

WASTE SUSTAINABILITY, ENVIRONMENTAL POLICY AND  
MAFIA RENTS: ANALYSING GEOGRAPHICAL AND  
ECONOMIC DIMENSIONS

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# Waste Sustainability, Environmental Policy and Mafia Rents: Analysing Geographical and economic dimensions

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## Abstract

Waste management / disposal performances and the delinking between income and waste trends are influenced by socio economic, institutional and policy factors. In highly regionalised settings many idiosyncratic factors of local interest influence waste management and disposal. The evolution of waste tariffs into cost recovery and market based instruments, and the occurrence of crime activities that exploit illegal / non market rents are key issues. Through the increase of policy enforcement costs, crime activities in an area and their geographical spillovers may negatively affect legal forms of waste management and disposal. Given its high regional heterogeneity and known plague of Mafia, Italy is a compelling case study for the analysis. In full consistence to a theoretical model that analyzes how legal disposal (landfill), illegal disposal and recyclable waste levels are influenced by waste tariff and crime — 1999-2008 panel based estimates on 103 Italian provinces show that separated collection and legal forms of waste disposal are lower when crime spills over its effects. Crime activities erode and slow down the enhancement of waste management and disposal brought about by socio economic, structural factors and by the introduction of newly crafted economic minded tariffs. Estimates also show that for separated collection the negative effect of crime comes even from outside the province, thus highlighting significant spatial phenomena.

Keywords: waste tariffs, crime, mafia, waste management and disposal, enforcement costs, recycling

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# 1. Introduction

The waste crisis that has driven waste policy in Italy since mid-nineties (D'Alisa, 2010) calls for a deep investigation of the drivers of waste production and management choices, as well as for a closer look at how environmental and waste related crimes affect such choices. Indeed, as suggested by Legambiente, the illegal waste business in Italy has tremendously enlarged over years, reaching a turnover of approximately 7 billion euros in 2009 (Legambiente, 2010), while millions tonnes of hazardous waste find yearly their way outside legal circuits.

Despite the relevance of waste crimes in the Italian waste management system, very few empirical studies have addressed the issue. We move a first step in filling this gap, by investigating, both theoretically and empirically, how accounting for waste related crimes and the presence of the mafia might affect policy and waste management choices, with a specific attention to recycling.

In the first part of the paper, we develop a simple model where an agent chooses the level of economic activity as well as the level of legal and illegal disposal of the consequent waste. The former can be done by separating waste or not; when sorting of waste materials does not take place then recycling is impossible and waste are either (legally) disposed of in landfills or just dumped illegally. When sorting takes place the material is instead recycled. Illegal disposal takes place at no cost, but generates social damages. Before choices concerning waste management have been taken an environmental regulator sets the enforcement effort to fight illegal disposal<sup>4</sup>.

We show that recycling is reduced by circumstances making illegal waste reduction more complex, while the presence of criminal organizations and of a pervasive illegal behavior bring about larger illegal dumping. On the other hand, a larger tax on legal disposal provides, as expected, stronger incentives towards recycling.

The empirical analysis is structured on a unique and rich panel dataset covering 103 Italian provinces over 1999-2008. Waste, economic, policy and social factors are merged together by using various official sources. The provincial level of analysis and the integration with municipal data allows great detail in the assessment of what lies behind north-south different performances, with a special attention to policy factors and crime-related issues. In addition to the socio-economic drivers of waste performance, the policy transition towards an incentive based tariff system is analyzed, in integration with the potential effect of negative influence on sustainability deriving from crime intensity in the province. Since data availability on

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<sup>4</sup>Though quite general, such a setting is coherent with the institutional framework in Italy

crime is limited, and the proxies generally used in literature - like number violent crimes - may generate misspecification errors due to their strong link with the level of enforcement, we exploit a unique datasets on municipal governments that were turned over by home ministry officials after it was judged guilty of mafia connections. The analysis will be realised through the use of Fixed effect model, in order to test if and in which context the implications of the theoretical model holds in the Italian scenario.

The theoretical model is based on two strands of literature. First of all, we connect to papers dealing with optimal waste policy in the presence of illegal disposal, in particular, to Sullivan (1987) and Fullerton and Kinnaman (1995). Specifically, Fullerton and Kinnaman conclude that the optimal fee structure is a deposit-refund system: a tax on all output plus a rebate on proper disposal through either recycling or garbage collection. In a more recent contribution, Choe and Fraser (1999) explicitly introduce monitoring cost into their model and identify the second-best optimal policy.

We also connect to the literature on the economics of (organized) crime. In particular, Grossman (1995) models organized crime as a competitor of the State in the provision of public services and shows that the existence of a mafia constrains the government's behavior. A similar tradeoff is likely to arise in waste disposal choices. On the other side, Almer and Goeschl (2010) study how public preferences regarding environmental quality and political economy variables may have an effect on environmental crime.

