WASTE SUSTAINABILITY AND CRIME IN DECENTRALIZED ENVIRONMENTS.

ILLEGAL DISPOSAL, TERRITORIAL ENFORCEMENT AND LOCAL POLICY

Abstract

This paper investigates if and how illegal disposal (waste-related crimes) is affected by waste tariffs that capture the decentralized policy commitment of the local government, and by enforcement policies on the part of the forestry corps. On the basis of a panel dataset at the provincial level that originally integrates waste, economic, policy and enforcement data, our empirical analysis presents three major insights: first, the hypothesis that a more diffuse waste management policy increases illegal disposal cannot be rejected; second, a non-linear bell shaped relationship exists between enforcement and illegal disposal, namely waste crimes tend to increase as enforcement becomes stricter--the effect is negative only after a (relatively high) level of controls is implemented. Finally, by focusing on northern and southern areas of Italy separately, we show that results are also driven by geographical factors. This evidence generally contrasts previous results; the implication for policy is that territorial controls in the Italian waste sector on average have not reached a critical level, supporting the existence of a deterrence effect. Only few areas are characterized by a significant deterrence effect caused by enforcement activity, which is highly needed as a second tool in the 'waste policy mix' to compensate for the illegal disposal that is 'generated' as a side-effect of waste policy.

JEL: Q53, K42, D73.

Keywords: waste management, illegal disposal, forestry corps, enforcement, regional settings, waste tariffs, ecological-economic data.

1. Introduction

Waste is one of the most problematic challenges to sustainability. Though various improvements have occurred in waste management and disposal over the recent decades in most advanced countries, an effective absolute delinking between waste generation and economic growth/consumption has not been achieved for all relevant streams of waste, from urban waste to packaging to construction and demolition waste (Shinkuma and Managi, 2011; Mazzanti and Montini, 2009; Mazzanti and Zoboli, 2009; Mazzanti and Nicolli, 2011; EEA, 2009). In addition, average national figures often hide rather heterogeneous regional performances (D'Amato et al., 2013) that might characterize 'hot spots', that is to say, failure of the economic, institutional and technological systems in finding a proper waste management and disposal equilibrium (Mazzanti and Montini, 2013; D'Alisa et al., 2010). Starting from seminal papers that outlined the general theoretical considerations on waste disposal issues (Pearce and Brisson, 1995), these observations have stimulated recent research on the 'regional features' of waste performance, especially in those economic systems that witness high levels of policy decentralization. Among others, we note that key works have concentrated on waste generation and disposal drivers, focusing on the analysis of regional frameworks in the EU and other OECD countries (Hage and Soderholm, 2008; De Jaeger and Eyckmans, 2008, Dijkgraaf and Gradus, 2009; Yamamoto et al. 2011) and, more in general, on the determinants of waste performances at EU (Mazzanti and Zoboli, 2009, EEA, 2009) and OECD levels (Johnstone and Labonne, 2004). Very recent works have emphasised that waste management systems and performance develop 'by clustering' (i.e. regions and provinces agglomerate within a given country), leading to virtuous high performance in some cases and to critical hot spots in others. Policy choices, social capital and crime are the main factors behind such divergences and agglomerations (Mazzanti and Montini, 2013).

An important role in determining the emergence of a 'waste crisis'--that is, idiosyncratic hot spots in a circumscribed territory--is played by illegal practices of waste disposal and trafficking, an overwhelmingly lucrative phenomenon mainly managed by criminal organizations. As indicated by UNEP and the Green Customs Initiative, "national and international crime syndicates worldwide earn an estimated US$ 20–30 billion dollars annually from hazardous waste dumping, smuggling proscribed hazardous materials, and exploiting and trafficking protected natural resources" (http://www.greencustoms.org/background/).

The illegal waste business has grown significantly especially in Italy (Pasotti, 2010), reaching a turnover of approximately 7 billion Euros in 2009 (Legambiente, 2010), while 20,000 tonnes of hazardous waste simply disappear every year, either dumped (on the land or in the sea) or illegally exported to other countries. Despite the complex legal and institutional framework implemented and enforced by the Italian government, several critical "hot spots" still persist, casting some doubt on the effectiveness of the deterrence effect of criminal sanctions.

The magnitude of illegal waste activity in Italy as well as the harm it causes to human well-being and the environment suggest the need to empirically investigate the determinants of waste crime and the effectiveness of enforcement in this area. Italy is a compelling case study given its high heterogeneity in terms of economic, environmental (Costantini et al., 2013; Mazzanti et al., 2008, 2012) and social capital characteristics (see Figures 1-3 as illustrative for the main waste performances: waste generation, separated collection, landfilled waste), as well as for the well-known role of crime.

(Figures 1-3 here)

The illegal disposal of waste is in fact determined by a variegated set of economic, institutional and policy factors: Among others, the development of the region; its institutional 'quality', which relates to factors such as social capital, policy commitment; and also the presence of organized crime willing to obtain profit off of illegal markets. These factors present strong idiosyncratic features that shape each territory in a specific manner. They all contribute to determining the quantitative and qualitative impacts of waste disposal along economic and ecological contents. It is therefore highly relevant to investigate local characteristics in order to analyze the drivers behind illegal disposal.

Several studies in the literature empirically test the impact of enforcement policies on the degree of compliance with environmental policy. Among others, Gray and Deily (1996) focus on air pollution from the steel industry in the US during the 1976-1989 period, concluding that enforcement actions significantly affect the degree of firms' compliance. Similar results are obtained in subsequent works by Deily and Gray (2007), focused on the same industry and period, and Gray and Shadbegian (2005), where pulp and paper mills in the 1979–1990 period are scrutinized in order to assess air pollution compliance responses to the EPA and state law enforcement actions. Other works devoted to the US addressing water pollution (Magat and Viscusi, 1990; Shimshack and Ward, 2005 and 2008) and toxic waste disposal (Alberini and Austin, 2002; Sigman, 2009) find evidence in support of a deterrence effect.

