LANDFILL DIVERSION IN A DECENTRALIZED SETTING: A DYNAMIC ASSESSMENT OF LANDFILL TAXES

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Landfill diversion in a decentralized setting: a dynamic assessment of landfill taxes

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Abstract. We analyse the process of landfill diversion and separated collection, two pillars of a waste related performance in a country, by embedding the dynamics in a frame where economic, geographical and policy variables enter the arena. We aim at investigating in depth what main drivers may be responsible for such a phenomenon. In addition to structural and economic drivers we primarily investigate the role of landfill taxes. Notwithstanding the Italian landfill tax dates back to 1996, there is a lack of effectiveness assessment, which primarily derives from the absence of a full coherent dataset covering all regions. In fact, the implementation is delegated to each region, a case study of real decentralisation, and the opposite for example of the UK situation, where the tax is set and administered by the Treasury. We first provide a descriptive analysis of the regional trends over the years on the basis of an original landfill tax dataset covering all Italy that we constructed through a scrutiny of regional bills, and web and telephone contacts. We exploit this peculiar and original aggregation of tax related information to test whether the tax has been effective in supporting landfill diversion. We test the hypothesis on the basis of an integrated dataset that merges economic, waste, policy variables together, at regional level and over the period 1999-2008. We check for results sensitivity the effect of the landfill regional tax by using provincial dataset over the same period. Panel regressions show that the effect of tax is significant, complementary to structural factors, population density and related opportunity cost among others. Spatial effects seem instead negligible. This is the first evidence on a large panel dataset that introducing and increasing landfill taxes over time is an effective way to cope with waste disposal. Regions that have increased such taxes over time have achieved better waste disposal performances. Landfill taxes are not the only instrument but they show to a relevant 'must have' in the policy package.

Key words: Landfill taxes, landfill diversion, recycling, decentralized policy, regional performance

JEL: C23, Q38, Q56

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1. Introduction

Reducing the amounts of waste going to landfill is a primary aim of European environmental policies related to climate change. The effectiveness of European policies will be based on sound implementation at the levels where waste is being generated and disposed of.

European efforts towards reducing landfill are a priority in the waste hierarchy, and one of the pillars of EU waste strategy is the 1999 Landfill Directive (EEA, 2009), which is being implemented at member state level in association with national efforts regarding waste management, such as separate collection, recycling, incineration, and disposal and usage of waste. These actions are devoted to diverting waste from landfill and reducing waste generated at source, to achieve a decoupling of different stages of the waste production chain. The EEA has acknowledged that it is increasingly important to provide answers to these questions because waste volumes in the EU are growing, driven by changing production and consumption patterns.

Indicators of this 'decoupling' are becoming increasingly popular for detecting and measuring improvements in environmental/resource efficiency with respect to economic activity. Extensive research on decoupling to produce indicators for reporting and policy-evaluation purposes is being carried out by the Organisation for Economic Cooperation and Development (OECD, 2003, 2002). The EU policy 'thematic strategies' on resources and waste, includes reference to 'absolute' and 'relative' indicators of delinking (Jacobsen et al., 2004): the former being a negative relationship between economic growth and environmental pressures, the latter a positive but decreasing, in terms of size, association. That is a positive, lower than unity elasticity in economic terms. Absolute and relative delinking trends are embedded in the more general Environmental Kuznets Curve (EKC) framework (Stern, 2004).

Overall, it can be said that landfiling is still the predominant option for the treatment of the EU's municipal waste, and that Italy's performance in terms of waste disposal is being constantly monitored and evaluated. In 2007, about 46.7 per cent of total municipal waste in Italy was landfilled while 10.3 per cent was incinerated. However, there are significant differences in how dependent different countries are on landfiling (various EU and Italian analyses on waste generation, landfiling, recycling drivers are found in Mazzanti and Zoboli, 2009; Mazzanti et al., 2008, 2011, 2012; Mazzanti and Montini, 2009; Mazzanti and Nicolli, 2011). A recent paper (D'Amato et al., 2011) analyzes how legal disposal (landfill), illegal disposal and recyclable waste levels are influenced by waste tariff and crime in Italy, thus adding evidence on other idiosyncratic factors that are relevant in decentralized environments.

