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ORIGINAL PAPER

Municipal performance in waste recycling: an empirical analysis based on data from the Lombardy region (Italy)

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Abstract By using a large cross-sectional dataset that observes municipalities from one of the most populated and wealthiest regions in Europe (Lombardy, Italy), this paper investigates how municipal waste re-cycling is correlated with a wide set of municipallevel variables. Results show that municipal waste recycling is linked to geographical, demographic, socio-economic and political variables. They also reveal that these tendencies vary according to municipalities' population size. This empirical analysis helps in identifying those municipalities that have higher probability of being virtuous in terms of waste recycling.

Keywords Waste management · Recycling · Local government

JEL Classification Q53 · Q58 · C25

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1 Introduction

In 1900 only 10% of the global population was living in urban centres while nowadays this percentage exceeds 50%. As a consequence, urban environmental problems have dramatically grown. One of those problems is waste management.

At the present time in the European Union (EU) waste management is regulated by EU members' national legislations, which adopt EU directives and principles. Nevertheless, waste management is usually planned at the regional level and materially carried out by local governments.

A high heterogeneity in waste management performances is observed when looking at different local contexts even in the same country. A recent and still expanding literature investigates this heterogeneity and points out that local performance in waste recycling is driven by a number of variables such as demographic and socio-economic features of population, cost of the service and of its alternatives, geographical features of the territory and government characteristics (Sidique et al. 2010; Mazzanti et al. 2011; Czajkowski et al. 2015).

This paper aims to contribute to this literature by empirically investigating correlates of municipal waste recycling in the Lombardy Region of Northern Italy. The analysis is drawn on an original cross-sectional dataset that observes almost all the municipalities in this region ($n = 1521$) and was built by gathering municipal data on recycling performances and on a number of municipality level possible covariates.

While, to the best of our knowledge no study has investigated municipal waste recycling in Lombardy, there are three reasons why focusing on this specific region is particularly interesting.

First, Lombardy has a great importance from a demographic point of view since it has the highest population among Italian regions and one of the highest population in in Europe (see Eurostat data). It is also very important from the economic point of view since, according to the 2014 Eurostat regional statistics, it is one of the richest European regions.

Second, Lombardy has the largest total production of urban waste in Italy and it is the sixth Italian region in terms of urban waste recycling performance (ISPRA 2013). Moreover, its integrated waste management system allows to allocate only 8% of the total urban waste production to landfills (which is the lowest value reported by the Italian regions), while 44% is incinerated (ISPRA 2013).

Third, although Lombardy is not the biggest Italian region in terms of surface, it reports the highest number of municipalities (1544) among Italian regions. This allowed us to build a large (>1500 observations) municipality-level dataset. The municipalities in the Lombardy region are very heterogeneous in terms of population size since some of them are very small (<2000 inhabitants) while others are substantially bigger (>200,000 inhabitants). The prevalence of small municipalities makes our study interesting also for understanding waste recycling performances in places that can only partially benefit from economies of scale whose existence in waste management has been proven (Lavee and Khatib 2010).

The paper is structured as follows. Section 1 presents a brief overview of the existing literature devoted to the analysis of determinants of waste recycling. Section 2 describes the data used in our empirical investigation and the methodology applied

in order to analyse them. Section 3 presents and discusses our results; finally, Sect. 5 concludes the paper.

2 Determinants of municipal waste recycling: literature review

Starting from the early 1980s, urban waste generation in industrialized economies increased exponentially and this put a significant pressure on disposal systems (Buclet 2000). The most commonly used facility for waste disposal—landfill sites—started to exhibit growing problems due to capacity constraints, while the creation of incinerators started to find significant social opposition due to the presumed pollution created by incinerator plants (for a review of contributions on this topic, see Buclet 2002). As a consequence, the economic and financial returns arising from alternative waste treatments started to be investigated (Rostirolla and Romano 2011) and new schemes for recycling and reuse were studied and progressively introduced.

Over the last 25 years scholars devoted increasing attention to the investigation of waste recycling. On the one hand, the theoretical literature mainly investigates those market conditions that affect waste diversion, by especially focusing on costs and revenues (Massarutto 2007; Huang et al. 2011). On the other hand, the empirical literature produced a number of studies that may be classified into two wide categories (Sidique et al. 2010). First, some contributions are based on individual-level (or household-level) data and aim to identify the micro factors correlated with the recycling decision. These studies integrate those that investigate individuals' environmental attitudes and their determinants (Ercolano et al. 2014) by examining citizens' attitudes towards a specific environment-friendly action such as waste recycling. Second, other contributions are based on macro-level data (municipal-level, regional-level or country-level data) and aim to identify those factors that characterize territories and communities that reveal a correlation with recycling performances.

According to these empirical contributions, there is a number of possible determinants of municipal waste recycling such as demographic variables, socio-economic variables, geographic variables, features of local governments.

