NOTA DI LAVORO

14.2015

Municipal Waste Selection and Disposal: Evidences from Lombardy

By **Francesco Silvestri,** University of Ferrara, Department of Economics and Management and eco&eco Ltd. Bologna (Italy)

Stefano Ghinoi, Alma Mater Studiorum University of Bologna, Department of Statistics (Italy)

Climate Change and Sustainable Development
Series Editor: Carlo Carraro

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Summary

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Keywords: Solid Waste, Waste Management, Fractional Logit Estimation, Regional Economics
JEL Classification: C21, L97, Q53, R11

Address for correspondence:
Francesco Silvestri
University of Ferrara
Department of Economics and Management
Via Voltapaletto 11
44121 Ferrara
Italy
E-mail: slnfnc1@unife.it, silvestri@eco-eco.it

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Abstract

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November 2014

*Corresponding Author, Via Voltapaletto 11 - 44121 Ferrara (Italy), slnfnc1@unife.it, silvestri@eco-eco.it

Introduction

In a previous work Silvestri (2014) claimed that the percentage of MW selected or diverted in an end-of-the-pipe facility is strictly related with market variables, namely the unit cost of diversion p and the unit revenue from selection $\tilde{p}$, and with the degree of openness of the diversion market.

In this paper, after a brief review on waste management estimation works (Section 1) we proceed estimating the correspondence of empirical data to the model used in the cited work.

For this aim, we elaborated a data base starting from the Waste Management Plan of Regional Government of Lombardy (Italy), published in 2012.

Besides of the accuracy and the topicality of published information, the choice of region Lombardy is motivated by other reasons: the size of observations (1.544 municipalities, the highest number for an Italian region), the relevance of the region for Italy (highest resident population, highest revenue per-capita), and the long-run practice in the MW management issue (fifth region in Italy for percentage of selected MW, one out of the seven able to fit the EU objective of 45% of selection by 2010, location for the most prominent multi-utility firm in Italy, one of the biggest in Europe). We considered a data base with 1.522 municipalities of Lombardy, dropping out 22 due to lack of relevant data (Section 2).

The estimation of the model developed in Silvestri (2014) gives some puzzling evidence. For this reason, we search for new factors to explain the main drivers for MW selection, finding new evidences and results (Section 3).

Before to proceed, a caveat is obliged: the discussion of the results frequently describes for stylistic reasons the effect of independent variables on a dependent variable. Indeed, given the cross-sectional nature of our data no exogenous variation is present that would allow a causal interpretation of our results, and our analysis has to be interpreted as the search for robust ceteris paribus correlations or statistical associations between variables.

1 Local Municipal Waste Management: a Review

Recent years have showed how household recycling and waste management are fundamental topics in environmental studies in Italy and all over the world. Literature focus is on firms, institutions and consumers behavior, assessing public policies effects on firms and consumers behavior. Many works using cost-benefit analysis to evaluate socioeconomic effects of incinerator or mechanical biological treatment (Marchettini *et alia,* 2007); some of the studies also look at NIMBY syndrome (Bottero and Ferretti, 2011); others are focused on the evaluation of the management process for waste disposal (Caruso *et alia*, 1993; Cherubini *et alia*, 2008).

We concentrate on socioeconomic factors and political factors that affect recycling rates in local communities, not only from an economic point of view. We do not want to assess local policy impacts, we want to test if there are other exogenous factors that may explain household recycling rates apart the cost paid by the municipality for the collection: at local level waste management activities are based on cost management and political orientation of local administrators (Kobus, 2003), cost minimization and maximum productivity are objectives of private and public collectors but ideological preferences are also important factors.

Sidique *et alia* (2010) classify the empirical studies on recycling and waste management into studies that utilize household level data and studies that utilize macro-level data such as a community or county-level data: we use cross-sectional data because we are interested in understanding local differences due to the presence of multiple waste disposal societies. Socioeconomic factors that affects recycling rates and solid waste disposal are unit pricing, disposal fee and per capita income (Jenkins, 1993; Medina, 1997; Sidique *et alia*, 2010; Saltzman *et alia*, 1993) include factors such as household's degree of ecological consciousness and the amount of time required to sort the recycla-

bles from waste. Curtis *et alia* (2009) use a panel data to identified the determinants of household waste generation and disposition in Ireland and find that the average size of households is negative for total waste production and positive for mixed waste quantity, but not statistically significant. Callan and Thomas (2006) find that household size and age are significant determinants of the demand for disposal service and education is a significant determinant of recycling. Oskamp *et alia* (1991), through interviews to a sample of randomly selected adults in a suburban city find that the most important factors affecting people's involvement in curbside recycling programs are demographic variables, attitudes and behavioural variables that pertained specifically to recycling.

Few studies have dealt with the political issues. Local government intervention can improve waste recycling through regulation, economic incentives and information programs, but policies are often driven by political orientation and election promises. Looking at the standard literature, Hage and Söderholm (2006) are among the first to analyze the role of the differing municipal waste management policies of of plastic packaging recycling in Sweden and the impact of environmental preferences. In particular, they find that a weight-based fee has a positive and statistically significant effect, even if it might have side-effects like incentive for illegal waste disposal. They also find that there is positive and statistically significant interaction between Green party support among households and the collection of plastic packaging, and a positive but not statistically significant representation of the Green party in the local government. Benito-López *et alia* (2011) consider as an exogenous factors of their model fot the evaluation of the efficiency of the street cleaning and refuse collection services in spanish municipalities the sign of the political party (conservative or progressive) in power in the municipalities and they find a positive value if municipalities are governed by progressive parties. Bornstein e Lanz (2008) show that willingness to contribute to public environmental goods reflect pre-existing ideological orientations.

The analysis in this paper want to add the above studies by using a cross-sectional data on recycling rates in Lombardy at the municipal level, analyzing interactions of socioeconomic and political variables. Instead of information on household recycling behaviour we collect county-level data on recycling rates, cost of total management and other variables and, through an econometric model, we want to explain the main drivers for MW selection.