On the other side, the empirical analysis is based on the so called WKC framework (Mazzanti et al., 2009, 2010), even though the scope of the present analysis is significantly different to the WKC one. If from the one hand WKC studies aims at testing for the presence of delinking in the waste realm, where delinking refer to the relationship between economic growth and environmental pressure (See among other Stern 1998, 2004, Cole et al., 1997), in this context the focus is more on ex post policy effectiveness and the effect of organized crime on waste management choices at decentralized level. Nevertheless, the choice of socio-economic regressors and control variable has been strongly guide by that strand literature.

The paper is organized as follows: section 2 introduces the theoretical model and derives some testable implications, section 3 introduces the empirical analysis, presenting the data set and the methodology adopt, section 4 presents regression results and comments, while section 5 concludes.

## 2. The Model

We model the waste management choice by a regulated agent that performs an economic activity, that we label as  $y$ . Such economic activity generates waste, that can be managed in three ways:

- legally but in an undifferentiated way, making recycling impossible; we label the corresponding quantity as  $g$ ;
- legally and sorting the different kinds of materials in such a way to make recycling possible; we label the corresponding quantity as  $r$ ;
- illegally, for example by giving waste to illegal firms that just dump them in rivers, lands etc. We label the corresponding quantity as  $b$ .

Of course, waste must be disposed of in some way; in other words,  $y=g+b+r$ , i.e. consumption or production must generate an equal amount of waste. We assume that the level of economic activity is given. As a result, and coherently with the empirical model, illegal disposal is given by the total amount of waste *minus* legal differentiated and not differentiated disposal, i.e.  $b=y-g-r$ .

The agent chooses among the different available disposal options on the basis of the related costs and benefits. In particular, the agent is subject to enforcement through an expected fine, that we label as  $F$ , and also has to pay a tax on legal unsorted disposal, that we label as  $t$ . The choices in terms of legal and illegal disposal are accounted for by an environmental authority acting as a Stackelberg leader with respect to the economic agent, choosing the level of enforcement to be adopted to discourage illegal disposal. The waste tax is, instead, treated as an exogenous variable.

### 2.1 Solution of The Game

In the second stage of the game a representative economic agent performs waste management taking the expected fine as given. Private management costs are given by a function  $\gamma(g,r)$  which is strictly convex and increasing in its arguments, i.e.  $\gamma_g > 0$ ,  $\gamma_r > 0$ ,  $\gamma_{gg} > 0$  and  $|H| = \gamma_{gg}\gamma_{rr} - \gamma_{gr}^2 > 0$ , where  $|H|$  is the Hessian determinant. A somewhat stronger assumption is made here for the sake of realism: marginal cost for legal disposal of type  $i$  ( $i=g,r$ ) increases more rapidly with disposal  $i$  than with

disposal  $j$  ( $j=g,r$  and  $j \neq i$ ). In other words, we impose that  $\gamma_{gg} > \gamma_{gr}$  and  $\gamma_{rr} > \gamma_{gr}$ . As a result, the total costs related to waste management are given by:

$$C(g, b, r) = \gamma(g, r) + tg + (y - g - r)F \quad (1)$$

where, as already outlined,  $t$  is the tax rate on legal unsorted disposal and  $F$  is the unit expected fine for illegal disposal. The first order necessary and sufficient conditions defining legal unsorted disposal, legal sorted disposal are:

$$Y_g(g, r) + t - F = 0 \quad (2)$$

$$Y_r(g, r) - F = 0 \quad (3)$$

Some straightforward comparative statics imply:

$$g_t = -\frac{\gamma_{rr}}{|H|} < 0$$

that is, illegal disposal decreases with  $t$ , and

$$r_t = \frac{\gamma_{gr}}{|H|} \gtrless 0 \text{ if } \gamma_{gr} \gtrless 0$$

Note that sorted disposal might be encouraged or discouraged by the tax on legal unsorted disposal, depending on whether sorted or unsorted disposal are complements or substitutes in the agents' cost function. Also, note that separability (i.e.  $\gamma_{gr}=0$ ) would imply  $\frac{dr}{dt} = 0$ .

Turning to illegal disposal, it is easily shown that

$$b_t = -g_t - r_t = \frac{1}{|H|} (\gamma_{rr} - \gamma_{gr}) > 0$$

that is to say, an increase in the tax on legal unsorted disposal brings about, as expected, an increase in illegal disposal.

Turning to the impact of the expected fine, we can easily conclude that:

$$g_F = \frac{\gamma_{rr} - \gamma_{gr}}{|H|} > 0$$

$$r_F = \frac{\gamma_{gg} - \gamma_{gr}}{|H|} > 0$$

$$b_F = -g_F - r_F = \frac{1}{|H|} (2\gamma_{gr} - \gamma_{rr} - \gamma_{gg}) < 0$$

Note that both kinds of legal disposal increase with the unit expected fine, while the opposite holds with respect to illegal disposal.