Most of the existing studies, then, focus on the effectiveness of environmental regulations in the US, with very few exceptions devoted to other countries. This is an important shortcoming in the literature, as differences among countries might significantly affect the impact of enforcement (Gray and Shimshack, 2011). Exceptions cover Canadian pulp and paper industry (Doonan, Lanoie, and LaPlante, 2005), manufacturing facilities in China (Dasgupta et al., 2001) and criminal enforcement in Germany (Almer and Goeschl, 2010a and 2010b, the latter focusing in particular, as does the present paper, on the impact of enforcement on waste crimes, also including political economy variables).

Our contribution draws on this still substantially underdeveloped current of literature. We aim at analyzing the deterrence effect of enforcement efforts with specific reference to the illegal disposal of waste in Italy. The Italian case appears to be particularly relevant, due to the extent of illegal practices in waste management and the influential role performed by Mafia-type organizations. The study is further justified by the availability of an original panel dataset based on two merged sources: data provided by the ISPRA (the environmental agency) on waste management performances and policy; and the dataset constructed by the Forestry Guard, the public entity that manages territorial control over illegal waste disposal[1]. We derive from the former data on waste management efforts made by provinces and from the latter relevant information on enforcement and various types of illegal disposal. This dataset allows us to test some hypotheses related to the potential relationships between waste crimes, waste policy and enforcement efforts.

The paper is structured as follows. Section 2 presents the main research hypotheses. Section 3 presents data and the empirical model. Section 4 comments on the main econometric evidence. Section 5 concludes.

[1] The Forestry Guard is a corps falling under the jurisdiction of the Ministry of Agriculture, divided regionally.

2. Theoretical background and research hypotheses

Under a theoretical point of view, our paper mainly links to the literature on public law enforcement, starting from the seminal contributions by Becker (1968) and Stigler (1970), followed by several contributions focused on specific issues and extensions, including the possibility of corruption, of mistakes in the enforcement process as well as the use of imprisonment as a sanction for illegal behavior (Polinsky and Shavell, 2000). Environmental economics literature has also more recently turned to explicitly including monitoring and enforcement in the debate concerning policy design issues, starting from Russel et al. (1986).
Focusing on the specific issue of this paper, illegal waste disposal is considered by a number of papers, originating from Sullivan (1987) and Fullerton and Kinnaman (1995), where the possibility of illegal dumping is explicitly accounted for. In subsequent papers, costly enforcement (Choe and Fraser, 1999) and transaction costs (Shinkuma, 2003) are addressed. In this section, we follow recent works by D'Amato et al. (2011) and by D'Amato and Zoli (2012), and derive the research hypotheses that will then be tested empirically using Italy as a relevant case study. Our underlying model is a very simple public enforcement model where neutral risk agents choose their compliance strategy according to the comparison between the benefits from illegal behavior (mostly savings in compliance costs) with expected costs, as determined by the monitoring effort and related sanctions. As in many other works, we rely on the number of violations as a proxy of illegal waste behavior (more detail below), in awareness of all the caveats outlined, among others, by Almer and Goeschl (2010a) and Gray and Shimshack (2011).
On the basis of the conceptual reasoning related to the exploration of the aforementioned literature, we present our key testable implication.

Testable implication H1. Larger legal disposal costs, summarized by a stricter waste policy (e.g. a larger landfill tax, and/or a more diffused economic-minded waste tariff) imply a stronger incentive towards illegal waste disposal.

This conjecture rests on the assumption that illegal waste disposal is mainly induced by economic motivations related to the possibility of saving legal disposal costs (Almer and Goeschl, 2010b), specifically by avoiding tax payments on legal disposal. In other words, we can expect that, ceteris paribus, an increase in the tax rate paid on legal disposal (a waste charge or landfill tax, for example) can increase the benefits of illegal disposal and, therefore, lead to a larger incentive towards illegal behavior. This is compatible with the standard literature on public law enforcement as well as with existing works testing the role of the strictness of waste policy on legal forms of waste disposal and management (D'Amato et al., 2011), where the possibility of a tradeoff between the strictness of waste policy and the criminal waste-related activities is indirectly demonstrated.

Testable implication H2. An increase in the enforcement effort, as measured by the number of controls, brings about a lower number of violations; in other words, enforcement bears a deterrence effect.

We aim at testing whether the monitoring effort is capable of achieving a reduction in illegal waste disposal. In principle, we can expect the (lagged) number of controls to affect regulated entities'

perception of the strictness in enforcement, so that deterrence may result. This is quite reasonable and, again, coherent with the received literature related to law enforcement: an increase in enforcement leads to an increase in the expected costs related to illegal disposal and, as a result, to a decrease in illegal waste disposal. On the other hand, the deterrence hypothesis cannot be taken for granted in Italy. As Gray and Shimshack (2011) underline, the specific institutional features of a country, as well as its level of development, might affect how enforcement effort translates into effective deterrence. Among the very few examples of works outside the US, Dasgupta et al. (2001) show that inspections are a crucial determinant of Chinese firms' environmental performance (more important than pollution charges). At the same time, anecdotal evidence on Italy suggests caution. As data from Legambiente shows, in relatively homogenous areas of the country, a greater number of crimes can be associated to a greater number of controls, casting some doubt on the deterrence effect of law enforcement vigilance; for example, the region of Tuscany (central Italy, capital Florence) features more controls per square kilometer than Emilia Romagna and, at the same time, a larger (lagged) incidence of crimes per square kilometer; the same reasoning can be applied to Lazio (capital Rome) and Marche (eastern-central Region, capital Ancona) (D'Amato and Zoli, 2012)[2].

3. The data and the empirical model

The dataset we exploit derives from the merger of two official datasets: ISPRA panel data on waste management and disposal indicators by province, and the Forestry Guard panel dataset on illegal disposal instances and enforcement activities (see Table A1 in the appendix for main descriptive statistics) This merger leads to a balanced panel dataset of 86 provinces (out of 103 in Italy) observed over 6 years[3].