2 The Data set

The data set is made of 1.522 observations (the number of municipalities) per two dependent variables (alternatively the quota of selected or unselected waste) and 17 independent variables: three of them belong to the "theoretical model" field and are used to estimate the fitting of the model we developed in Chapter 3; three of them belong to the structural (or physical/geographical) field; five are socio-economic variables; five are political. The following table describes each variable used in the estimations:

Field	Name	Description	Unit of measure	Year	Source
Dependent variable	*d*	Quota of total MW selected	Percentage	2012	Lombardy Regional Waste Management Plan
	q	Quota of total MW unselected (opposite to the previous)	Percentage	2012	Lombardy Regional Waste Management Plan
Theoretical model	*k*	Number of different MW categories collected	Absolute value (no. of units)	2012	Lombardy Regional Waste Management Plan
	p_{tot}	Cost of total management (collection, selection, diversion) per kilogram of MW	Index (€/kg)	2012	Lombardy Regional Waste Management Plan
	e	Turnout at 2013 national elections	Percentage	2013	Italian Ministry of Interior
Physical/ geographical	*dens*	Demographic density in the municipality	Index (Inhab/km$^{2)}$	2012	ISTAT + Municipal Registry offices
	height	Altitude above the sea level	Absolute value (m)	2001	ISTAT Italian Census
	dist	Linear distance between the municipality (Town Hall) and the municipality of the as-	Absolute value (km)	2014	Our calculation on Lombardy Regional Waste management

		signed disposal facility			Plan data
Socio-economic	*school*	Quota of graduated inhabitants out of 18 years old and more inhabitants	Percentage	2001	ISTAT Italian Census
	wage	Per capita wage of population	Average value (€ per capita)	2011	Italian Revenue Agency
	inhab_fam	Average number of people per household (total population over number of households)	Average value (no. of units)	2012	ISTAT + Municipal Registry offices
	age	Average age of inhabitants	Average value (years)	2012	ISTAT + Municipal Registry offices
	house	Average real estate value per square meter	Average value (€/m^2)	2012	Italian Territory Agency
Political	*gov_6*	Political affiliation of the Major in a scale 1-6: 1 = Lega Nord; 2 = PdL-Lega Nord; 3 = Civic list (Right); 4 = Civic List (Apolitical); 5 = Civic list (Left); 6 = PD and allies	Scale 1-6	2012	Italian Ministry of Interior
	gov_3	Political affiliation of the Major in a scale 1-3: 1 = Right; 2 = Civic List (Apolitical); 3 = Left	Scale 1-3	2012	Italian Ministry of Interior
	gov_2	Political affiliation of the Major in a scale 0-1: 0 = Civic list; 1 = Political alliance	Dummy 0-1	2012	Italian Ministry of Interior
	cont	Political continuity or discontinuity of the ruling Major with predecessor	Dummy 0-1	2012	Italian Ministry of Interior + research on local press
	tia	Enforcement of a waste tariff in place of a general tax	Dummy 0-1	2012	Lombardy Regional Waste Management Plan

Table 2.1 Description of variables in the data set

The previous list of variables claims for a further explication:

d and *q* are the standard dependent variables of the model introduced in Chapter 3; we express them in terms of percentage of the whole amount of MW generated and collected inside the municipality.

k, *p* and *e* are the independent variables of the mentioned model. We express *k* (an indicator of the size of the differentiated collection capacity provided by the Collector, see Par. 3.1) as the number of different MW categories collected in each municipality (such as organic, paper and cardboard, glass, plastic, iron, aluminium, wood, green, electrical/electronic devices, clothes and canvases, oils, and so on). The rationale of this choice is that any different category claims for a specific organization of the collection chain, and the higher the number of categories, the more sophisticated – and costly – the provision of equipments to deal with them.

p_{tot} is the cost of total management per kilogram of MW paid by the municipality, considering the whole MW chain (collection, selection, diversion in and end-of-the-pipe facility). This means that the proxy we use in the estimation integers both p and $\tilde{p}$, in a way that is impossible to disentangle.

e is the turnout at the National Elections of march 2013, the closest to the year of data survey in which all inhabitants of the whole group of municipalities have been simultaneously convened to vote. Since we can consider it an indicator of the social capital of the population, according to a wide literature on regional studies (D'Amato *et alia*, 2011), we use it as a proxy of the effort of local council in selection.

Apart from the variables introduced in the model, we consider a set of regressors of different kinds: physical, socio-economic, and political characteristics.

Among the physical variables, *dens* and *height* are standard items provided by the Italian national board of statistics (ISTAT), regarding respectively the demographic density (number of inhabitants over the area of the municipality) and the altitude over the sea level calculated in the place where the municipal Town Hall is located. A more sophisticated variable is *dist*, that is the linear distance from each municipality to the municipality where is located the disposal facility (landfill, incinerator or pre-treatment plant) associated to the initial municipality by the Lombardy Regional Waste management Plan. The rationale of employing this variable is straightforward: we want to study if the distance and the related travel costs to be borne to transport unselected MW to the assigned disposal facility are a motivation for higher rates of selection.

The disposal facilities considered to calculate this variable are the following (the linear distance is computed between the town halls of the two municipalities:

Facility	Municipality	Reference Area
Incinerator REA	Dalmine (BG)	Whole province of Bergamo + whole province of Sondrio
Incinerator Aprica A2A	Brescia (BS)	Whole province of Brescia
Pre-treatment plant Econord	Como (CO)	126 municipalities in province of Como
Landfill Econord	Mozzate (CO)	6 municipalities in province of Como
Incinerator AEM	Cremona (CR)	Whole province of Cremona
Incinerator Silea	Lecco (LC)	Whole province of Lecco
Pre-treatment Plant Belissolina	Montanaso Lombrado (LO)	Whole province of Lodi
Incinerator Prina Ltd	Trezzo sull'Adda (MI)	Whole province of Monza and Brianza
Incinerator AMSA	Milan (MI)	Whole province of Milan
Pre-treatment plant Mantova Ambiente	Ceresara (MN)	Whole province of Mantua
Incinerator Lomellina Energia	Parona (PV)	Whole province of Pavia
Incinerator ACCAM	Busto Arsizio (VA)	116 municipalities in the province of Varese
Landfill Econord	Gorla Maggiore (VA)	24 municipalities in province of Varese + 22 municipalities in province of Como

Table 2.2 List of disposing facilities and related reference area.
Source: Lombardy Regional Waste Management Plan, 2013

Among the socio-economic regressors, besides of standard indexes of education (*school*), economic well-being (*wage*), household size (*inhab_fam*), age (*age*), we computed the average real estate value per squared metre according to the National real estate register of Italian Territory Agency, a branch of Italian revenue and tax agency. We considered for all the municipalities the same category of values, namely the residential units of intermediate quality, labelled as "normal". The rationale is to verify if municipalities where the opportunity cost of establishing a diversion facility is higher because of higher real estate values, prefer to turn to MW selection.