Demographic variables are considered among the most important drivers of municipal waste recycling. Population size is often considered as crucial (Mazzanti and Zoboli 2009; Kinnaman and Fullerton 1999). On the one hand, it positively affects the cost of providing recycling schemes (Carroll 1997) while alternative end-of-the-pipe solutions, such as incineration, potentially benefit from economies of scale (Daskalopoulos et al. 1997). On the other hand, social cohesion and social control, which are potential drivers of recycling (Knussen et al. 2004), are likely to be more developed in less populated towns.

Beside population size, also population density is usually considered as a determinant of municipal waste recycling. From one perspective, population density is normally associated to smaller residences and to lack of space that negatively affects households' attitude towards recycling. According to this reasoning, a negative correlation between population density and recycling is expected. Nevertheless, a positive correlation is also theoretically possible. Indeed, population density is also supposed to trigger investments in recycling infrastructure (Sidique et al. 2010) because it usu-

ally determines high cost of land which, in turn, has some impact on setting landfills (Mazzanti et al. 2008).

Household size has been found to be negatively correlated with total waste production and positively correlated with mixed waste quantity (Curtis et al. 2009). Callan and Thomas (2006) find that household size negatively affects the demand for disposal service. Following Jenkins et al. (2003), the positive impact of household size on recycling performances may be due to the fact that household recycling benefit from economies of scale.

Also population age is one of the most often quoted drivers of municipal recycling performance (Schultz et al. 1995). Nevertheless, the existence of a link between age and recycling is controversial and the direction of the relationship between these two variables is ambiguous. Gamba and Oskamp (1994) report the existence of a statistically significant negative correlation between them. This is consistent with the idea that recycling turns out to be complex for older people. Instead, Vining and Ebreo (1989) claim that older residents are more likely to recycle, which is consistent with the idea that recycling behaviours are positively affected by the conservation habit that is more widespread among older people (Li 2003) and with the idea that elder individuals have more free time to be invested in recycling (Dijkgraaf and Gradus 2004). Folz and Hazlett (1991) find a negative correlation between age and recycling across communities where recycling was mandatory, while in communities with voluntary recycling programs these two variables are found to be positively correlated.

Moving to socio-economic variables that exert influence on municipal recycling performance, education is one of the most important. Indeed, education allows for a better understanding of the benefits arising from environmental-friendly behaviour, it enhances ecological consciousness and the perception of an ethical or social reward arising from giving a positive contribution to societal goals (Berglund 2006; Czajkowski et al. 2015).

While income is usually correlated with education, it is considered as exerting itself some influence on waste recycling. On the one hand, it determines the opportunity cost of recycling and therefore it is expected to be negatively correlated with the share of recycled waste. On the other hand, a positive link between income and recycling is expected since the environment is considered as a luxury good (Michall et al. 2015). Empirical analyses provide support for this latter perspective, since income is commonly found to be positively correlated with waste recycling (Callan and Thomas 2006; Hong et al. 1999).

Alongside citizens' demographic and socio-economic characteristics also features of local governments are presumed to play a role in driving municipal recycling performances. On the one hand, governing parties attitudes towards environmental issues are crucial since they can adopt programmes aimed at promoting recycling. Not surprisingly, in a study focused on Swedish municipalities, Hage and Söderholm (2006) find that the presence of a green party in local governments significantly enhances collection of plastic packaging. On the other hand, political competition may yield to environmental policy improvements (Wilson and Damania 2005) and Feiock and West (1993) specifically support the hypothesis that it exerts a positive impact on recycling performances.

Also the geographical context where people live is presumed to play a role in determining municipalities' recycling performances. Indeed, morphological features of one territory exert some influence on the organization of waste management because of structural constraints (the presence of mountains affects logistic) or economic constraints (e.g. tourism linked to the presence of natural beauties). For example, Abrate and Ferraris (2010) analyse Italian data and find that altitude has a remarkable negative impact on municipalities' total waste collection in Southern regions probably due to the massive presence of tourism on the coasts.

Finally, scholars claimed that also organizational features of the waste collection service impact on recycling performances by creating incentives that enhance recycling collection. Hong et al. (1993), for example, highlight that the existence of disposal fees on unsorted waste, together with discount schemes on recycled quantities, positively affect citizens' attitudes towards waste selection. Consistently, Jenkins et al. (2003) find that curbside recycling programs increase households' intensity of recycling.

3 Data

In order to identify the correlates of MW recycling among the municipalities in the Lombardy region of Italy, we built an original municipal-level cross-sectional dataset by gathering data from multiple sources.

Drawing on 2012 data provided by the Lombardy Regional Waste Management Plan, we built one variable measuring municipalities' share of waste recycling on total MW generated. This variable, which is labelled RECYCLING in the following, measures municipalities' performance in waste recycling and is used as the dependent variable in regressions whose methodological features will be extensively presented in next section.