In the first stage the environmental regulator chooses the enforcement level (as measured by the expected fine) to maximize social welfare; assuming that fines and taxes are net social transfers, as well as normalizing environmental damages from legal disposal to 0, the regulator's problem can be rewritten as

$$\min_F \gamma(g, r) + \delta(b) - \eta(r) + \theta F \quad (4)$$

subject to (1), (2) and (3), where  $\theta$  are unit enforcement costs,  $\delta(b)$  are social (increasing and convex, i.e.  $\delta_b > 0, \delta_{bb} > 0$ ) damages from illegal disposal while  $\eta(r)$  are (increasing and concave, i.e.  $\eta_r \geq 0, \eta_{rr} \leq 0$ ) social benefits from recycling. Assuming interior solutions, the first order conditions with respect to F imply:

$$(\gamma_g - \delta_b)g_F + (\gamma_r - \delta_b - \eta_r)r_F + \theta = 0$$

In order for the above FOCs to be sufficient, we also need (4) to be strictly convex, i.e.

$$(\gamma_{gg} - \delta_{bb})g_F^2 + (\gamma_{rr} - \delta_{bb} - \eta_{rr})r_F^2 > 0$$

From now on, in order to simplify comparative statics, and without loss of generality,  $y$  is normalized to 1. Some straightforward calculations imply:

$$F_\theta = -\frac{1}{(\gamma_{gg} - \delta_{bb})g_F^2 + (\gamma_{rr} - \delta_{bb} - \eta_{rr})r_F^2} < 0$$

and:

$$F_t = -\frac{(\gamma_{gg} + \delta_{bb})g_F g_t + (\gamma_{rr} + \delta_{bb} - \eta_{rr})r_F r_t}{(\gamma_{gg} + \delta_{bb})g_F^2 + (\gamma_{rr} + \delta_{bb} - \eta_{rr})r_F^2}$$

The relationship between the tax rate and the optimal enforcement level depends in a non-straightforward way on the second derivatives of the  $\gamma$  function as well as on the features of the damages from illegal disposal and the benefits from recycling. More specifically, we can have two cases:

1. when  $\gamma_{gr} < 0$ , then  $r_t < 0$ . We can therefore conclude that the optimal enforcement level, as measured by the expected fine, increases with the tax rate, i.e.  $F_t > 0$ .
2. when  $\gamma_{gr} > 0$ , then  $r_t > 0$  and matters are more complex, as the sign of  $\frac{dF}{dt}$  cannot be determined in general. In this second case,  $F_t > 0$  requires

$$\frac{g_F}{r_F} > -\frac{r_t (\gamma_{rr} + \delta_{bb} - \eta_{rr})}{g_t (\gamma_{gg} + \delta_{bb})}$$

Note that the above condition is more likely to be satisfied the more (less) reactive is unsorted (sorted) legal disposal to the tax rate, and the less concave the benefits from

recycling are. On the other hand, the degree of convexity of the social damages from illegal disposal has an ambiguous impact.

## 2.2 Testable Implications

We assume that the presence of organized crime and, more generally, a deeper presence of criminal activities in the waste cycle, generates an increase in unit enforcement costs, i.e. an increase in  $\theta$ . The consequences of such a change can be derived by summing up the results obtained in the preceding section. More specifically:

$$\frac{\partial g}{\partial \theta} = g_F F_\theta < 0$$

i.e. legal non-recyclable disposal decreases when the mafia enters the waste cycle, making enforcement more difficult.

$$\frac{\partial r}{\partial \theta} = r_F F_\theta < 0$$

i.e. legal recyclable disposal decreases when the mafia enters the waste cycle, making enforcement more difficult.

As a larger enforcement cost, for example due to the presence of criminal organizations, implies a smaller enforcement (as measured by a smaller unit expected fine), then legal disposal decreases both in terms of recyclable and non-recyclable waste, while illegal disposal increases.

Turning to the impact of changes in the waste charge/tariff:

$$\frac{\partial g}{\partial t} = g_t + g_F F_t$$

$$\frac{\partial r}{\partial t} = r_t + r_F F_t$$

From the preceding section, we can conclude that when  $g$  and  $r$  are cost substitutes, i.e.  $\gamma_{gr} < 0$ , then  $r_t < 0$  and  $F_t > 0$ . In such a case, no general sign can be derived for the impact of  $t$  on sorted and unsorted disposal. On the other hand, when  $g$  and  $r$  are cost complements, i.e.  $\gamma_{gr} > 0$ , so that  $r_t > 0$ , then either  $F_t < 0$ , so that  $\frac{dg}{dt} < 0$  while no a priori can be derived concerning  $\frac{dr}{dt}$ , or  $F_t > 0$ , so that  $\frac{dr}{dt} > 0$  while no general conclusion can be drawn on  $\frac{dg}{dt}$ .

The comparative statics results we aim at testing empirically in the following sections, as well as the expected signs, are summed up in table 1.