Finally the political variables elicited are five. Three of them are different aggregations of an investigation on the political majority governing the municipality in 2012, the year of data collection; we considered a variable (*gov_6*) where the parties are catalogued in six classes: 1 = Lega Nord; 2 = PdL-Lega Nord alliance; 3 = Right-oriented Civic list; 4 = Apolitical Civic List; 5 = Left oriented Civic list; 6 = PD and allies. The same classification is given back in just three classes (*gov_3*), merging on one side the previous categories 1, 2, and 3, and on the other the previous categories 5 and 6, and obtaining in this way: 1-3: 1 = Right; 2 = Apolitical Civic List; 3 = Left. Finally (*gov_2*), we focus on the kind of the political support the local government, differentiating between civic lists of any kind (= 0), and political alliances of any kind (= 1).

Another regressor (*cont*) deals with the political continuity (=0) or discontinuity (= 1) of the executive body governing the municipality in 2012 with the previous one. Notice that for about 5% of observation it has been impossible to recover this kind of data[1]. The rationale for the last type of analysis is to understand if political orientation has an effect on the degree of MW selection operated in a municipality.

Finally, following Mazzanti *et alia* (2012) we consider as a political item the regressor *tia*, expressing the enforcement (= 1) of a specific MW tariff (the environmental hygiene tariff, *Tariffa Igiene Ambientale*), more related to the amount of MW produced by each household, in place of the general tax on waste management services (= 0)[2].

The data set is too wide to be inserted or annexed in this work and it is available on request.

[1] Starting from official data on local elections published by Italian Ministry of Interior, we developed the analysis on the political orientation of the winner of the elections and on the continuity/discontinuity of the ruling political movement analyzing websites, programmes of candidates, and local press.

[2] The TIA tariff is composed of two parts: a fixed part, which covers the fixed costs of waste management (such as costs of cleaning streets), and a variable part, which covers the variable costs of the service, such as costs of waste collection and disposal, based on four kinds of coefficients. The general waste tax (TARSU) is simply related to the size of household living space, not following any cost-recovery principle (Mazzanti *et alia*, 2012).

3 Estimation and Drivers of Waste Selection

3.1 Estimation of the Theoretical Model

We use the first set of variables to estimate some representations of the model illustrated in Silvestri (2014).

The first equation we are interested to analyse describes the mechanism to produced differentiated MW:

$$d = (ek)^{\frac{1}{2}} \qquad [1]$$

To have a more general result, in the evaluation we remove the condition of constant return of scale, estimating the equation in the version:

$$d = e^{\alpha} \times k^{\beta}$$

Because of the functional form of the equation, we run a log-log estimation with *d*, *e*, and *k* given by the observations described in Table 1.1:

$$\log\_d = \_cons + \alpha \log\_e + \beta \log\_k \qquad [2]$$

The outcome of the regression is the following:

Source	SS	df	MS
Model	103,0567	2	51,5284
Residual	132,6679	1519	0,08734
Total	235,7247	1521	0,15498

Number of obs	1522
F(2,1519)	589,98
Prob>F	0
R-squared	0,4372
AdjR-squared	0,4365
RootMSE	0,2955

log_d	**Coef.**	**Std.Err.**	**t**	**P>t**	**[95% Conf Interval]**	
log_e	0,7881	0,1295	6,09	0,00	0,5341	1,0421
log_k	0,7981	0,027	29,55	0,00	0,7451	0,8511
_cons	-2,5846	0,0856	-30,19	0,00	-2,7525	-2,4167

Table 3.1 Outcome of the regression [2]

In a framework where fitting of the model is satisfactory and the regressors significant, we obtain very close results for the parameters ($\alpha = 0{,}788$, $\beta = 0{,}798$, confirming the assumption that the effort made by households and the capital provided by the Collector play substantially the same fundamental role in producing MW selection.

On the other hand, we see that both parameters are a 57% higher than the assumed value of 0,5, and, what is more relevant, that the production function of selected MW shows increasing return of scale.

According to the previous equation the quota of MW selection depends on the exogenous variables *k* and *e*. The exercise developed in Silvestri (2014) allowed to endogenize the model, obtaining through backward induction a relation between *q* (complementary to *d*) and the market variables *p* and $\tilde{p}$; *q* can take alternatively similar but not identical functional forms in accordance with the degree of openness of the disposal market. We can write it down in a general form independent from the market regime as follows:

$$q = \alpha\left[1 - \frac{p^2}{8}(\tilde{p} - p)\right] \qquad [3]$$

A problem we have with independent variables is that the observed item do not permit to separate p from $\tilde{p}$, so that we use p_{tot} as a proxy of an integrated version of both prices.

As a consequence, the final functional form we consider to study the empirical compliance of the theoretical model is:

$$q = \alpha\left[1 - \frac{1}{8} p_{tot}^{\ \beta}\right] \qquad [4]$$

where α and β are the parameters to be estimated. The rationale is on one side to verify the degree of openness of the disposal market, intercepted by α, on the other to understand the functional relation between unselected MW and cost of disposing, given by β. The last question is particularly relevant, since the function described in [3] descends even from the assumption of constant return of scale of [1]. The fact that this assumption has been contradicted by the evidence of [2], showing increasing return of scale, suggests that with the quadratic form could not fit the real relation between the two variables.

To estimate [4] we run a non linear regression with selected initial points to run the interpolation of data set respectively at 0,5 and 1 for α, and at 2 for β.