The set of covariates used in these regression analyses was selected on the basis of the hints provided by the literature surveyed in Sect. 2. According to this literature, five groups of municipal-level covariates were considered: demographic characteristics, socio-economic features, variables that observe characteristics of the territory where the municipalities are, variables related to organizational features of the local waste management service, and political features.

First, according to the literature surveyed in Sect. 2, four demographic covariates are included among regressors. Number of inhabitants is considered in order to take into account municipalities' population size (POPULATION). Alongside this variable, also population density (DENS), as given by the number of inhabitants over the municipality surface, and the municipal average age of inhabitants (AGE) are included. Finally, one variable measures the municipal average number of people per household (INHAB_FAM).

Second, in order to control for the effect of education and income on waste recycling performances, the share of graduates among inhabitants over 18 (EDUCATION) and the municipal average per capita wage (WAGE) are included among covariates. To deepen the analysis of the income effect on recycling, our set of socio-economic regressors also includes data concerning the municipal average real estate value per square meter observed for residential units of intermediate quality (HOUSE). This data

is collected by the national real estate register of the Italian territory agency which is a branch of the Italian revenue and tax agency. Indeed, the inclusion of this variable among covariates is interesting in order to check whether municipalities with higher real estate values prefer to recycle due to the high opportunity cost of establishing a diversion facility.

Third, in order to take into account the characterization of the geographical area were the municipality is, altitude over the sea level (ALT) is considered. As the literature reviewed in Sect. 2 suggests, altitude presumably determines logistic difficulties for waste management. This might be particularly serious for municipalities that are located in mountain areas since their accessibility might be problematic also because their territory is frequently divided into different suburbs. According to this reasoning, while altitude does not directly impact on households' attitude towards recycling, it might inflate costs of waste management; this, in turn, can induce municipalities to prefer waste disposal instead of recycling, which is definitely more expensive.

Fourth, in line with the literature briefly surveyed in Sect. 2, two variables concerning the organizational features of local waste management were considered.

A first variable measures the linear distance from each municipality to the one that the Lombardy Regional Waste Management Plan identifies as the location of its disposal facility (landfill, incinerator or pre-treatment plant). This variable was calculated by looking at the distance between the town halls of the two municipalities and is labelled DIST in the following analyses. While DIST does not directly affect citizens' attitude towards recycling, it presumably exerts some influence on the companies that carry out waste management and organize the collection scheme (Reggiani and Silvestri 2015). Indeed, when disposal facilities such as landfill, incinerator or pre-treatment plant are far, transport costs (Massarutto 2007)—which represent one of the most important cost items in the management of the waste service—are high and this might translate into an incentive for the municipality to promote waste recycling. In other words, being far from the facility would suggest a reduction of the quantity of MW to be addressed to disposal in order to save transportation costs and this, in turn, translates into an incentive to increase the quota of recycling.

Following Mazzanti et al. (2012), a second variable included in this set of regressors is a dummy variable labelled TIA (Tariffa Igiene Ambientale, i.e. environmental hygiene tariff,) that takes the value of 1 for those municipalities where some scheme of unit pricing is applied and the value of zero, instead, for those municipalities where a general waste tax (tassa smaltimento rifiuti solidi urbani), with substantially no relation with the amount of waste produced, is applied.

According to the Italian system, local governments may choose to introduce an environmental hygiene tariff or a general waste tax; the former is made up by two parts, a fixed part which covers the fixed costs of waste management in a broad sense (such as costs of streets cleaning), and a variable part that varies according to unselected waste produced by the each household. The general waste tax, instead, is merely calculated on the basis of some proxy of the size of household (their living space or the electric energy consumption) and this calculation does not follow any cost-recovery principle. Since paying for the amount of unsorted waste produced represents an incentive for increasing recycling rates, unit pricing schemes such as the environmental hygiene tariff are presumed to be positively correlated with recycling performances.

Furthermore, as Mazzanti and Montini (2014) claim, the implementation of the tariff-based system is a sign of local government's stronger policy commitment for recycling and therefore may be positively linked to the share of recycled waste. While other incentives for recycling (such as garbage bags pricing) exist in Italian municipalities, data that allow to identify them are not available.

Fifth, one political-related variable is also considered in order to measure political continuity or discontinuity of the municipality government observed in 2012 with respect to the government that was in office during the previous legislature. This variable, which is labelled POL_CON, is a dummy that takes the value of zero when no political change has been recorded and takes the value of one otherwise. In contexts characterized by high political competition, change in government may arise because of bad performances of previous governments in managing waste recycling.

Table 1 provides a description of all the variables presented so far and reports data sources and summary statistics. In addition to these variables, our regressions analyses also include province dummies in order to account for unobserved provincial heterogeneity in municipal waste recycling.