**Table 1**

Parameter	Variable	
	<b>g</b>	<b>r</b>
$\theta$	-	-
$t \begin{cases} \gamma_{gr} < 0 \\ \gamma_{gr} > 0 \text{ and } F_t < 0 \\ \gamma_{gr} > 0 \text{ and } F_t > 0 \end{cases}$	? - ?	? ? +

### 3. Data and empirical Model

The analysis uses the yearly editions of the ISPRA waste report (ISPRA, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009) as data sources. These reports provide a very rich set of waste management data, including data on MSW recycled and landfilled in all the Italian Provinces (n 103) and covers the period 1999–2008. We merge these data with official data on provincial level socio-economic drivers, like value added, population density and tourist related flows, a crucial factor in waste management issues for many Italian provinces. Waste performances differ widely among Italian provinces, making the provincial level of analysis the most indicated one. As we can see from the maps below, though northern Italy is rapidly evolving towards high level of recycling, the average figure for the country is still dominated by landfilling as news from southern areas, like Campania, have confirmed. Nevertheless, even some northern regions suffer from landfill criticalities given the increasing lands scarcity in physical and economic terms (opportunity costs) and the non-decreasing, at least stabilized, trend for waste generation. It is clear how an ‘average’ national picture is insignificant in providing clear evidence of real dynamics occurring at regional levels, and a decentralized analysis is needed.

The specification tested in the panel-based analysis is the following one:

$$\text{Log (waste)}_{it} = \alpha_i + \beta_1 \log(\text{economic driver})_{it} + \beta_2 \log(\text{socio-economic factors})_{it} + \beta_3(\text{environmental policy})_{it} + \beta_4(\text{crime variable}) + \epsilon_{it}$$

where the first term is an intercept parameter that vary across provinces, and  $\beta_1$  refer to the main economic driver (VA)<sup>5</sup>. Other socio-economic factors are added to the core specification as control variables, and possible additional significant drivers of waste generation. In our model, they include population density and tourist numbers. Population density may control for different land value in different country (we assume here that in more populated areas the opportunity cost of land is bigger), and for the presence of agglomeration and scale effect. For this reason we suppose it to be negatively correlated with landfilling, and positively correlated to recycling. Tourist flow, on the other side, controls for different choices made by tourism-oriented municipalities, in which the amenity value of landscapes may play an important role in waste management. For this reason we assume it to be positively related to landfill diversion. The third term ( $\beta_3$ ) refers to policy oriented proxies, i.e. the share of provincial municipalities and the provincial population covered by the new ‘waste tariff’ regime, which substitutes for the old ‘waste tax’ regime. With respect to the policy-related variables, the waste management tariff was introduced by Italian Law No. 22/1997, and substitutes for the former waste management tax. The tax, however, is still in force in many Italian municipalities because law 22/1997 provides for a transition phase that is quite gradual and slow. The tax was calculated on the size of household living spaces, while the tariff is based on principles of full-cost pricing for waste management services<sup>6</sup>. Effective implementation of the tariff system remains highly dependent on local policy decisions and practices and is partly based on the choices made by the municipalities. Early implementation of the new tariff-based system, therefore, may be a sign of policy commitment. We note that implementation is heterogeneous even across areas with similar incomes and similar socio-economic variables. The shift from tax to tariff should also capture the incentive effect of the latter, although the impact on waste generation, if any, may be not visible in the short term. The crime related variable, has been created thanks to an existing database collecting all these municipal governments that were turned over because judged guilty of mafia connections. A value equal to one in the “mafia” variable means that a municipal government inside the relative province has turned over in a given year. Moreover, the variable is discounted on yearly base, assuming a decreasing effect of mafia connections through time. In the analysis two different crime variable has been tested: a “narrow” one, in which only provinces with mafia connections are assigned

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<sup>5</sup> According to WKC literature, in our specification we generally tested also a squared Value Added term, in order to account for non-linearity.

<sup>6</sup> Part of the tariff covers fixed costs and part refers to the variable management costs. The former correlates to the size of household living space and, as a new element, to the number of people in the family. The variable part is associated with the (expected) amount of waste produced, which is calculated on the basis of past trends and location-related features. The variable part is abated by around 10–20% if households adopt domestic composting and/or join garden-waste door-to-door collection schemes.

a positive value, and a broad one, in which also neighbour provinces are assigned with a positive value, accounting for proximity and geographical spillover effects. Variables are summarized in table 2. Figures 1, 2 represent waste indicator trends through time and Figure 3 gives an illustration of Italian waste localization across provinces.

