not a substitute for recycling and household waste reduction.

Regarding geographic characteristics, we find rural areas are less likely to adopt either curbside recycling or PAYT as expected. This could be due to cost and capacity constraints. It also can be an indication that rural areas have more opportunities for illegal disposal and thus

municipal leaders are more reluctant to implement a PAYT program. We had expected places with higher density to be more likely to implement both programs. Our models find this is true for curbside recycling but not for PAYT. Curbside collection is expensive; but with rising density, it becomes more cost effective. PAYT, by contrast, is usually administered by some kind of tag system and thus does not contribute to increased costs the way curbside recycling does; thus, we do not find density is significant in our PAYT model. Our models show no large regional differences, as curbside recycling is common across the country and PAYT, though uncommon, is not regionally concentrated.

Among other social-demographic variables, we had expected larger, more educated and richer places to be more likely to implement both programs due to greater capacity to innovate. While places with more poverty were less likely to implement curbside recycling as expected, our model results show, surprisingly, that places with higher per capita income were less likely to adopt PAYT. It may be that higher income communities feel less compelled to explore PAYT because they are not motivated by its revenue generation potential. Educational attainment was only important in the PAYT model. Adoption of PAYT requires a public understanding of economics and the incentive effect of unit based pricing on household waste reduction. This is a more complicated concept that may be harder to implement in communities with lower education.

4 Discussion and Conclusion

Curbside recycling is the most common method that local governments in the US use to divert waste from a landfill. However, in less than 10 percent of communities is it used in combination with waste-to-energy programs or PAYT. Curbside recycling is a resource intensive form of waste collection that is more common in municipalities with higher density,

larger government budgets and lower poverty. This suggests capacity constraints may be barriers to adoption in rural and poor communities.

PAYT is a less common strategy overall. It is rarer in rural areas due to capacity constraints (and possibly due to concerns about illegal disposal). It is also less common in richer communities. This is a surprise. While we expected education to be higher in communities implementing PAYT, due to the complexity of the issue, we did not expect richer communities to be less likely to implement PAYT. This raises challenges with regard to both education and the economics of waste reduction.

PAYT may be more effective than curbside recycling in actually reducing household waste production, but capacity constraints are not the primary barrier; education is. In order to adopt PAYT systems, a local government must educate consumers on the effectiveness of economic incentives and convince municipalities that the benefits are worth the costs. Early work in France found the economic benefits of PAYT may not be sufficiently high to incentivize implementation at the municipal level. Le Bozec (2008) found the application of unit-pricing may not meet the budget constraint of the localities over the first three years due to the complexity of cost-benefit analysis of the system. Even if PAYT is cost-saving in the long-term, the cost for switching might hinder the transition to unit-pricing.

Waste-to-energy programs are another part of the picture. We find municipalities that generate electricity from their waste are also more likely to undertake curbside recycling, but not PAYT programs. We suspect that the funds generated by power production help offset the costs of solid waste disposal and therefore reduce the need for the potential economic advantages generated by PAYT programs. The sign of the relation between curbside recycling and a waste to energy facility is puzzling. It could be that environmental concerns with respect to landfills drive this result. However, economic aspects also could be important. In the Netherlands, curbside collection of plastic waste is the norm and still 25% of the collected

household plastic is used for energy recovery (Gradus et al. 2017). As the use of plastics is increasing and the amount of recycled plastic in the US is still low (9.5%), future research should address plastic recycling and incineration (US EPA 2016).

Our models also suggest the need to look more closely at equity concerns. One problem with PAYT programs in lower income communities is that the unit cost is relatively more expensive for poor families and may lead to illegal disposal (Ando and Gosselin 2005; Reichenbach 2008; Lane and Wagner 2013). Our models find communities with larger household sizes are less likely to implement PAYT (perhaps due to equity concerns), but we find richer communities are also less likely to implement PAYT, in contrast to early work on PAYT by Callan and Thomas (1999). This raises a different equity consideration. The early adopters of PAYT in the US are actually the lower income communities with higher education levels.

While curbside recycling can be more expensive, it is also more acceptable to the public. But is it effective in actually reducing waste generation? With the dramatic shifts in recycling markets (especially the 2018 closure of Chinese markets for some recycled commodities), municipalities are searching for alternatives to promote waste reduction (ICMA 2018). PAYT systems can offer promise but require attention to economic incentives at both the household and municipal level, and attention to equity, capacity constraints and illegal disposal.

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