We employ various econometric models to test the following reduced form specification, which is aimed at assessing the set of research hypotheses:

$$crime_{it} = \alpha_i + enforcement_{it} + enforcement^2_{it} + policy_{it} + population\ density_{it} + \varepsilon_{it} \quad (1)$$

On the basis of the information provided by the Forestry Guard, we can consider four different typologies of 'waste disposal related crime'[4], and use them as a dependent variable: (1) Criminal violations ('reati'), (2) Reporting / Charge ('denuncia'), (3) Requisition ('sequestro'), (4) Criminal offences ('illeciti')[5]. 1-3 are penal crimes, the fourth is a crime of administrative nature. In the analysis we will test our hypotheses using these four variables and a single index generated by applying a principal component analysis (PCA). One of the main advantages of PCA is its ability to synthetize in one or more sub-indexes the variability of an original set of variables. In particular, the application of this technique on a large set of variables creates a smaller subset of variables, called

[2] Costantini et al. (2013) provide recent updated information on economic and environmental figures for Italy at a regional level.
[3] We have omitted 17 provinces due to missing data in the Forestry Guard dataset.
[4] As codified by the Forestry Guard register. More information is available upon request. All data is available for replication.
[5] Italian terms in brackets.

components, each of which represents a share of the variance in the original data. In particular, the first component extracted accounts for the greatest share of variability among the original variables, the second one for the greatest share of the remaining variability, and so on. For this reason, this technique is often used in all cases, like ours, in which researchers seek to synthetize in a single index the overall variability of a wider set of data[6]. Moving on to the regressors, α_i is the provincial level fixed effect, enforcement is proxied by the number of waste related controls performed by the Forestry Guard every year at the provincial level, while population density controls for different anthropic pressures on the waste system. It is a common control variable in empirical waste studies (Mazzanti and Zoboli, 2009) and can be either positively or negatively correlated with waste management performances depending on factors such as economies of scale and land opportunity costs in urban and densely inhabited areas. As a policy variable we adopt the share of population living in municipalities where the waste tariff has replaced the former waste tax (as in Mazzanti et al., 2010). In the last years Italy has undergone a transition from the old taxation system (TARSU, Tassa sui Rifiuti Solidi Urbani) to the new Italian waste tariff, TIA (Tariffa di Igiene Ambientale)[7]. The TARSU was simply related to the size of household living space, and did not follow any cost-recovery principle. For this reason we do not expect it to have any impact on waste reduction. Instead, TIA should move waste management towards a full-cost pricing/polluter pays principle (PPP) based system. The tariff is composed of two elements: a fixed element, which covers the fixed costs of waste management (such as street cleaning costs), and a variable element, which covers the variable costs of this service, such as the costs of waste collection and disposal. We may note that TIA has more rigorous criteria than TARSU in order to measure the actual amount of waste generated, and for this reason we can consider this variable as a good proxy of the overall commitment that municipalities put towards waste management issues.
Figures 4-5 show the geographical characterization of both Forestry Guard controls and the share of Municipalities in the province that have shifted to the new waste tariff (the two main covariates by which we test H1 and H2). Figures 6-9 depict the geographical distribution of illegal disposal, varied by typologies of criminal offences[8].

(Figures 4-9 here)

4. Econometric evidence

Table 1 below presents the first results on the basis of fixed effect panel estimation. We use this evidence as a benchmark; a follow up series of robustness checks will then be provided in Tables 2-4. In the first column of Table 1 and in Tables 3 and 4, we used the single index derived with PCA

[6] For instance, Nicolli and Vona (2012) use this technique in order to create a single policy index starting from a wide set of renewable energy policies.
[7] The new waste management tariff was introduced by Italian Law No. 22/1997, and should in theory substitute the former waste management tax. The tax, however, is still in force in many Italian municipalities because law 22/1997 allows for a transition phase that has shown to be 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 and delivers some market-based incentives to the system.
[8] It is worth noting that information on fines and sanctions is statistically less meaningful since they are more or less constant over time and across areas.

as a dependent variable, while in order to disentangle the effect of the Forestry Guard's controls on different types of waste crimes, columns 2 – 5 distinguish each of the aforementioned typologies of 'waste disposal related crime'. Considering the count nature of these four indicators, in this analysis crime variables and controls have been divided by the total amount of waste generated at the provincial level. This transformation on the one hand makes it possible to use OLS and estimate a FE panel, and, on the other, allows to weight the number of crimes for the size of the provincial waste management system.

Estimates show a rather homogeneous picture regarding the effect of waste tariffs (which empirically test H1) and enforcement efforts (to test H2). As far as H1 is concerned, we cannot reject the hypothesis that stricter (more diffuse) environmental policy tends to favor the emergence of illegal disposal[9]. The effect is statistically and economically significant for what concerns columns 2-4, and statistically very significant for the case where the dependent variable is the factorial.

This poses a problem in the overall effectiveness of waste management: even if it is true that more diffuse economic-minded policy instruments such as waste tariffs might positively correlate to higher waste management and disposal performances (Mazzanti and Montini, 2013), drawbacks (in terms of greater illegal disposal practices) are possibly present.

The effect of law enforcement is quite surprising here: estimate results show the existence of a positive, but concave relationship between waste crimes and enforcement efforts. This suggests that controls presumably catch up with criminal activities at least up to a certain level of enforcement. After the turning point, however, deterrence effects become visible and our hypothesis H2 cannot be rejected. Contrary to the bulk of the existing literature, then, we find that in most of the Italian provinces policy controls related to illegal disposal practices do not exert significant deterrence on criminal behaviors. A negative relationship between enforcement and waste crimes can be identified only for very high levels of enforcement efforts. Turning points (TP) are estimated between 76% and 90% of the maximum level we observe for the enforcement variable.