Due to missing data, our final dataset included 1522 observations and this means that our analysis considers approximately 99% of the municipalities of the Lombardy region.

4 Methodology

The cross-sectional nature of the data under scrutiny precludes the identification of any causal link among the variables considered. Nevertheless, running a regression analysis on the data presented so far allows us to descriptively investigate the diffusion of waste recycling among municipalities in the Lombardy region by inspecting the existing ceteris paribus correlation between recycling and the municipality-level features presented in the previous section. This represents a useful step in the process of identification of those municipalities whose recycling performances need to be improved and provide useful hints in order to design further investigation aimed at identifying specific policies that are able to trigger drivers of local recycling performances.

As we already reported in section two, our dependent variable measures the share of recycling among the total amount of waste produced by the observed municipalities. Therefore, this variable's values theoretically range from 0 to 1. In our dataset values range from 0.05 to 0.87 as it is reported in Table 1.

When a proportion is used as regressand, the bounded nature of this variable leads to biased OLS estimates because of impossible predictions that fall outside the possible 0–100 range, non-normality of residuals and heteroscedasticity. In order to overcome these problems, the our empirical strategy relies on the fractional logit model (FL; Papke and Wooldridge 1996) that is a quasi-likelihood estimation method appropriate for the investigation of proportions. More specifically, according to the fractional logit model the municipal share of waste recycling is modelled as follows:

$$R_i = \frac{e^{X_i\gamma+\varepsilon_i}}{1+e^{X_i\gamma+\varepsilon_i}} \tag{1}$$

Table 1 Descriptive statistics of variables

Label	Description	Unit of measure	Source	Obs.	Mean	SD	Min	Max
RECYCLING	Quota of total MW selected	Share of total waste	Lombardy Regional Waste Management Plan	1522	0.53	0.17	0.06	0.87
ALT (×1.000)	Altitude above the sea level	Meters	ISTAT Italian Census	1522	0.28	0.25	0.01	1.82
POPULATION (×1.000)	Total population	Number of inhabitants	ISTAT Italian Census	1522	0.64	3.38	0.00	126.21
DENS (×1.000)	Demographic density	Inhab./km^2	ISTAT + municipal registry offices	1522	1.18	3.66	0.00	115.07
INHAB_FAM	Average number of people per household (total population over number of households)	Number of people	ISTAT + municipal registry offices	1522	2.35	0.20	1.42	3.01
AGE	Average age of inhabitants	Years	ISTAT + municipal registry offices	1522	43.56	3.10	33.87	60.41
EDUCATION (×10)	Quota of graduated inhabitants out of 18 years old and more inhabitants	Percentage	ISTAT Italian Census	1522	2.52	0.68	0.57	7.07
HOUSE (×1.000)	Average real estate value per square meter	€/m^2	Italian Territory Agency	1522	1.11	0.44	0.53	4.90
WAGE (×1.000)	Average per capita wage	€ per capita	Italian Revenue Agency	1522	12.99	2.51	2.08	32.86
POL_CONT	Political continuity or discontinuity of the ruling Major with predecessor	Dummy 0–1	Italian Ministry of Interior affairs+ research on local press	1522	0.71	0.45	0.00	1.00
TIA	Enforcement of a waste tariff in place of a general tax	Dummy 0–1	Lombardy Regional Waste Management Plan	1522	0.17	0.37	0.00	1.00
DIST	Linear distance between the municipality (Town Hall) and the municipality of the assigned disposal facility	km	Our calculation on Lombardy Regional Waste management Plan data	1522	26.30	17.61	0.00	110.00

where R is the share of waste recycling reported by the i-th municipality, X is the vector of covariates presented in Sect. 2, γ represents the parameters to be estimated and ε is the error term.

When carrying out the FL estimates, we started by running a very simple specification that includes municipalities' geographical characterization and the augmented this specification by progressively including the other regressors presented in Sect. 3.

For each specification considered, the existence of severe multicollinearity among regressors, which may lead to inflated standard errors and therefore bias the statistical significance of our analyses, was checked by calculating the Variance of Inflactor Factor (VIF) after OLS. VIF results are not reported in order to save space and are available upon request. They indicate that multicollinearity is not a big issue in our analysis.

5 Results

Results achieved through the FL estimates are presented in Table 2. Four alternative models are illustrated in order to investigate the robustness of results when the set of covariates considered is augmented. With the aim to ease the interpretation of the results, marginal effects evaluated at the mean of the explanatory variables are reported.

Overall, the results reveal that municipal waste recycling is statistically significantly correlated with most of the demographic and socio-economic characteristics considered as well as with physical features of the territory and features of the waste service.

Moving to a detailed analysis of our estimates, it is worth noting that the variables used in order to observe demographic characteristics of the municipalities under investigation turn out to be statistically significant, with few exceptions.