**Table 2**

<b>Acronym</b>	<b>Variable Description</b>	<b>Mean</b>	<b>Min</b>	<b>Max</b>
RECYCLING	Municipal Solid Waste yearly recycled (kg per capita)	115.5638	.0982274	378.3482
LAND-WASTE	Municipal Solid Waste yearly Landfilled (kg per capita)	318.4889	0	1898.466
VA	Provincial yearly value added per capita (base: Euro 2000)	18267.36	9386.468	30889.24
DENS	Population/surface (inhabitants/km2)	246.8535	31.16718	2646.92
TURIST	Annual tourist attendances (per capita)	7.225511	.3948027	58.83242
TARPOP	Share of population living in municipalities that introduced a waste tariff substituting the former waste tax (%)	13.50073	0	100
TARMUN	Share of municipalities that introduced a waste tariff substituting the former waste tax (%)	7.814796	0	100
CRIME <sub>narr</sub>	Presence of at least one municipality guilty of mafia connection inside the province.	.0786408	0	1
CRIME <sub>spill</sub>	Presence of at least one municipality guilty of mafia connection inside the province, or in a nearby province.	.1941748	0	1
SOC-CAP	Electoral Participation Share (At provincial Level)	82	57	90

Figure 1 – Waste trends, 1999-2008.

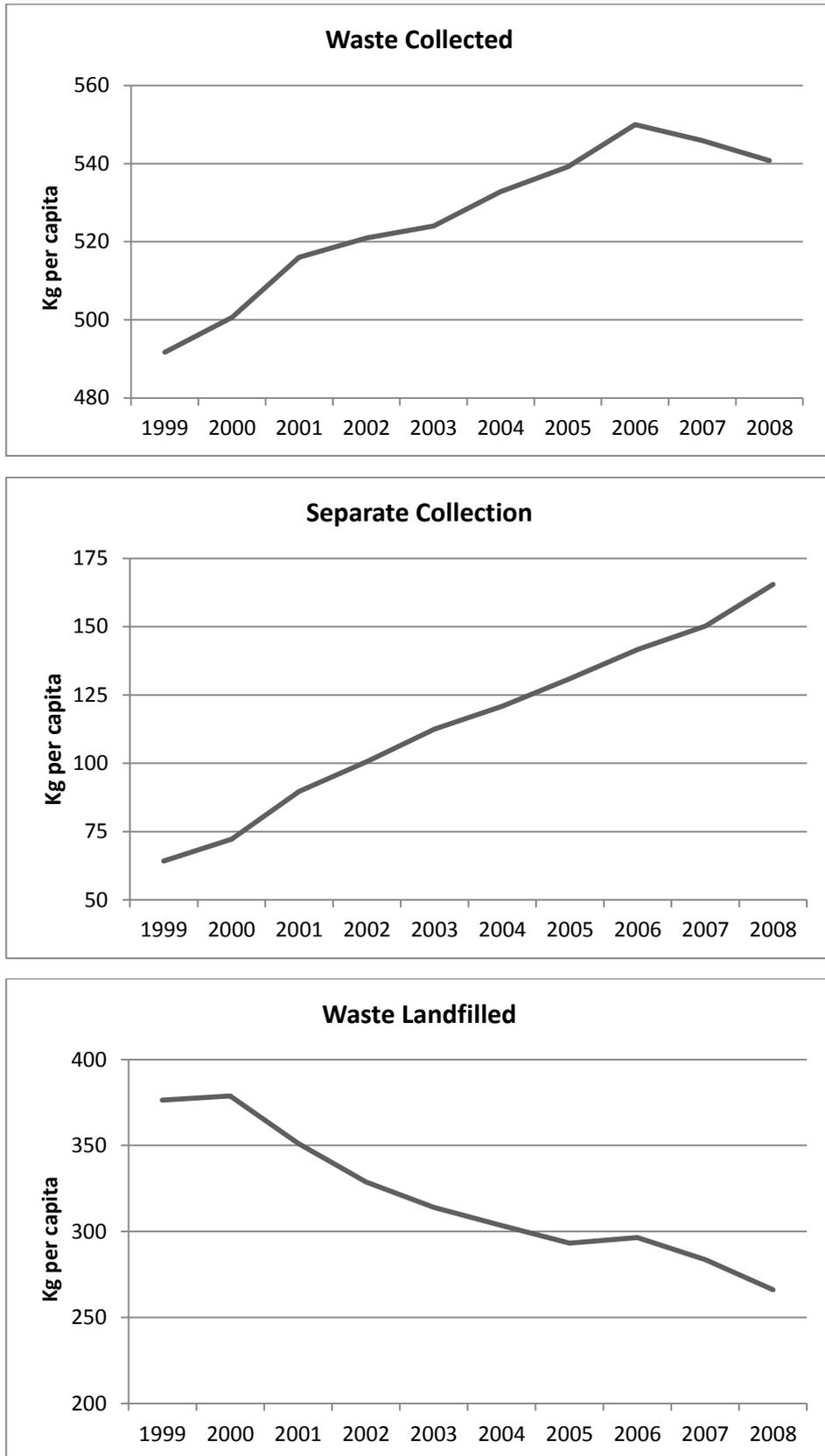


Figure 2 - Landfilled waste per capita (kg, 2008).



Figure 3 - Recycling per capita (kg, 2008).