Table 2 presents the first robustness check. We estimate (1) through a negative binomial model. Outcomes of Table 1 are generally confirmed. The enforcement effect is significantly non-linear. The waste policy effect is significant as before for column 1, 3 and 4, but only weakly significant for column 2 (about 15% for the remaining two columns). This is somewhat coherent with the fact that more stringent waste policies might generate negative spillover effects (midnight dumping). This effect seems 'crime specific'. It is of interest to note that the more diffuse waste policies are (waste tariffs[10]), the 'heavier' the amount of illegal disposal that takes place. In fact, the effect is not registered in the case of administrative offences.

New robustness checks are attempted by using lagged enforcement variables and instrumental variables (IV) (Table 3). Previous estimates are overall unaltered. We note that the inclusion of IV (employment and social capital measures, namely electoral turnover), relevant in accounting for

[9] Waste management/policy oriented proxies are captured by the share of provincial municipalities and the provincial population covered by the new 'waste tariff' regime, which substitutes the old 'waste tax' regime.

[10] The use of landfill taxes is prevented by the fact that they are set at the regional level, contrary to tariffs and tariff diffusion, which vary across provinces and capture the high decentralisation that occurs in the country with respect to waste management policies.

potential endogenously determined variables, slightly reduces the level of TP but does not affect results[11].

Finally, Table 4 provides some further evidence by geographical area. The size of the panel allows for focusing attention on the potential heterogeneous evidence by area. Table 4 provides estimates for northern, central and southern Italy, and additional regression where some areas are excluded. The main result is that the effects of enforcement and waste tariffs appear to be driven by some different geographical factors. When taking a closer view, we can observe how the 'waste tariff/policy' effect (H1) is mainly driven by northern areas (see estimates in the regression that exclude the north, where the tariff factor is not significant) and provinces. This is coherent with the fact that tariffs have been mainly diffused and implemented in northern provinces. Dumping effects are more relevant in these areas as a consequence. It is also of interest to note that the TP is rather low when only the north is accounted for (column 1). The north-western part of Italy (Turin, Genoa, and Cuneo among others) is on the right side of the TP of enforcement (which shows lower levels on average in northern-central areas). On the contrary, the enforcement effect appears to be driven by the south ('south excluded' regression). Indeed, we see that when excluding southern provinces enforcement vanishes.

(TABLES 1-4 here)

5. Conclusions

This paper conceptually and empirically addresses the drivers of illegal waste disposal at a decentralised level of government. The investigation is relevant given the territorial structure of waste management policies and controls (enforcement) in many countries. In fact, most economic systems manage natural resources such as waste and material at a very decentralised level. Italy is a compelling example, given the rich heterogeneity it presents across provinces and the well-known north-south socio-economic divide, which also relates and eventually leads to diverse environmental performances. Waste management policies and enforcement activities both operate at the local level, often in absence of a real coordination, given that different policy makers are responsible for the implementation of controls aimed at tackling illegal disposal on the one hand, and at supporting better management and disposal performances on the other. In Italy, the Forestry Guard (a corps under the jurisdiction of the Ministry of Agriculture, divided regionally), along with municipalities and provinces are responsible respectively for reaching enforcement and waste management objectives.

We find that enforcement activities, that is the control and monitoring of the territory, and waste management policies are to some extent 'complementary'. More precise complementarity assessments are left to further research as they require different econometric techniques. We here stress that from a 'policy mix' point of view, given that the first hypothesis, according to which the

[11] OLS estimates are actually preferred by tests that compare IV and OLS (Davidson and McKinnon which report a value equal to 0.11 in column 3). The inefficiency introduced by IV estimations is well-known. The use of IV should be parsimonious and test-based. All tests are available upon request. Regarding social capital indicators, we refer the reader to seminal papers on the issue which address the role of social capital in regional studies analysis and contexts that are socio-economically varied (Putnam, 1995; Tabellini, 2010).

possibility that more diffuse and intense waste management policies do increase illegal disposal is not rejected, stricter levels of territorial enforcement by police corps are needed to compensate this negative but somewhat unavoidable spillover of waste management actions. The econometric evidence tells us that enforcement, though non linearly related to illegal disposal, is effectively reducing it beyond a threshold. This means that high (higher than the current levels in the Italian case study) enforcement levels are necessary to reduce illegal disposal while waste policies aim at increasing recycling and reducing legal disposal of waste. Further research might add insight by increasing the level of detail of policy actions, and by extending the spatial analysis of illegal waste phenomena.

Table 1. Illegal disposal drivers – panel estimation[12]

	(1) Factorial	(2) Violations	(3) Charges	(4) Land Requisition	(5) Offences
Control	0.0024***	0.0437***	0.0507***	0.0303***	0.1088**
	(0.0006)	(0.0133)	(0.0156)	(0.0102)	(0.0491)
Control squared	-0.0000***	-0.0000***	-0.0000***	-0.0000**	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Copcomtar	0.0149***	0.3320***	0.3177**	0.1884**	-0.7759
	(0.0052)	(0.0956)	(0.1304)	(0.0825)	(0.9586)
Popdens	0.0042	0.3520*	0.0692	-0.1037	-1.2126
	(0.0090)	(0.2038)	(0.2544)	(0.1123)	(0.8986)
_cons	-3.6276	-113.2690**	-39.2519	11.1546	350.9176
	(2.2168)	(50.7262)	(66.8463)	(25.8955)	(235.9739)
Turning point	6415	6829	6025	5779	5927
FE	Yes	Yes	Yes	Yes	Yes
N	516	516	516	516	516

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 2 – Negative Binomial estimations

	(1) Violations	(2) Charges	(3) Land Requisition	(4) Offences
Control	0.0011***	0.0012***	0.0012***	0.0007***
	(0.0002)	(0.0002)	(0.0003)	(0.0002)
Control squared	-0.0000***	-0.0000***	-0.0000**	-0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
copcomtar	0.0086**	0.0050	0.0115**	0.0054*
	(0.0035)	(0.0037)	(0.0047)	(0.0029)
popdens	-0.0001	0.0002	0.0008*	0.0002
	(0.0003)	(0.0003)	(0.0004)	(0.0002)
_cons	0.7979***	0.1265	-0.1828	0.7875***
	(0.1792)	(0.1831)	(0.1912)	(0.1551)
Turning point	3827	2808	3264	2366
FE	Yes	Yes	Yes	Yes
N	504	504	510	504

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

[12] The dependent variable and the enforcement covariate (controls) are divided by the waste generated in the province. Waste generation gives the size of the waste market.