POPULATION is found to be highly statistical significant ($p < 0.01$) with a negative sign. On the one hand, this finding might arise because of the strong and positive linkage between social cohesion, which is difficult to be reached in more populated cities, and recycling. On the other hand, it supports those contributions that claim that waste management solutions different from recycling will prevail in those cities whose population size allows economies of scale.

AGE shows a highly statistically significant ($p < 0.01$) and negative correlation with the dependent variable. According to this result, the older the municipalities' population is, the lower the share of waste recycling is. This finding supports the idea that recycling turns out to be complex for older people who show a definitely higher attitude to avoid it compared to younger people.

A positive and highly statistically significant ($p < 0.01$) correlation is reported by INHAB_FAM. This result supports the hypothesis that larger families benefit from intra-household economies of scale in the organization of recycling. At the same time, given that large families are usually more frequent in rural areas rather than in urban ones, this finding may also reflect a more pronounced attitude for recycling expressed by people living in rural areas. Therefore, future research may explore this finding in a more detailed way.

Table 2 Correlates of municipal waste recycling in the Lombardy region (Italy)

Variables	(1)	(2)	(3)	(4)
ALT (×1000)	−0.185***	−0.172***	−0.171***	−0.155***
	(0.018)	(0.017)	(0.017)	(0.019)
POPULATION (×1000)	−0.002***	−0.003***	−0.003***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
DENS (×1000)	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
INHAB_FAM	0.143***	0.150***	0.150***	0.150***
	(0.024)	(0.024)	(0.024)	(0.024)
AGE	−0.006***	−0.007***	−0.007***	−0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
EDUCATION (×10)	0.030***	−0.002	−0.002	−0.002
	(0.006)	(0.009)	(0.009)	(0.009)
HOUSE (×1000)		0.012	0.012	0.005
		(0.009)	(0.009)	(0.009)
WAGE (×1000)		0.011***	0.011***	0.011***
		(0.003)	(0.003)	(0.003)
POL_CONT			−0.009	−0.007
			(0.006)	(0.006)
TIA				0.054***
				(0.009)
DIST				−0.000
				(0.000)
Province dummy	Yes	Yes	Yes	Yes
Observations	1521	1521	1521	1521

Fractional logit estimates. Marginal effects and robust standard errors (in parentheses)
The dependent variable is the share of municipal recycling over total waste (RECYCLING)
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

DENS is the only demographic variable in our models that is not significantly correlated with the municipal share of waste recycling. This contradicts the theoretical expectations reported in section two.

Moving to the examination of the estimates calculated for the socio-economic covariates, an interesting first result is that EDUCATION is found to be positively correlated with waste recycling only when income (WAGE) is not considered. WAGE, instead, reveals a positive correlation with recycling and this result is highly statistically significant ($p < 0.01$) in all the specifications run. Two main considerations originate from these findings. First, education exerts its influence on people's attitudes towards taking care about waste recycling mainly by allowing them to obtain economic wellbeing which, in turn, triggers demand for environmentalism. Second, a higher income is not perceived as a higher opportunity cost of recycling. Instead, in the municipalities under investigation economic wellbeing incentivize post-material concerns such as environmental care.

Contrary to WAGE, HOUSE is not statistically significant in any of the specifications run. This suggests that waste recycling is not driven by incentives determined by cost of residences. Evidently, the hypothesis that the higher the cost of soil, the lower the use of it to build landfill and incinerator is not confirmed.

Turning our attention to the inspection of the results we obtained for the variables that measure the geographical characterization of the municipalities, the management of the waste collection service and the political context, three main results arise.

First, our estimates visibly highlight that geographic location of municipalities predicts waste recycling. Indeed, ALT turns out to be negatively correlated with waste recycling and this result is highly statistically significant ($p < 0.01$) in all the models considered. This finding is consistent with the idea that recycling might be not incentivized by those municipalities that experience high logistic costs because of altitude.

Second, mixed results are obtained for the two features of the local waste management system that are considered by our models. TIA is found to be positively associated with municipal waste recycling. In other words, these estimates strongly confirm the idea, provided by the literature (Mazzanti et al. 2012; Mazzanti and Montini 2014), that substituting a generic tax that finances waste management with a waste tariff connected with the actual amount of waste produced by the household, represents an incentive to increase separate collection (Mazzanti et al. 2012). Nevertheless, the cross sectional nature of the dataset investigated does not allow any causal interpretation of this result. Indeed, the TIA positive and statistically significant coefficient may originate from the unobserved stronger commitment for environmental issues by local governments and/or from unobserved stronger environmental concern shown by population. Still, our result suggest that the analysis of the link between TIA and waste recycling among municipalities in the Lombardy region deserves further study.