## 4. Econometric results

We summarise main outcomes regarding the drivers of recycling (separately collected waste allocated to recycling and recovery options) and landfill diversion (legally non recyclable waste disposal). We refer to tables 3 and 4. Though analysing a rich array of determinants ranging from economic, structural, policy variables, we focus attention to the effects exerted by the diffusion of economic minded tariff instruments (aimed at full cost recovery and including elements of ‘pricing’ to affect environmental consumer behaviour) and by the diffusion of crime (with various assumptions on its geographical spillover). Outcomes now build up on fixed effect regressions.

### 4.1 Recycling / recovery

Consistently with previous analyses on waste generation (Mazzanti et al., 2008) and with the rare specific evidence on recycling (for the EU see Mazzanti and Zoboli, 2008), income is non linearly related to waste performances. The bell shape highlights that separated collection follows the waste generation dynamics and not an exponential one: income drives recycling, but exerts diminishing effects in the end. The turning point is estimated at reasonably high levels (around 24-25,000€ per capita of provincial value added). It is worth being investigated the effect of year 2008 (the first of the recession) on this path.

More interestingly, the opportunity costs related to incineration and landfilling, and economies of scale, appear to drive recycling performances up in a very consistent and robust way. Similar considerations are valid when including into the specification an additional covariate (TOURISM) that captures scale effects of waste generation and opportunity costs of eventual disposal without recovery. It is good news that on average the Italian performance seems placed on the right track, besides specific hot spots that could be scrutinised by regional or case study analysis (e.g. the well known case of Naples and Campania region, where high population density, but probably low economic opportunity costs of the land, has not brought about options other than landfilling and incineration).

Moving to the primary focus of the analysis, we also note how (both) variables that capture the diffusion of ‘cost recovery / market based incentives’ oriented tariffs positively affect separated collection. The economic size is somewhat marginal, but definitely significant. These results could signify that an intensification of the ‘market based’ properties of the tariff would be beneficial. It remains that this tariff is a strong sign of local commitment to addressing waste by

means of new and restyled tools. This is what the theoretical model was predicting: higher tariffs enhance recycling performances.

Opposite to this commitment, we analyze the effect of ‘crime related effects’ on the waste performances of provinces<sup>7</sup>. Also consistent with the theoretical prescriptions, where crime is higher and consequently enforcement costs are higher, recycling performances tend to be lower. The two crime related proxy we constructed are both significant, and show relevant economic and statistical robustness. The ‘narrower’ crime effect (columns 1-2 table 3) captured by CRIME<sub>narr</sub><sup>8</sup> is nevertheless less prominent. It statistically vanishes as long as TOURISM enters the regression. The ‘wide’ crime factor (in terms of geographical assumed spillover) is instead very significant from both statistical and economic points of view across specifications (columns 3-4). This is truly reasonable, considering that separate collection activities are often characterised by strong linkages between local authorities and waste utilities. The bad news is that waste performances are affected by what occurs in contiguous provinces. The spatial spillovers that characterise crime and specific Mafia networks negatively affect the waste recycling performance, that in itself depends on the good management of the waste filiere from vertical (waste hierarchy) and horizontal (waste chains, actors and sectors managing waste) integrated perspectives. This is an expected but very gloomy aspect of crime spatial effects. Crime networks spill over specific administrative and geographical jurisdictions.

Moreover, following Greene (2000), we run a modified Wald statistic test for groupwise heteroskedasticity for all the specifications presented. In this way we can test the hypothesis of homoscedasticity specific to each cross-sectional unit, i.e.  $\sigma_i^2 = \sigma$ , for  $i = 1, N_g$ , where  $N_g$  is the number of cross-sectional units. Considering that the test rejects the null hypothesis of homoscedasticity, column 3 and 4 in the table below present heteroskedasticity corrected estimation results, that completely confirm previous empirical evidence, except for the case of population density that shows now a lower level of significance.

On the other side, specification 5 provides another robustness check, that deal in this case with the potential presence of endogeneity that may arise in context like the present one in which the policy variable (TARPOP and/or TARMUN) may depend by recycling (i.e. the dependent variable). In such cases, the eventual presence of simultaneity may cause biased regression results. For this reason, in column 5 we adopt an instrumental variable approach, instrumenting the policy

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<sup>7</sup> The correlation between crime covariates and tariff diffusion is negative and quite significant, but under 0.25 value. Multicollinearity is not an issue.