The results of the estimation are interesting, but substantially disappointing:

Source	SS	df	MS
Model	340,4361	2	170,2181
Residual	42,1613	1520	0,0277
Total	382,5974	1522	0,2514

Number of obs	1522
R-squared	0,8898
AdjR-squared	0,8897
RootMSE	0,1665
Res. Dev.	-1139,066

q	**Coef.**	**Std.Err.**	**t**	**P>t**	**[95% Conf Interval]**	
/alfa	0,548	0,0263	20,86	0,000	0,4964	0,5995
/beta	- 0,0619	0,2022	- 0,31	0,759	-0,4585	0,3346

Table 3.2 Outcome of the regression [4]

As we can see, the model fits the data and the parameter α takes a value compatible with the research hypothesis of inclusion in the interval [0,5; 1]. More specifically, the final outcome gives back the picture of a Lombardy disposal market substantially closed to competition (0,55), where each disposal facility enjoys a condition of *de facto* monopoly.

But the values assumed by parameter β are non significant besides of counterintuitive, since they suggest a positive relation between cost of landfilling and demand for it.

The reasons of this non-compliance could be of different kinds: first of all, the fact that the item used as independent variable is not the price of the end-of-the-pipe disposing service, but the general cost borne by the Local Council to let the MW removed. Secondarily, the recalled increasing return of scale of [2], that influences the functional form of [4]. Finally, we have to consider the hypothesis that in the studied situation, namely the MW industry in Lombardy, other drivers different from the market values are more relevant to explain the real trends of selected and unselected MW: a set of items that range from physical to socio-economic to political variables.

3.2 The Empirical Model and the Check of Robustness

We regress the dependent variable d on the set of items described in Section 2. To do so, we need to treat together different variables expressed in terms of absolute values, percentages and indexes. The simplest model to develop this line of research is to use a linear semi-log model, where absolute values are raised to the power of the parameter and regressed in logarithmic form, while percentage values are multiplied by the parameter and regressed linearly. As a consequence, the functional form to be tested is:

$$d = dens^{\alpha} \times height^{\beta} \times dist^{\gamma} \times \delta school \times wage^{\phi} \times inhab^{\eta}\_fam \times age^{\lambda} \times house^{\mu} \quad [5]$$

with a regression function that becomes:

$$d = kost + \alpha \lg dens + \beta \lg height + \gamma \lg dist + \delta school + \phi \lg wage + \eta \lg inhab\_fam + \lambda \lg age + \mu \lg house \quad [6]$$

We consider the correlation of independent variables:

	dens	*height*	*dist*	*school*	*wage*	*inhab_fam*	*age*	*house*
dens	1,000							
height	- 0,0372	1,000						
dist	- 0,1849	0,3129	1,000					
school	0,1247	- 0,2714	- 0,1766	1,000				
wage	0,1385	- 0,2715	- 0,3281	0,7505	1,000			
inhab_fam	0,0508	- 0,3872	- 0,2457	- 0,0805	- 0,0555	1,000		
age	- 0,1247	0,2674	0,3432	- 0,0772	- 0,0768	- 0,6778	1,000	
house	0,1670	0,0965	- 0,1089	0,4294	0,4039	- 0,1362	-0,1011	1,000

Table 3.3 Correlation matrix of independent variables in [5]

Not surprisingly there is a strong positive correlation between *school* (an indicator of education) and *wage* (the per-capita income), and a negative correlation between *inhab_fam* (the average number of members per household) and *age* (a proxy of the elderly ratio), maybe reflecting the disappearing in Lombardy of patriarchal families and the fact that young people come out from the original family to establish a new household. Another remarkable association is between *house* (reflecting the cost of residential real estate) and the couple of variables *school* and *wage*; it is a correlation that surely descends from the common linking to the wealth of inhabitants, but that, being under 50%, suggests other relevant determinants for the variable *house*.

Testing equation [6] for misspecification, robustness and normality of residuals, we find out that it is intrinsically nonlinear. Using log-transformed independent variables to make the relationship linear, we still have problems with ordinary least-squares (OLS) regression because of the non-normality of the residuals and the presence of heteroschedasticity. To solve it, we addressed to the fractional logit model (Papke and Wooldridge, 1996), a quasi-likelihood estimation method for regression models with a fractional dependent variable: it is a generalized linear model (GLM) with a binomial distribution and a logit link function which models the dependent variable (in our case, *d*) as a function of covariates, estimated with a robust variance-covariance matrix of the estimators (VCE). After estimating fractional logit model we analyzed the average marginal effects, that provide a good approximation to the amount of change in *d* correlated with a one-unit change in covariates, finding almost the same values of OLS regressors.

Finally, equation [6] is enhanced with the introduction of the political variables (see Section 2), activated as dummy regressors, i.e. independent variables which take the value of either 1 (for one category of the factor) or 0 (for the other category). In our case, the political dummies are as follows.

gov_6_1: takes the value of 1 if the ruling party is Lega Nord, 0 otherwise;

gov_6_2: takes the value of 1 if the ruling party is Il Popolo della Libertà-Lega Nord coalition, 0 otherwise;

gov_6_3: takes the value of 1 if the ruling party is a centre-right oriented civic coalition, 0 otherwise;

gov_6_4: takes the value of 1 if the ruling party is an apolitical civic coalition, 0 otherwise;

gov_6_5: takes the value of 1 if the ruling party is a centre-left civic coalition, 0 otherwise;

gov_6_6: takes the value of 1 if the ruling party is a centre-left political coalition, 0 otherwise.

We run the regression dropping from estimation variable *gov 6_4*, i.e. relating all other dummies to it.

gov_3_1: takes the value of 1 if the ruling party is a centre-right oriented coalition, 0 otherwise (aggregating previous gov_6_1, gov_6_2, and gov_6_3);

gov_3_3: takes the value of 1 if the ruling party is a centre-left oriented coalition, 0 otherwise (aggregating previous gov_6_5 and gov_6_6)[3];

Again, we run the regression dropping from estimation variable *gov 6_4*, i.e. relating all other dummies to it.

gov_2_2: takes the value of 1 if the ruling party is a civic coalition of any political orientation, 0 otherwise (i.e. as the expression of a political parties coalition)

tia: takes the value of 1 if the municipality enforces a calculated tariff instead of levying a general tax to cover MW costs, 0 otherwise

cont: takes the value of 1 if the municipality government has the same political orientation of predecessor, 0 otherwise

3.3 The Results of the Empirical Analysis

The total results of the models are shown in Tab. 3.5 (OLS regression) and Tab. 3.6 (average marginal effect with Fractional Logit model for covariates in the two most complete model specifications), while Tab. 3.7 checks for the robustness of regressors. Both models are illustrate to underline the differences between each other.