While TIA provides interesting results, we did not find any statistically significant finding for the variable DIST. This contradicts the hypothesis, presented in section three, that distance from disposal facilities creates an incentive for municipalities to promote recycling. According to our estimates, such effect does not find any support.

Finally, in all the models estimated a negative coefficient is found for POL_CON; this is consistent with the idea that political competition, which translates into government discontinuity, incentivizes waste recycling performances. Nevertheless, this variable does not turn out to be statistically significant at any conventional level and therefore also the existence of a link between political continuity and waste recycling is not supported by our estimates.

In order to check the robustness of the results provided so far, we tested their variation across subsamples of the dataset which were made up according to municipalities' size. In more detail, additional investigation was carried out by specifically focusing on small municipalities. One reason for focusing on small municipalities is that they represent an important feature of the Italian institutional framework (Oecd 2001) and of Lombardy one. Indeed, alongside Austria, Finland, Norway and Malta, in mid-1990s Italy was considered one of those countries in Europe that reported an absolute majority of municipalities with fewer than 5000 inhabitants (Martins 1995). These figures are confirmed by recent ones, according to which 58% of Italian municipalities have fewer than 3000 inhabitants and represent about 11% of the Italian population

(Oecd 2001). The spread of small municipalities is even more evident in Lombardy since our data reveal that 69.82% of the municipalities included in our sample report less than 5000 inhabitants.

A second reason for focusing on small municipalities is that they may experience serious problems in organizing waste management service, since they can exploit economies of scale more hardly.

In order to carry out this additional analysis, we started by defining small municipalities as those that report 5000 inhabitants or less (as we already mentioned, these municipalities are 1062, 69.82% of our original sample). This definition is consistent with the one provided by the Italian National Association of Italian Municipalities (ANCI 2011) and by one bill establishing forms of support and valorisation of Italian small municipalities' that was approved by the Italian national Parliament on the 18th of April 2007. Furthermore, given that the Italian electoral law (law number 215/2012) identifies special rules for municipalities reporting a population between 5000 and 15,000 inhabitants, we also focused our analyses on municipalities that belong to this specific class of population size (349 out of 1521 municipalities in Lombardy considered in this paper, 22.96% of our full sample).

Table 3 reports the results of regression analyses based on these two subsamples of municipalities. The first two columns show the estimates obtained when specifically looking at municipalities that have less than 5000 inhabitants. As in the case of Table 1, marginal effects are presented. Both regressions are based on one specification that includes the full set of covariates used in our previous analyses. In the third and in the fourth column of the table, instead, the empirical investigation is based on the subsample of municipalities of the Lombardy region whose population size is between 5000 and 15,000 inhabitants.

When comparing the results obtained by looking at small municipalities and those presented in Table 3, where the whole sample was investigated, four main differences are worth noting.

First, the effect of population size is positive and statistically significant when looking at <5000 municipalities while the opposite is reported when the sample is restricted to bigger but still small municipalities (5000–15,000) as well as when analysing the whole sample. This suggests that population size has a nonlinear effect on our dependent variable. One possible explication is that a sort of economies of scale do exist even for the municipal organization of recycling, but over a threshold of 5000 inhabitants the social cohesion effect prevails.

Second, the impact of DENS varies according to the size of municipalities under investigation and turns out to be statistically significant only when those with more than 5000 and less than 15,000 inhabitants are considered. The interpretation for this result from a theoretical point of view is hard and therefore needs further inspection

Third, altitude (ALT) shows a negative and statistically significant correlation with waste recycling when very small <5000 inhabitants municipalities are investigate while the same variable turns out to be not statistically significant in the subsample made up by bigger 5000–15,000 municipalities. This is consistent with the idea that waste management logistic costs determined by altitude are particularly onerous for very small municipalities and therefore recycling is less promoted in these contexts. In bigger municipalities, instead, this logistic costs are definitely more negligible and

Table 3 Correlates of municipal waste recycling in the Lombardy region (Italy)

	Municipalities with <5000 inhabitants	Municipalities with more than 5000 and less than 15,000 inhabitants
ALT (×1.000)	−0.143***	−0.032
	(0.022)	(0.066)
POPULATION (×1.000)	0.117***	−0.052**
	(0.039)	(0.025)
DENS (×1.000)	0.007	0.012**
	(0.007)	(0.005)
INHAB_FAM	0.109***	0.127*
	(0.027)	(0.071)
AGE	−0.004**	−0.009**
	(0.002)	(0.004)
EDUCATION (×10)	0.003	−0.010
	(0.009)	(0.018)
HOUSE (×1.000)	0.012	−0.015
	(0.012)	(0.019)
WAGE (×1.000)	0.009***	0.012**
	(0.003)	(0.005)
POL_CONT	−0.006	−0.010
	(0.007)	(0.011)
TIA	0.053***	0.059***
	(0.016)	(0.012)
DIST	−0.001*	0.001
	(0.000)	(0.001)
Province dummy	Yes	Yes
Observations R^2	1062	349

Subsamples made up by small <5000 inhabitants municipalities and by municipalities between 5000 and 15,000 inhabitants. Fractional logit estimates. Marginal effects and robust standard errors (in parentheses) The dependent variable is the share of municipal recycling over total waste (RECYCLING)
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

therefore altitude does not determine any specific incentive for waste companies to support waste disposal or, alternatively, waste recycling.