<sup>8</sup> We recall that such crime dummies are time variant and assume a lag between the ‘event’ (crime is recognised) and the cause (crime presence). We assume that crime exerts its effects for the 3 years before the presence of crime is formally revealed by the State through judiciary system).

variable<sup>9</sup> with the provincial share of Electoral participation (SOC-CAP), considered as a proxy of local social capital. Following the literature on Social Capital and regulation (Among others, Ng & Wang, 93; Hettige et al. 96), we presume that SOC-CAP may be a valid instrument, expected to be correlated with the policy effort and exogenous to the main relationship. The regression results for the instrumental variables estimations are reported in column 7, and generally confirm previous results. Nevertheless, tests on the instruments used, reported in Table 3 cast doubt on the validity of this last estimation. In particular we conducted an Underidentification test (Hall et al., 2006), that rejects the null hypothesis that the equation is underidentified, a Weak identification test (Stock and Yogo, 2005), that does not reject the null hypothesis that instruments are weak, and the Sargan-Hansen Test, that once again rejects the null hypothesis, casting doubt on instruments validity. Moreover, we also conducted a Davidson Mackinnon (1993) test of Exogeneity that, not rejecting the null hypothesis seems to suggest that in this case, an ordinary least squares (OLS) estimator of the same equation would yield consistent estimates<sup>10</sup>. These last evidences, leave us with an open question, suggesting that more attention to this aspect needs to be paid in future analysis.

We conclude by noting that specifications that use as dependent variable the separated collection for specific materials (organic waste, glass, and plastic, not shown here) confirm the above results. The wider crime effects dominate from economic and statistical points of view. For glass only, an easy recyclable material, even the narrower crime factor is significant at 1%.

Moreover, as a robustness check, we run some more regressions using as dependent variable the single recycled materials (Plastic, Glass, Paper, Organic), that show very similar results to what we found for overall recycling, confirming as these trends are very homogeneous among different technologies and do not only characterize some single waste streams<sup>11</sup>.

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<sup>9</sup> In Table 3 we report only the regression results with TARPOP as instrumented policy variable for brevity.

<sup>10</sup> The same result is obtained by the Hausman test.

<sup>11</sup> These results are not shown for brevity reasons, and are possible given the highly disaggregated nature of the data provided by ISPRA.

**Table 3 - Separated collection of waste**

	1	2	3§	4§	5^
LVA	199***	194***	189***	184***	195.2***
LVA2	-9.92***	-9.67***	-9.41***	-9.17***	-9.7***
DENS	2.423***	3.304***	2.468	3.359*	1.04
TOURISM	1.046***	1.062***	1.036***	1.051***	.99***
TARIFFpop	0.006***		0.006***		.001*
TARIFFgeo		0.005***		0.004**	
CRIME <sub>narr</sub>	-0.093	-0.075			
CRIME <sub>spill</sub>			-0.288***	-0.285***	-.265***
Under identification					0.000
Weak Identification					13.06 <sup>12</sup>
Over identification					0.000
Davidson-MacKinnon					0.53
N	1030	1030	1030	1030	1030

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01; R2 and F statistics (not shown) present very good fit. §Corrected for heteroskedasticity. ^ IV-estimations results.

## 4.2 Landfiling

As already found in previous works (Mazzanti et al., 2010), economic value per se is not a significant driver of landfill diversion<sup>13</sup>. Table 4 shows relevant regressions taking as dependent variable ‘waste landfilled per capita’.

Already confirming previous evidence at various national and EU scale, but still very relevant to observe, population density is a striking force behind reduction of waste going to landfill. Economic and health related opportunity costs again explain this evidence, which is here affirming that a 1% increase in population density through urbanization leads to a 3% increase in landfill diversion. Again, this is valid on average with Naples as most famous possible outlier as far as this relationship is concerned. The effect of density is made robust by the economic and statistical significance effect of TOURISM. Summing up things, then, where opportunity costs and potential economies of scale driven by density of populations and inflows of tourists are higher, separated collection is higher and landfilled waste lower. This

<sup>12</sup> 10% critical value 16.38.

<sup>13</sup> For this reason LVA and LV2 coefficients are not included in Table 4.

certainly is the primary pre condition for recycling and recovery options. The effect of tariffs, in line with previous evidence (Mazzanti et al., 2009, 2010), is negative as expected, and the waste driving forces related to crime present very robust messages. Though only in the case of CRIME<sub>narr</sub> (crime activities revealed within provincial boundaries, not affected by extra province crime spillovers), the likelihood that the structural presence of Mafia networks increases landfill diversion is strong (columns 1 and 2). This is not good news in the end. As the theoretical model prescribes, it is also true that crime related activities increase illegal disposal. In the absence of official and valid data on illegal waste disposal, this is an untestable hypothesis on a direct way. However, we can affirm that crime activities specifically located in the province reduce both separated collection and legal forms of landfilling. The latter evidence might be a positive news, but in face of increasing waste generation and absence of incinerators in the areas mostly affect by Mafia, we end up with the theoretically postulated positive relationship between higher enforcement costs, crime activities on the one hand and higher illegal disposal on the other hand<sup>14</sup>. As in the recycling case, The main regression results are influenced by the presence of Heteroskedasticity, as shown by test results not presented in the following table for brevity. For this reason, Column 3 and 4, present regression results obtained with a robust estimator<sup>15</sup>. Moreover, also in this case the policy variable can be simultaneous to the dependent variable; it is plausible to think that policy effort is more stringent where waste management is more complicated. It might be for example that provinces with higher share of waste to landfill may have imposed in the last ten years more stringent waste regulations in order to fill the gap with more efficient provinces. For this reason, in column 5 we instrumented the policy variable with both the social capital measure and with Value added. Also in this case IV results confirm Fixed effect results, but now, instruments perform much better than in the previous case. The identification test reported in the table below in fact do not cast any doubt about instrument validity. Nevertheless, also in this case, Davidson and MacKinnon test do not reject the null hypothesis which states that an OLS estimator would produce consistent estimates<sup>16</sup>.