Table 3 – Lagged enforcement and instrumental variables

	(1) Factorial	(2) Factorial	(3) Factorial
Lagged Control	0.0013**		
	(0.0006)		
Control		0.0065***	0.0051***
		(0.0025)	(0.0018)
Lagged Control squared	-0.0000**		
	(0.0000)		
Control squared		-0.0000**	-0.0000**
		(0.0000)	(0.0000)
Copcomtar	0.0188***	0.0197	0.0180
	(0.0067)	(0.0134)	(0.0124)
Popdens	-0.0019	-0.0126	-0.0066
	(0.0120)	(0.0166)	(0.0144)
_cons	-0.5293		
	(3.2261)		
Turning Point	5108	4743	4961
FE	Yes	Yes	Yes
N	430	516	516
Hansen		0.000	0.306

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 4. Robustness checks by sub geographical areas (benchmark column 1 table 1)

	(1) North	(2) Centr-South	(3) North_excl	(4) Centre_excl	(5) South_excl	(6) Islands_excl
Control	0.0034**	0.0030***	0.0030***	0.0026***	0.0022*	0.0024***
	(0.0015)	(0.0007)	(0.0007)	(0.0007)	(0.0012)	(0.0006)
Control Squared	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Copcomtar	0.0191***	0.0150*	0.0134*	0.0162**	0.0146***	0.0158***
	(0.0059)	(0.0076)	(0.0073)	(0.0067)	(0.0050)	(0.0053)
Popdens	-0.0004	-0.0008	-0.0005	0.0064	0.0042	0.0041
	(0.0080)	(0.0194)	(0.0193)	(0.0106)	(0.0086)	(0.0090)
_cons	-2.4727	-3.1708	-3.1888	-4.5923	-3.0613	-3.6123
	(1.9738)	(4.6903)	(4.6883)	(2.7806)	(2.1099)	(2.2121)
Turning Point	2201	6414	6409	6272	3098	6417
FE	Yes	Yes	Yes	Yes	Yes	Yes
N	246	264	270	390	378	510

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

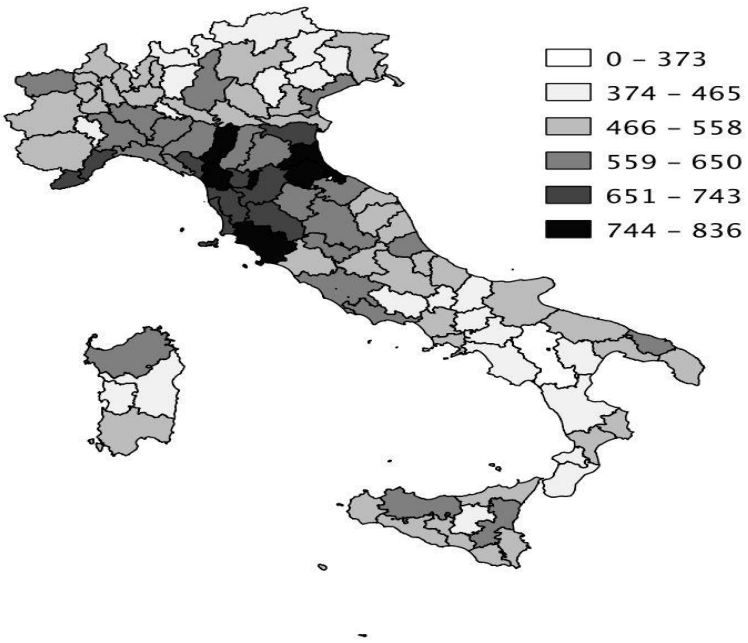

Figure 1 - Municipal Waste Generation. kg per capita (average 2005-2010)

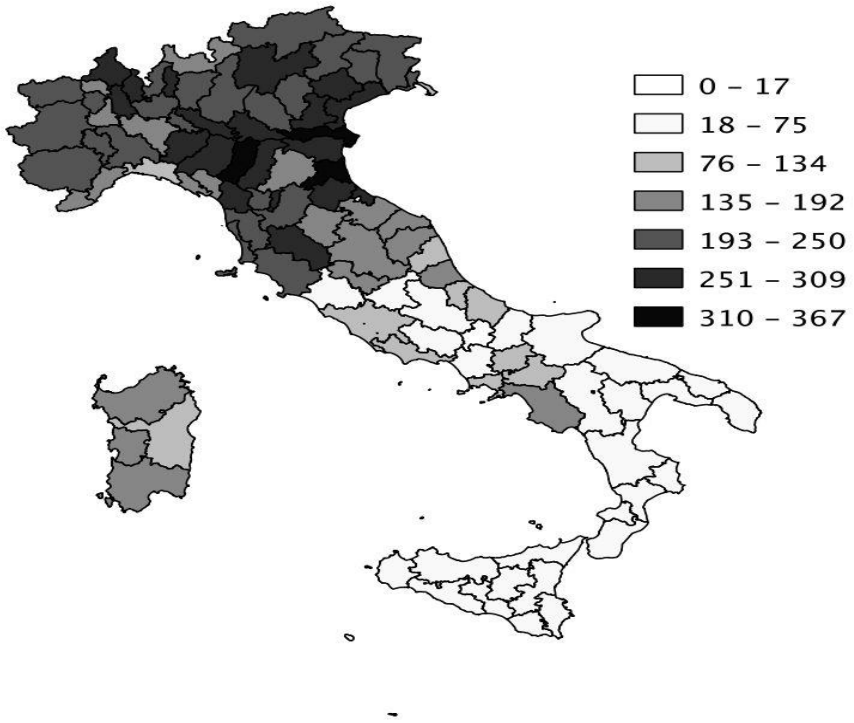

Figure 2 - Separated collection of waste - kg per capita (average 2005-2010)