Finally, distance from the assigned facility (DIST) shows a negative correlation with our dependent variable when <5000 inhabitants are analysed while results for the subsample made up by bigger municipalities are in line with those obtained for the whole sample. While this result is barely statistically significant ($p < 0.1$) it is contrary to the expectations presented in section three; for this reason this finding deserves future analyses aimed at explaining it.

6 Conclusions

Lombardy is one of the most highly populated and richest regions in Europe. Its performance in waste recycling are below the targets suggested by the EU, although they are above those reported by most of the other Italian regions.

A high cross-municipality variability in waste recycling is observed within this region. Indeed, according to 2012 data, the municipal shares of recycled waste range from 6 to 87%. This paper investigated the possible sources of this heterogeneity by using cross-sectional data that cover almost the entire number of the municipalities existing in the region (n = 1522).

The empirical analysis allowed us to extensively investigate partial correlations between municipal waste recycling and a wide set of covariates. It provides evidence about connections between waste recycling and a number of municipality-level characteristics. As a matter of fact, our fractional logit estimates suggest that geographic (altitude), demographic (population size, household size, population age), socio-economic (income) variables are statistically significantly correlated with municipal waste recycling. Furthermore, also organizational features of waste management, such as the existence of tariff-based system, show a statistically significant correlation with recycling performances.

References

Abrate G., Ferraris M.: The environmental Kuznets curve in the municipal solid waste sector. HERMES working paper, n. 1 (2010)

ANCI: Atlante dei piccoli Comuni. Publication available at http://www.anci.it/Contenuti/Allegati/ATLANTE_PICCOLI_COMUNI.pdf. Last access on 15 Apr 2016 (2011)

Berglund, C.: The assessment of households' recycling costs: the role of personal motives. Ecolog. Econ. **56**(4), 560–569 (2006)

Buclet, N. (ed.): Municipal Waste Management in Europe: European Policy Between Harmonisation and Subsidiarity. Kluwer, Amsterdam (2002)

Buclet, N.: Municipal waste management in France. In: Buclet, N., Godard, O. (eds.) Municipal Waste Management in Europe: A Comparative Study in Building Regimes. Kluwer, Amsterdam (2000)

Callan, S.J., Thomas, J.M.: Analyzing demand for disposal and recycling services: a systems approach. East. Econ. J. **32**(2), 221–240 (2006)

Carroll, W.: The Costs and Performance of Residential Recycling Programs: Evidence from Wisconsin. Working paper series, University of Wisconsin (1997)

Curtis, J., Lyons, S., O'Callaghan-Platt, A.: Managing Household Waste in Ireland: Behavioural Parameters and Policy Options, ESRI working paper, 295 (2009)

Czajkowski, M., Hanley, N., Nyborg, K.: Social norms, morals and self-interest as determinants of pro-environment behaviours: the case of household recycling. Environ. Resour. Econ. (2015). doi:10.1007/s10640-015-9964-3

Daskalopoulos, E., Badr, O., Probert, S.D.: Economic and environmental evaluations of waste treatment and disposal technologies for municipal solid waste. Appl. Energy **58**(4), 209–255 (1997)

Dijkgraaf, E., Gradus, R.: Cost savings in unit based pricing of household waste: the case of the Netherlands. Resour. Energy Econ. **26**, 353–371 (2004)

Ercolano, S., Gaeta, G.L., Romano, O.: Environmental tax reform and individual preferences: an empirical analysis on European micro data. J. Behav. Exp. Econ. **51**, 1–11 (2014)

Feiock, R.C., West, J.P.: Testing competing explanations for policy adoption: municipal solid waste recycling programs. Polit Res Q **46**(2), 399–419 (1993)

Folz, D.H., Hazlett, J.M.: Public participation and recycling performance: explaining program success. Public Adm Rev **51**, 526–532 (1991)