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<sup>14</sup> We highlight that the presence of crime positively correlates with southern provinces, and negatively correlates to the presence of incinerators. Population density is not correlated with crime at all.

<sup>15</sup> In this case, following test results, we only corrected for heteroskedasticity and not for intra-group correlation like in the separate collection case.

<sup>16</sup> Also the Hausman test, not shown for brevity, confirms this result.

**Table 4 – Legal disposal of waste**

	1	2	3§	4§	5^
DENS	-2.86***	-2.73***	-3.07***	-2.91***	-.331
TOURISM	-.746***	-.731***	-.079***	-.077***	-.667***
TARIFFpop	-.003**		-.002**		-.011**
TARIFFgeo		-.006***		-.006***	
CRIME <sub>narr</sub>			-.404**	-.428**	-.392***
CRIME <sub>spill</sub>	-.05	-.08			
Under identification					0.000
Weak Identification					28.2 <sup>17</sup>
Over identification					0.796
Davidson-MacKinnon					0.328
N <sup>18</sup>	930	930	930	930	930

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01; R2 and F statistics (not shown) present very good fit. §Corrected for heteroskedasticity. ^ IV-estimations results.

## 5. Conclusions

We theoretically and empirically analysed how waste management and disposal performances are influenced by economic, policy and crime related factors. This is relevant for the assessment and understanding of the delinking between income and waste trends, especially in highly regionalised settings where many idiosyncratic factors of local interest influence waste management and disposal. The analysis of the extent to which crime (mafia) influences waste performances at local level is an unexplored issue in the economics of waste literature, notwithstanding its hot current relevancy in countries such as Italy. In those decentralised and regionalised settings many socio economic, policy, institutional factors contribute to the final waste performance outcome. Two are of primary relevance, the evolution of waste tariffs into cost recovery and market based instruments, and the occurrence of crime activities that exploit illegal / non market rents. We analyse crime effects in a theoretical model, assuming that enforcement costs are positively related to crime. We develop a model where an agent chooses the level of economic activity as well as the level of legal landfilling, recycling and illegal dumping. Illegal disposal takes place at no cost, but generates social damages. Before choices concerning disposal have been taken an environmental regulator sets the enforcement effort towards illegal disposal. We show that both recycling and legal disposal (landfilling) is reduced by an increase in enforcement costs. Thus, the presence of criminal organizations brings about larger illegal dumping. When cost recovery tax/tariffs are

<sup>17</sup> 10% critical value is 18.

<sup>18</sup> N is lower than 1030 due to 4 provinces that do not present landfills and other that closed down sites during the observed period. Two stage procedures may be implemented to deal with zero values. The number of 0 is nevertheless limited; previous works showed that results were not affected.

taken as exogenous, their influence is positive on the level of recycling and negative on legal disposal.

Overall, then, we may empirically test the hypothesis that crime activities in an area and their geographical spillovers may negatively affect legal forms of waste management and disposal. Given its high regional heterogeneity and known plague of Mafia, Italy is a compelling case study for the analysis. Italy has also experienced a slow transition towards a system of cost recovery and market based tariffs. Both factors present high cross section and time variability. We merge waste, economic and crime (mafia) datasets deriving from the ministry of environment and from the Home office. In order to reduce intrinsic endogeneity of crime data, we exploit the Home office dataset of municipality officially plagued by Mafia according to judiciary intervention. We end up with a 1999-2008 panel based estimates on 103 Italian provinces on the basis of which we study the drivers of separated collection of waste and of landfilled waste.

In full consistence to the theoretical model legal disposal and recyclable waste levels are significantly influenced by waste tariff and crime. We specifically show that separated collection and legal forms of waste disposal are lower when crime exerts its effects. Given the increasing waste generation and the absence of incineration in zones where Mafia is more locally diffused, it is also indirectly demonstrated that crime activities and slow implementation of market based instruments positively relates to higher levels of illegal disposal in landfills. Thus, crime activities erode and slow down the enhancement of waste management and disposal brought about by socio economic, structural factors and by the introduction of newly crafted economic minded tariffs. Estimates also show that for separated collection the negative effect of crime comes even from outside the province, thus highlighting significant spatial phenomena and negative spill over of crime that are imported. This is reasonable given the strong networking nature of crime activities and the possibility that they spoil 'waste infrastructure' and filiere that are also necessarily characterised by horizontal and vertical types of production chain and by local networking between contiguous provinces. Further insights will be provided by fully addressing spatial issues and by tackling the potential endogeneity of tariffs and crime factors.

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