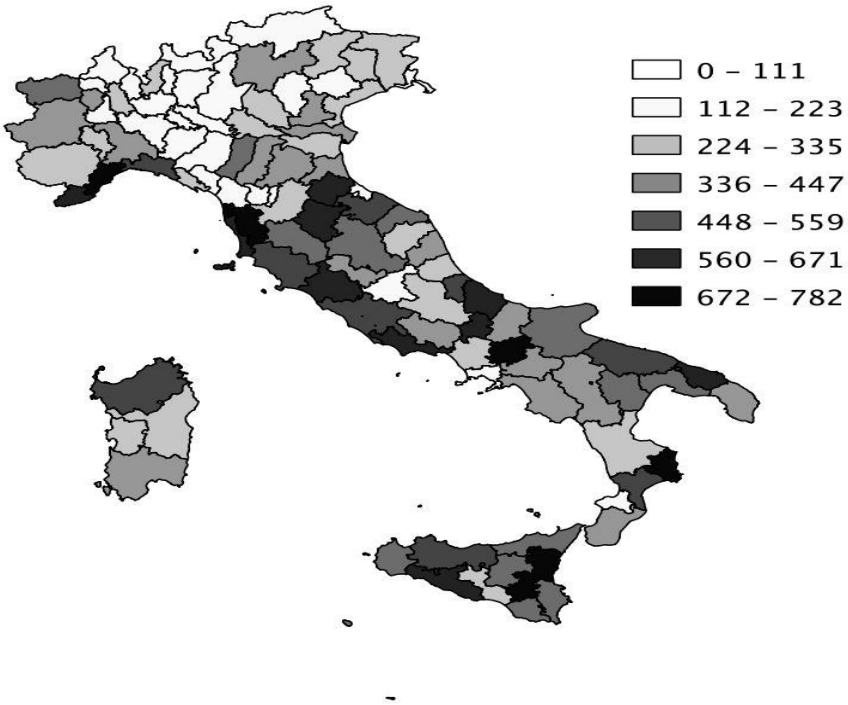

Figure 3 - Landfilled waste - kg per capita. (average 2005-2010)

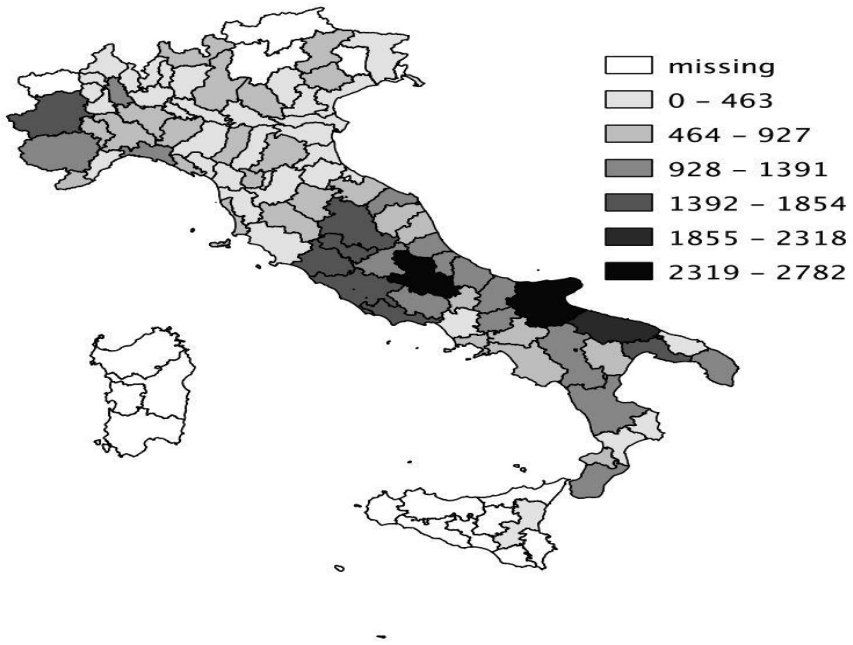

Figure 4 - Controls by Forestry Guard (Enforcement) - average 2005-2010 by province