Physical/geographical (*dens*, *height*, *dist*) and socio-economic variables (*school*, *wage*, *hinab_fam*, *age*, *house*) are all significant at 1% both with OLS and fractional logit estimation.

Considering the first group, it is remarkable the negative sign of the regressor *dist*, claiming that a higher distance from the assigned facility reduces the percentage of selection implemented by the municipality. This outcome is counter-intuitive with respect to expectations, since transportation is one of the most costly activities in MW management, with a direct influence on unit costs (Massarutto, 2007). Being far from the facility would have to suggest to reduce the quantity of MW to be addressed to disposal, saving in this way the transportation costs, and to increase automatically the quota of selection. One possible explication of this result is that some other variable stronger than distance drives the recourse to landfill and incinerators: This driver is the existence of property relations and vertical integration between Collectors and Disposers. We develop this intuition in next Par. 3.4.

Turning to the other two variables of the block, *dens* is positively correlated with the percentage of selection (the higher the demographic density of the municipality, the higher the implemented MW selection). This outcome fulfils literature (Mazzanti *et alia*, 2011) and expectations, since it is quite usual to have more successful MW selection schemes in urban downtowns and where population concentrates.

On the contrary, *height* is negatively correlated with *d*, suggesting that altimetry is a deterrent to MW selection, and the reason explication is quite similar to the previous: higher locations of the households mean a more complex organization of collection turns and higher transportation costs for collected materials with respect to single turns requested to remove unsorted MW.

The second subset of variables deals with socio-economic characters (*school*, *wage*, *hinab_fam*, *age*, *house*), and – with the exception of the education index *school*, they all emerge as quite relevant. Regressors are all significant, but with different signs; *school* and *wage* are positively correlated with *d*, suggesting that both the education and the income of population are drivers that boost the MW selection but, notwithstanding the high correlation between the two independent variables,

[3] The no. 3 political taxonomy would have been completed by the *gov_3_2* class, expressing the case when ruling party is an apolitical civic coalition. But it is easy to see that this group is the same of *gov_6_4*, so that we do not need a brand new variable to represent it.

we register a remarkable difference in the calculated marginal effects, almost unappreciable for *school* and more relevant for wage (see Tab. 3.6). The same positive correlation is shown with respect to *inhab_fam*, even though This final outcome could be affected by the fact that both MW selection and large families are more frequent in small-medium urban centres, rather than in more populated towns. In this sense, a causal interpretation of the results would be much more misleading than for other regressors.

Two members of this subset of inputs are negatively correlated with the dependent variable. The first one is the elderly average (*age*), reflecting the easy predictable evidence that, because of its complexity and the requested state of attention for it, MW selection is *no country for old men*. The second one is the value of residential real estate (*home*) and this outcome is counter-intuitive for at least two reasons: on one hand, because of its partial correlation with the variable *wage* (see Tab. 3.3), both meters of richness of a community; on the other, because where land is more precious it would be more efficient to allocate it to most profitable activities than the hosting of disposal facilities.

One possible explanation of this unexpected result is related with tourism. Tourism is an activity that on one side contributes to boost real property prices through the demand for second homes and vacant dwellings (Ruggieri, 2008) and that asks for higher amenity values conflicting with the establishment of landfills (Mazzanti *et alia*, 2011; Mazzanti *et alia* 2012); on the other, because of temporary stay at the destination, no participation in local social capital and difficulties in understanding the local MW collection organization, tourist places are less devoted to MW selection (Mc Kercher, 1993; Coggins, 1994; Lebersorger and Beigl, 2011; Mateu-Sbert *et alia*, 2013).

To verify this intuition, we use a new estimation variable (*tourism_ratio*) given by the number of tourist nights spent in 816 out of 1.522 municipality of Lombardy over the number of inhabitants[4], and we correlate it with the variable *home*. The result is the following:

	house	*tourism_ratio*
house	1,000	
tourism_ratio	0,341	1,000

Table 3.4 Correlation between real estate values and tourism ratio

The correlation value is 0,34 and positive. In addiction, four out of the top 10 municipalities for real estate value (Madesimo, Livigno, Bormio, and Sirmione) are in the top 10 even for tourism ratio (eight in the top 20). For this reason, we suggest that the regressor *house* is affected by the tourism dynamics and its influence on MW selection percentage is negative.

Finally, we consider the block of political variable, all expressed as dummies. The repartition of the political panorama in six positions gives just two significant regressors: the one associated to *gov_6_2* (municipal government of a centre-right coalition) and the one associated to *gov_6_5* (left-oriented civic coalition), both positively correlated to the independent variable.

This trend is confirmed by the three-class repartition (right-wing, apolitical civic coalition, left-wing), with both dummies *gov_3_1* and *gov_3_3* significant and with the same signs of the previous case. Finally, when the political orientation of the ruling group is mixed up, discriminating between civic (*gov_2_2*) and political coalition the regressor is not significant. From this analysis we can infer the implication that MW selection is a political issue, and – as we will see in last Section - that the left-wing orientation influences the decision of boosting it up.

The political nature of the decision to select MW is confirmed even by the continuity of government regressor (*cont*), that is negatively correlated with the dependent variable, even though non-

[4] Original data are extracted from Lombardy Region-Éupolis data base, and referred to 2013. Due to defence of privacy, the data base permits to extract values only for municipality with at least four accommodation structures. For this reason, we have data from 436 municipalities with more than 3 accommodation sites and from 430 municipalities with no accommodation and, as a consequence, no presence of tourists over the year.

significant[5]: increasing the percentage of MW selection is a measure that marks the difference from the previous municipal government, signalling a new political course with respect to the predecessors; but when this political difference do not exist (i.e. when there is political continuity), the attention for MW selection is negative, whatever the political orientation of the ruling coalition.