Gamba, R., Oskamp, S.: Factors influencing community residents' participation in commingled curbside recycling programs. Environ. Behav. **26**, 587–612 (1994)
Hage, O., Söderholm, P.: An econometric analysis of regional differences in household waste collection: The case of plastic packaging waste in Sweden. Waste Manag. **28**(10), 1720–1731 (2006)
Hong, S., Adams, R.M., Love, H.A.: An economic analysis of household recycling of solid wastes: the case of Portland, Oregon. J. Environ. Econ. Manag. **25**(2), 136–146 (1993)
Huang, J.-C., Halstead, J.M., Saunders, S.B.: Managing municipal solid waste with unit-based pricing: policy effects and responsiveness to pricing. Land Econ. **87**(4), 645–660 (2011)
ISPRA: Rapporto Rifiuti Urbani. Edizione 2013, ISPRA, Rapporti n.176/2013, ISBN 978-88-448-0596-8 (2013)
ISTAT: Conti Economici territoriali 2011–2013, available at http://www.istat.it/it/files/2015/02/Conti_regionali-2013.pdf?title=Conti+economici+territoriali+-+09%2Ffeb%2F2015+-+Testo+integrale.pdf. Last access on 23 Mar 2016 (2015)
Jenkins, R., Martinez, S.A., Palmer, K., Podolsky, M.J.: The determinants of household recycling: a material-specific analysis of recycling program features and unit pricing.J. Environ. Econ. Manag. **45**, 294–318 (2003)
Kinnaman, T.C., Fullerton, D.: The Economics of Residential Solid Waste Management. NBER working paper 7326 (1999)
Knussen, C., Yule, F., MacKenzie, J., Wells, M.: An analysis of intentions to recycle household waste: the roles of past behaviour, perceived habit, and perceived lack of facilities. J. Environ. Psychol. **24**, 237–246 (2004)
Lavee, D., Khatib, M.: Benchmarking in municipal solid waste recycling. Waste Manag. **30**(11), 2204–2208 (2010)
Li, S.: Recycling behavior under China's social and economic transition, the case of metropolitan Wuhan. Environ. Behav. **35**(6), 784–801 (2003)
Martins, M.R.: Size of municipalities, efficiency, and citizen participation: a cross-European perspective. Environ. Plan. C Gov. Policy **13**(4), 441–458 (1995)
Massarutto, A.: Municipal waste management as a local utility: options for competition in an environmentally-regulated industry. Util Policy **15**, 9–19 (2007)
Mazzanti M., Montini A.: Waste management performances beyond the Italian north-south divide: spatial analyses of geographical, economic and institutional dimensions. In: Kinnaman C.T., Takeuchi K. (eds.) Handbook on Waste Management. Cheltenham, UK (2014)
Mazzanti, M., Montini, A., Nicolli, F.: Embedding landfill diversion in economic, geographical and policy settings. Regional and Provincial panel data evidence from Italy, Paper presented at the XX Conference of the Italian Society of Public Economics, Pavia (2008)
Mazzanti, M., Montini, A., Nicolli, F.: Embedding landfill diversion in economic, geographical and policy settings. Appl. Econ. **43**(24), 3299–3311 (2011)
Mazzanti, M., Nicolli, F., Biolcati Rinaldi D.: Multi-tasking in the waste realm. Theoretical and empirical insights on management and disposal performances. EuroEconomica **31**(5), 88–101 (2012)
Mazzanti, M., Zoboli, R.: Municipal waste Kuznets curves: evidence on socio-economic drivers and policy effectiveness from the EU. Environ. Resour. Econ. **44**(2), 203–230 (2009)
Michallet, B., Gaeta, G.L., Facchini, F.: Greening up or not? The determinants political parties' environmental concern: an empirical analysis based on European Data (1970–2008). MPRA paper (2015)
OECD: OECD Territorial Reviews OECD Territorial Reviews: Italy 2001, publication available at http://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-territorial-reviews-italy-2001_9789264193420-en. Last access on 20 Apr 2016 (2001)
Papke, L.E., Wooldridge, J.M.: Econometric Methods for Fractional Response Variables with an Application to 401 (K) Plan Participation Rates. J. Appl. Econom. **11**, 619–632 (1996)
Reggiani, C., Silvestri F.: Municipal waste collection: market competition and the EU policy. Nota di Lavoro 90.2015, Milan, Italy: Fondazione Eni Enrico Mattei (2015)
Rostirolla, P., Romano, O.: A multi-objective model for selecting treatment facilities in a regional special waste management plan. J. Appl. Sci. **11**, 671–678 (2011)
Schultz, P.W., Oskamp, S., Mainieri, T.: Who recycles and when? A review of personal and situational factors. J. Environ. Psychol. **15**, 105–121 (1995)
Sidique, S.F., Joshi, S.V., Lupi, F.: Factors influencing the rate of recycling: an analysis of Minnesota counties. Resour. Conserv. Recycl. **54**, 242–249 (2010)

Vining, J., Ebreo, A.: An evaluation of the public response to a community recycling education program. Soc Nat Resour **2**, 23–36 (1989)
Wilson, J.K., Damania, R.: Corruption, political competition and environmental policy. J. Environ. Econ. Manag. **49**(3), 516–535 (2005)