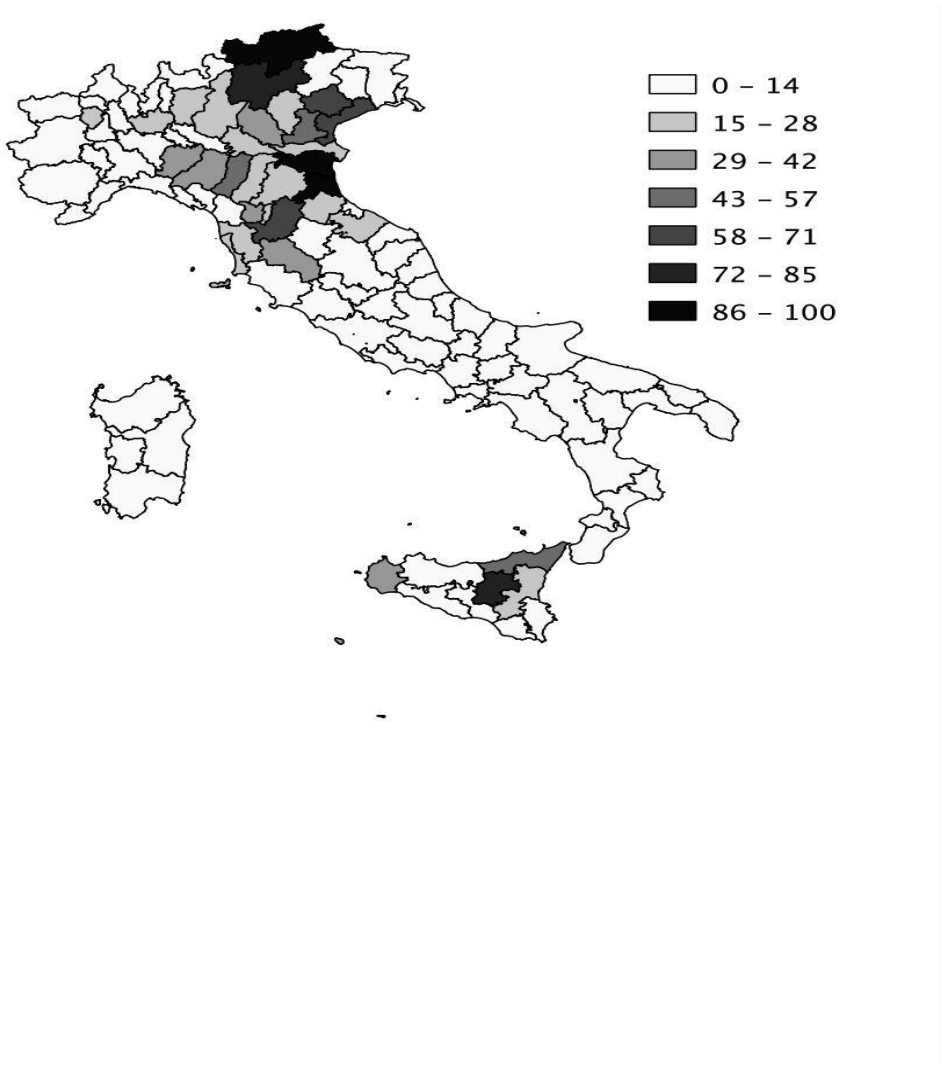

Figure 5 - Share of Municipalities in the province that have shifted to the new waste tariff (%)