The last variable considered is *tia*, associated with the implementation of a waste tariff connected with the actual amount of waste produced by the household, in substitution of a generic tax to finance waste management. In the strategy of municipalities, the implementation of the tariff is an incentive to increase separate collection (Mazzanti *et alia*, 2012) and our estimation confirms this behaviour: as a matter of fact, we find the regressor *tia* both significant and positively associated to MW selection, with a marginal effect, calculated as the amount of change in the dependent variable generated by a one-unit change in covariates, of almost five percentage points (see Tab. 3.7).

	OLS			Fractional Logit		
Variables	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
log_dens	0,0194***	0,0192***	0,0196***	0,0813***	0,0801***	0,0820***
	(0,00319)	(0,00306)	(0,00309)	(0,0124)	(0,0117)	(0,0121)
log_height	-0,0235***	-0,0237***	-0,0269***	-0,0982***	-0,0987***	-0,112***
	(0,00462)	(0,00457)	(0,00445)	(0,0197)	(0,0194)	(0,0193)
log_dist	-0,0161***	-0,0158***	-0,0164***	-0,0644***	-0,0631***	-0,0654***
	(0,00584)	(0,00584)	(0,00573)	(0,0237)	(0,0237)	(0,0232)
school	0,00296***	0,00303***	0,00287***	0,0130***	0,0132***	0,0126***
	(0,000747)	(0,000744)	(0,000723)	(0,00370)	(0,00368)	(0,00354)
log_wage	0,0853***	0,0868***	0,0965***	0,354**	0,361***	0,399***
	(0,0259)	(0,0258)	(0,0245)	(0,137)	(0,137)	(0,128)
log_hinab_fam	0,464***	0,467***	0,473***	2,000***	2,013***	2,035***
	(0,0583)	(0,0581)	(0,0570)	(0,291)	(0,289)	(0,278)
log_age	-0,168**	-0,168**	-0,209***	-0,725**	-0,728**	-0,894***
	(0,0736)	(0,0734)	(0,0728)	(0,347)	(0,346)	(0,340)
log_house	-0,0826***	-0,0811***	-0,0661***	-0,342***	-0,336***	-0,276***
	(0,0146)	(0,0144)	(0,0139)	(0,0561)	(0,0556)	(0,0531)
gov_6_1	0,0139			0,0516		
	(0,0161)			(0,0593)		
gov_6_2	0,0373***			0,147***		
	(0,0127)			(0,0530)		
gov_6_3	0,0207*			0,0812		
	(0,0114)			(0,0502)		
gov_6_5	0,0475***			0,191***		
	(0,00943)			(0,0383)		
gov_6_6	0,0323			0,126*		
	(0,0279)			(0,0740)		
gov_3_1		0,0252***			0,0991**	
		(0,00919)			(0,0392)	
gov_3_3		0,0459***			0,185***	
		(0,00932)			(0,0376)	
gov_2_2			-0,00619			-0,0227
			(0,00930)			(0,0368)
tia	0,0438***	0,0443***	0,0504***	0,182***	0,184***	0,209***
	(0,00979)	(0,00977)	(0,00967)	(0,0391)	(0,0390)	(0,0384)
cont	-0,0115	-0,0125		-0,0479	-0,0518	
	(0,00787)	(0,00778)		(0,0328)	(0,0323)	
Constant	0,497	0,471	0,461	0,00477	-0,101	-0,137
	(0,400)	(0,399)	(0,391)	(1,992)	(1,986)	(1,921)
No. of obs	1.436	1.436	1.509	1.436	1.436	1.509
R-squared	0,398	0,397	0,386			

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

Table 3.5 Outcome of the OLS and of the Fractional Logit regressions on [6] with added dummies

[5] Notice that non-significance of the variable disappears when we run a quantile regression (Koenker and Bassett, 1978), a procedure that solves heteroschedasticity and nonlinearity and bootstrap to obtain robust regression coefficients, standard errors and confidence intervals of the OLS model.

Variable	Marginal effect	Std.Err.	z	P>|z|	[95% Conf Interval]	
log_dens	0,0202	0,0031	6,54	0,000	0,0141	0,0263
log_height	- 0,0245	0,0049	- 4,99	0,000	- 0,0341	- 0,0149
log_dist	- 0,0160	0,0059	- 2,71	0,007	- 0,0276	- 0,0044
school	0,0032	0,0009	3,51	0,000	0,0014	0,0050
log_wage	0,0881	0,0342	2,57	0,010	0,0210	0,1551
log_hinab_fam	0,4982	0,0726	6,87	0,000	0,3560	0,6405
log_age	- 0,1807	0,0865	- 2,09	0,037	- 0,3502	- 0,0112
log_house	- 0,0852	0,0140	- 6,09	0,000	- 0,1125	- 0,0578
gov_6_2 (*)	0,0365	0,0131	2,79	0,005	0,0109	0,0621
gov_6_5 (*)	0,0474	0,0945	5,02	0,000	0,0289	0,6592
tia (*)	0,0451	0,0096	4,69	0,000	0,0263	0,0640

Variable	Marginal effect	Std.Err.	z	P>|z|	[95% Conf Interval]	
log_dens	0,0200	0,0029	6,82	0,000	0,0142	0,0257
log_height	- 0,0246	0,0048	- 5,08	0,000	- 0,0341	- 0,0151
log_dist	- 0,0157	0,0059	- 2,66	0,008	- 0,0273	- 0,0042
school	0,0033	0,0009	3,60	0,000	0,0015	0,0051
log_wage	0,0898	0,0342	2,62	0,009	0,0227	0,1570
log_hinab_fam	0,5016	0,0722	6,95	0,000	0,3601	0,6431
log_age	- 0,1815	0,0861	- 2,11	0,035	- 0,3502	- 0,0127
log_house	- 0,0837	0,0139	- 6,04	0,000	- 0,1108	- 0,0565
gov_3_1 (*)	0,0247	0,0097	2,53	0,011	0,0056	0,0437
gov_3_3 (*)	0,0458	0,0093	4,93	0,000	0,0276	0,0641
tia (*)	0,0457	0,0096	4,76	0,000	0,0269	0,0645

(*) = Marginal effect for discrete change of dummy variable from 0 to 1

Table 3.6 Marginal effect of significant independent variables on d *according to model 1 (a) and 2 (b)*

Variable	Regressors with OLS	Marginal effect on *d* with Fraclog	Elasticity with OLS (absolute value)
log_dens	0,0194	0,0202	1,9%
log_height	-0,0235	- 0,0245	2,4%
log_dist	-0,0161	- 0,0160	1,6%
school	0,00296	0,0032	0,3%
log_wage	0,0853	0,0881	8,5%
log_hinab_fam	0,464	0,4982	46,4%
log_age	-0,168	- 0,1807	16,8%
log_house	-0,0826	- 0,0852	8,3%
gov_6_2	0,0373	0,0365	Non-computable
gov_6_5	0,0475	0,0474	Non-computable
gov_3_1	0,0252	0,0247	Non-computable
gov_3_3	0,0459	0,0458	Non-computable
tia	0,0438	0,0457	Non-computable

Table 3.7 Regression values and marginal effects of significant independent variables on d *according to model 1 and 2 and absolute value of elasticity for independent variables*

According to this analysis MW selection reacts particularly to the political and socio-economic variables, and less to structural (physical) ones: being ruled by a left-wing major means almost five percentage points in MW selection more than being ruled by an apolitical civic coalition, twice the increase registered with right-wing coalition. Almost the same result is observed when the municipality enforces a tariff on MW production instead of a general tax. Other very sensitive variables seem to be the average number of members of households and the mean age, whose elasticity are higher respectively than 46% and 16%, followed by "wealth" indicators, per capita income and real estate values, having substantially the same incidence (around 8,5% in terms of elasticity), even though opposite signs. Very interesting the irrelevance of the education in the issue: albeit its significance, the elasticity with respect to MW selection is lower than 1%; this is a quite surprising outcome when compared both with standard literature on the subject (Kinnaman and Fullerton, 1999; Berglund, 2006) and with the result observed in the estimation of [2], where MW selection is strongly associated with social capital.

Even though significant, structural variables seem to be low correlated with selected MW, being the elasticity of the three regressors attested around 2%.

3.4 The Relation among Collectors and Disposers: a Social Network Analysis

In previous pages we remarked the puzzling evidence of variable *dist*, according to which unselected MW increases for local councils more distant to the assigned facility. We postulate that this counter-intuitive result descends from the MW industry organization, with the majority of Collectors integrated or related because of common properties with Disposers.

The rationale is that the common property of both a facility and a collecting company pushes forward end-of-the-pipe disposing, as demonstrated in Par. 3.3.4 with respect to vertical integration. To verify if the assumption is correct, in this paragraph we use Social Network Analysis (SNA) to analyze the property linkages existing among the 13 facilities enlisted in Tab. 2.2 and the set of 24 Collectors serving at least 1% of total population in Lombardy. The following table show the companies considered in the SNA and acts as a key for Figure 3.1.

Code	Company	Service Provided in Lombardy	Collection Population Served (%)
1	AMSA Milano	Collection+Incineration	14,5%
2	Econord	Collection+Pre-treatment+Landfilling	10,9%
3	Aprica/A2A	Collection+Incineration	7,1%
4	Sangalli Giancarlo	Collection	4,6%
5	Aimeri Ambiente	Collection	4,6%
6	Mantova Ambiente	Collection+Pre-treatment	3,1%
7	San Germano	Collection	3,0%
8	Gelsia Ambiente	Collection	2,5%
9	COGEME Gestioni	Collection	2,3%
10	Ditta Colombo Biagio	Collection	1,9%
11	Area Sud Milano	Collection	1,8%
12	SCS Gestioni	Collection	1,8%
13	ASM Pavia	Collection	1,5%
14	SECAM	Collection	1,4%
15	AEMME Linea Ambiente	Collection	1,4%
16	Bergamelli	Collection	1,3%
17	SABB	Collection	1,3%
18	AGESP	Collection	1,2%
19	Masciadri Luigi & C.	Collection	1,0%
20	ASPEM	Collection	1,0%
21	Garda Uno SpA	Collection	1,0%
22	ASPEM Gestioni	Collection	1,0%
23	Casalasca Servizi	Collection	1,0%
24	REA Dalmine Spa	Incineration	
25	AEM	Incineration	
26	Silea SpA	Incineration	
27	Belissolina Srl	Pre-treatment	
28	Prima Srl	Incineration	
29	Lomellina Energia	Incineration	
30	ACCAM SpA	Incineration	

Table 3.8 List of MW Management Companies Considered in the SNA (Year 2012) and Key for Figure 3.1. Source: Lombardy Regional Waste Management Plan, 2013

The graph is visualized in Figure 1. The red spots identify the shareholders of each considered company; the green squares are companies operating in both upstream and downstream segments of the market, the blue squares are just collecting companies and the yellow ones are companies operating just in the disposal segment.

In four cases, the same company provides both collection and disposing. In addiction, we can see four more clusters linking together respectively four (no. 1, 3, 20, and 27), eight (no. 9, 12, 13, 15, 17, 22, 25, 29), two (no. 18, 30), and two (no. 6, 23) companies. Finally, the green circle links together two Collectors (no. 13 and 5) with a company (no. 26) that, besides of running an incinerator, is the regulator of collection in the province where they operate.