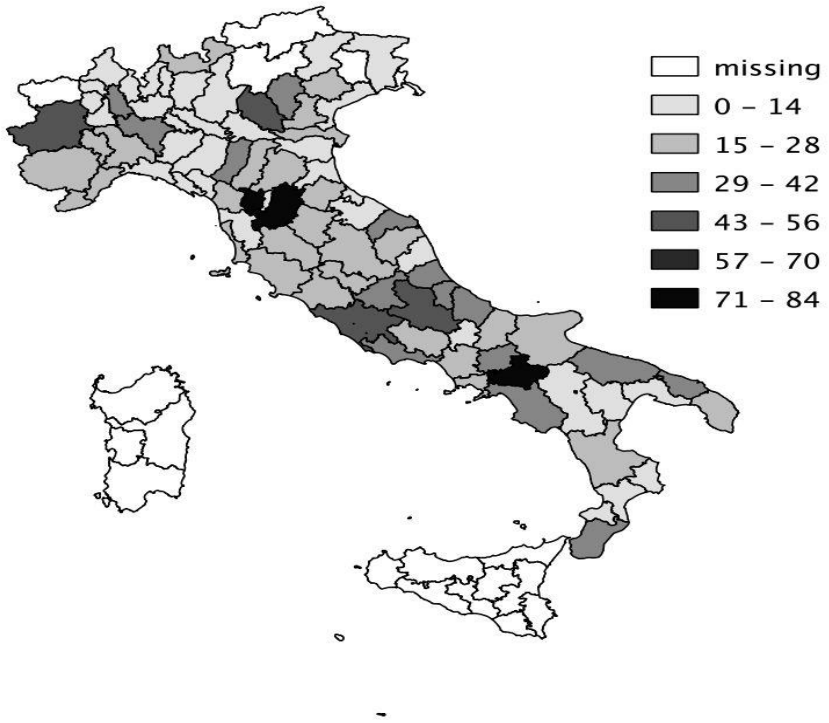

Figure 6 - Criminal offences, average 2005-2010 by province

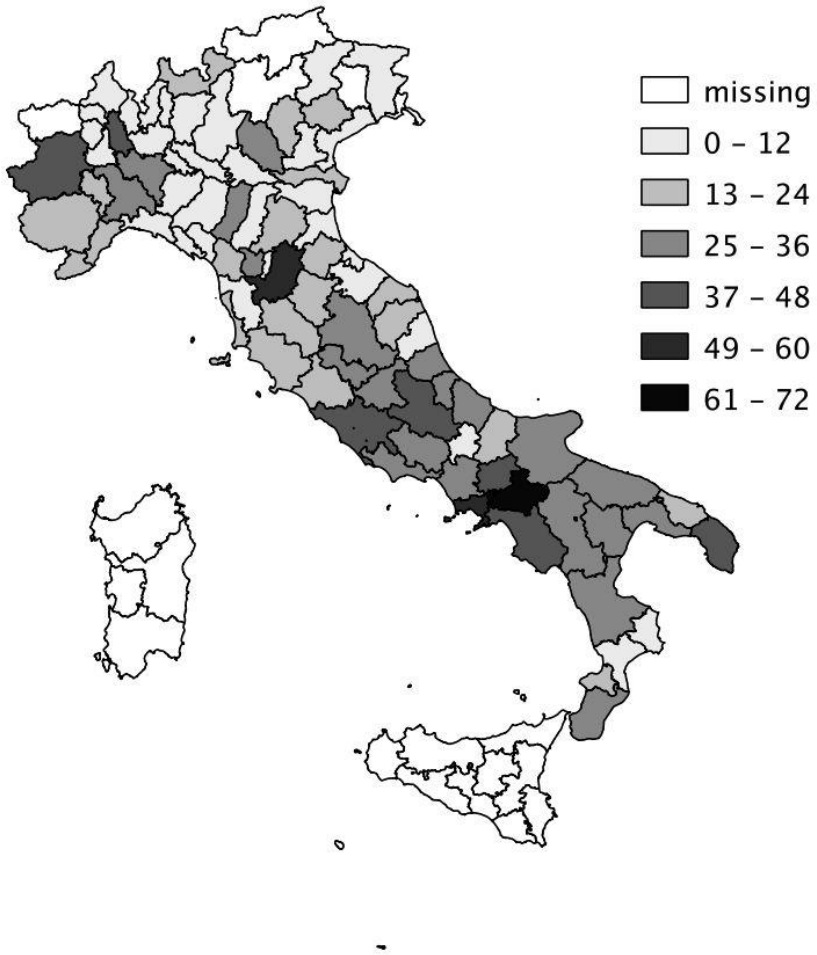

Figure 7 – Criminal violations, average 2005-2010 by province

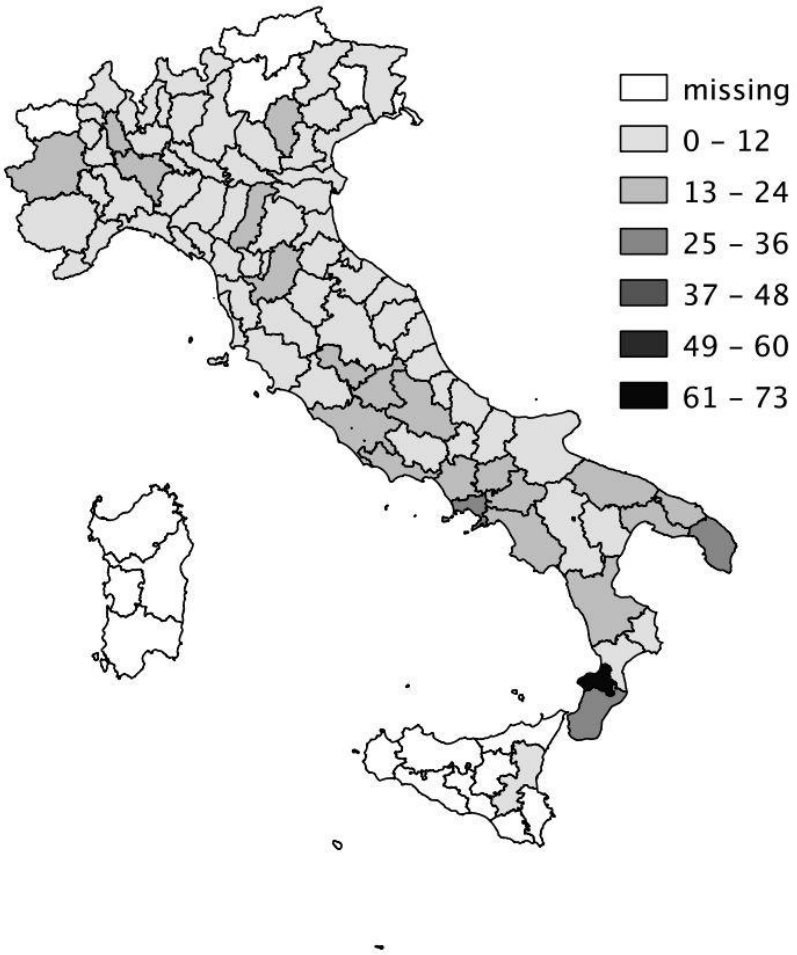

Figure 8 - Requisition of Land, average 2005-2010 by province

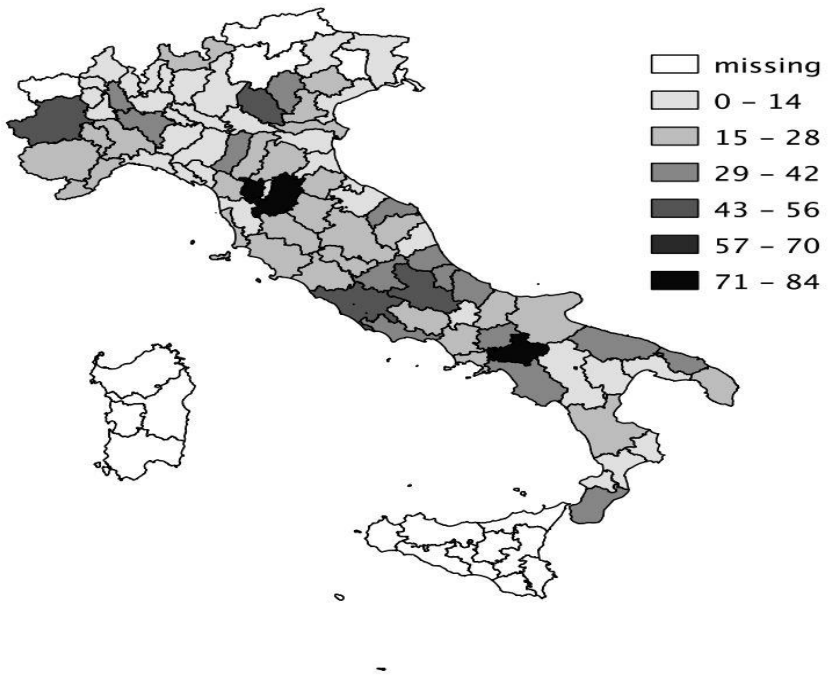

Figure 9 - Criminal charges, average 2005-2010 by province

Appendix - Table A1

Table A1. Descriptive statistics

Acronym	Description	Mean	Min	Max
Factorial	Single crime index derived with PCA (divided by total MSW generated in Table 1, 3, 4)	-4.18e-09	-0.851	7.614
Violations	Number of violations (divided by total MSW generated in Table 1, 3, 4)	15.69	0	158
Charges	Number of charges (divided by total MSW generated in Table 1, 3, 4)	16.82	0	368
Land requisition	Number of land requisitions (divided by total MSW generated in Table 1, 3, 4)	7.20	0	391
Offences	Number of administrative offences (divided by total MSW generated in Table 1, 3, 4)	55.37	0	2864
Control	Number of controls carried out by the Forestry Guard (divided by total MSW generated in Table 1, 3, 4)	583.77	0	3799
Copcomtar	Share of municipalities covered by the new tariff system	24.69	0	104.24
popdens	Population density	252.39	31.03	2635.59

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