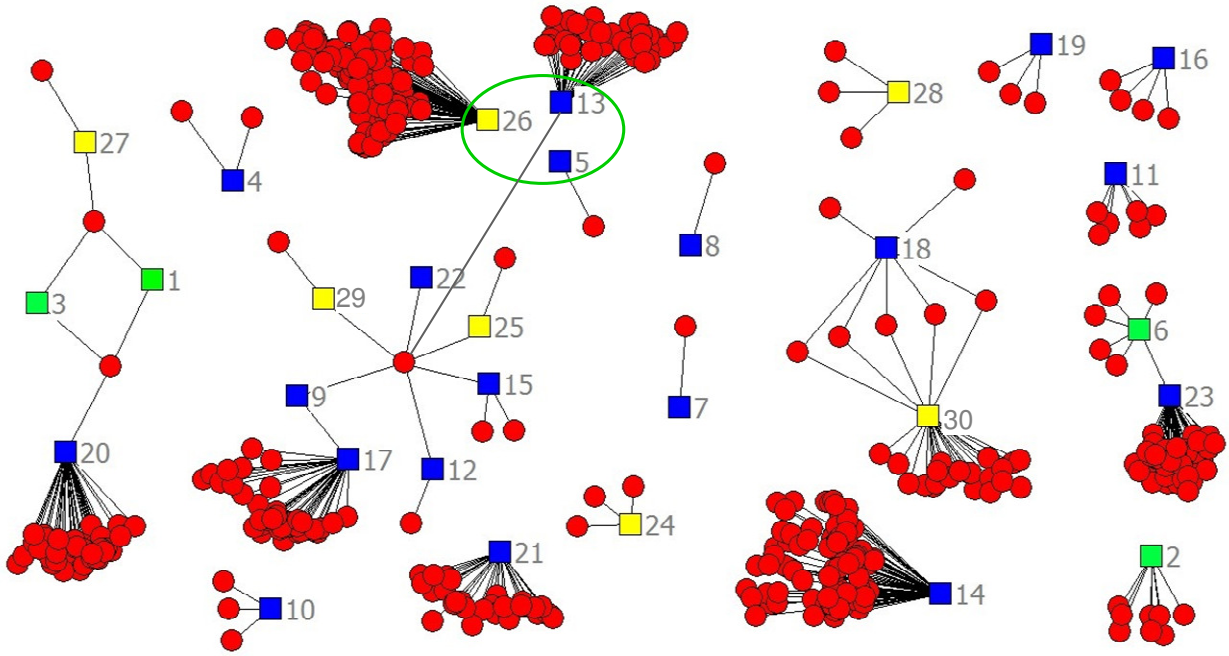

Figure 3.1 The SNA of the MW Industry in Lombardy

Even ignoring this last link, since not-based on property relations, they are 17 companies out of 30 with some kind of reciprocal integration and, what is more relevant, they gather 46,6% of the population served in Lombardy.

For this percentage of inhabitants there is a stronger commitment involving the providers of the collection service to dispose MW instead of select it[6].

Conclusions

In this paper we have gone inside the correlation between the quota of selected (and the complementary quota of unselected) MW and a set of variables of different kinds, using a data set with cross-section observations on 1.522 municipalities in Lombardy.

The starting point has been the estimation of the theoretical model developed in Silvestri (2014), reprised in the two general equations [2] and [4]. While the estimation of the first one, based on exogenous variables, complies with the hypothesis, the second one do not, and the correlation between the market variable represented by the unit total cost of MW management and unselected percentage of MW is non significant.

For this reason, according with literature we have looked for other independent variables of other kinds, finding new correlations that confirm the intuition of Ackerman (1997) on the role of non-market motivations in household recycling.

As a matter of fact, structural, socio-economic, and political variables show significant correlations with selected MW, even though with at least two counterintuitive evidence: the real estate value for residential, and the distance from the assigned disposal facility, both negatively correlated with the dependent variable. We explain the first negative association with the influence of tourism places, that push contextually real estate values and unselected MW; the second one with the incidence of interlinked MW management companies, providing the service of both collection and dis-

[6] In our analysis we apply to Collectors that serve at last 1% of the total population. This means considering just the first 24 companies, serving the 72,7% of the whole population of Lombardy. In this sense, the 46,6% computed takes even much more emphasis.

posing, and with a consequent interest in discouraging MW selection in favour of end-of-the-pipe solutions. Notice that this can be even an explication of the non-significance of the regressor of variable p_{tot} in equation [4], a reflection that deserves further explorations in future works.

The most interesting evidences are from the behaviour of political variables. Apart from the implementation of a specific tariff or a general tax, an issue that deals with environmental policies rather than political addressing, this kind of items are rarely used in the waste field, and with no conclusive evidence. Many contributions in the track of the so-called "convergence" school, according to which modern societies challenged by the same kind of problems use the same set of solutions, so that ideological differences have narrowed in last decades, claims that political differences do not matter to explain variations in policy outputs (Skinner, 1976; Thomas, 1980). Nonetheless, Feiock and West (1993), find out confirmations on the influence of party competition and interest groups activity on the percentage of household recycling, while Benito-López *et alia* (2011), argue that municipalities governed by progressive parties are more efficient in implementing MW management.

Our results claim that it does exist a positive and significant correlation between MW selection and the ruling of the municipality by a political-oriented coalition, and that when the government is left-winged the percentage of selection is higher than in the other cases. This interpretation would be confirmed by the evidence that interest in MW selection fades away when the ruling coalition has been confirmed in last elections, but this final observation is not supported by the results for the regressor *cont*, that are significant when we run a quantile regression of [6], but not with other estimation procedures (OLS or Fractional Logit).

Another political variable that shows a tangible correlation with *d* is *tia*, an outcome that confirms the interconnection between recycling and the enforcement of unit pricing tariffs enlightened by national surveys[7], and literature (Nestor and Podolsky, 1998; Kinnaman and Fullerton, 1999; Bilitewski, 2008; Le Bozec, 2008; Mazzanti *et alia*, 2012)

Among socio-economic variables, the real surprise is given by the education index, whose connection with the percentage of selection looks neglectable, while very relevant appear all the other regressors, from households size to per capita income, and real estate values. On the contrary, the elasticity of MW selection with respect to geographical variables is quite low.

Finally, in same cases the verse of causality between dependent and independent variables is ambiguous a priori, and confounding factors could influence the connection: this could be the case for distance from facility, probably affected by the kind of relationship existing between Collector and Disposer, and for real estate values, possibly pressured by tourism dynamics.

For this reason, we have to recall once again and finally that the whole analysis presented in this pages dealt with correlation between variables and not with the causality issue.

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[7] For a complete review see European Environmental Agency National Annual Reports on MW management.

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