The economic analyses on landfiling have predominantly focused on cost benefit assessments of relative externalities. A rare case is the IVM report (IVM, 2005) on landfill tax effectiveness in the EU. Some specific studies have been done on the evaluation of the EU landfill Directive and the well established (since 1996) UK landfill tax. Given the lack of extensive (panel) data, these studies provide interesting, but only qualitative assessments. During the first phase of implementation of the UK landfill tax, Morris et al. (1998) offered some insights on its potential and expected contribution to sustainable waste management, analysing its general structure, comparative landfill costs and the waste hierarchy. Morris and Read (2001) and Burnley (2001) provided updates to this analysis, highlighting certain operational weaknesses and debating some preliminary reviews. Burnley (2001) linked the EU directive to national UK implementation. Another interesting assessment, which is quite pessimistic in its conclusions, was provided by Martin and Scott (2003), who stressed that tax has failed to significantly change the behavior of domestic waste producers. The UK landfill tax was intended to motivate to a transition from landfiling of waste, towards recovery, recycling, re-use and waste minimization. They find evidence for progress towards recycling, but none in relation to re-use or waste minimization. Among more recent works, we would refer the reader to Davies and Doble (2004), who monitored the UK landfill tax from its

introduction, and offer insights on future evolutions, criticalities and externality evaluation. Phillips et al (2007) provide one of the most recent UK-specific regional assessments of waste strategies. However, regional based analyses are at best rare, though are worthwhile since the implementation of environmental and resource waste taxes is often a matter of decentralisation, which it is well known is associated with costs and benefits.

This paper attempts to fill gaps in the literature through various analyses on the process of delinking of Municipal waste (MSW) landfill trends, within a framework in which economic, geographic and policy variables play a role.

We specifically focus on the effects of landfill taxes on landfill diversion, in order to assess whether the level of the tax, which might also capture other policy elements linked to 'policy commitment', may have affected the landfiling performance.

The Italian case study is relevant. In fact, Italy witnesses a highly decentralised environmental policy making which suffers from lack of accurate effectiveness analyses. One major constraint is often the lack of reliable data that the decentralisation process generates as side effects, in absence of sound central coordination. This prevents the implementation of economic assessments. Following this criticality, we have first created a brand new original panel dataset (1999-2008 for the 20 Italian regions) that merges economic and environmental data (ISTAT and ISPRA/APAT agencies sources).

The Italian landfill tax is an important case study at international level. It is first of all an 'old' tax that was implemented back in 1996, even before the famous UK tax (Martin and Scott, 2003; EEA, 2009; Pearce, 2004; DEFRA, 2004). Differently from the UK tax which is defined and administered by the Treasury HM, landfill taxes in Italy are delegated to and defined by Regions (20 in Italy). This is typical decentralisation of competencies that n many fields, including environmental issues, has been more and more present since the reform of the article 5 of the Constitution. The tax and the revenue are managed by regions under general guidelines provided by the Treasury.

This allows a proper assessment of its effects. It is also worth noting that the landfill tax is maybe the only considerable environmental tax in Italy, generating an overall tax revenue of around 185 millions€ in 2010, consistently decreasing over time since a peak of 360 millions was reached in 1997. It is a revenue of around 38% the total revenue (negligible, half billion €) generated by environmental and resource taxes in Italy, and the 0.005% of total environmental and energy tax revenue (Figures 1-3). The decrease in tax revenue is certainly related to the decrease in landfill diversion to a greater extent. The real matter is whether this diversion has occurred at least partly as a consequence of the tax itself.

Given the absence of official data on the tax in Italy, we have surveyed each specific regional implementation through the use of official Region web sites, complementing this step with telephone interviews to regional offices in order to fill gaps and verify the web related information.

We have ended up with a reasonably full panel dataset that offers room for sound econometric analysis. As far as we know, this is the first example of a full and long panel dataset (cross section examples are possibly existent, but suffers from well known problems in the phase of econometric assessment and use) for landfill tax implementation.

Table 1 offers insights on the 'history' of landfill taxes since 1999, the first year for which waste data are available in Italy (initial year of the dataset we use; the full 1996-2012 dataset on landfill taxes is available). We might note some points. First, as usual in the field of environmental and resource taxation, the dynamics shows stable trends. Adjustments are rare since the first introduction, which exposes taxes to real value erosion over time. The tables offer some comments on the details of regional implementation. We note that the heterogeneity in the tax levels is quite high: the average tax over the period was 14.9€ per tonne of MSW landfilled, with a peak of 25.8€ in Piemonte, a (rare) case where taxes have increased over time, and a lowest value in Campania (5.2€). We note that various increases are observed after 2008. Those might be reactions to the

more stringent targets defined by the 2008 Waste Framework Directive, and by the increasing social costs related to landfills that appear more and more evident at local level. The Campania value might be related to the well known poor waste management and disposal. Landfill rents of legal and illegal nature persist and many forces play against a proper landfill diversion process.
Besides the UK landfill tax, that is correlated with marginal costs of landfiling and set on the basis of a time increasing escalator, most environmental taxes are introduced and never redefined for years. Examples include the Danish weight based packaging tax that was introduced in 2001 according to Life cycle social cost accounting of materials and never successfully updated since then. Revenue generation is often the main motivation behind such taxes. Further research may test the extent to which the 'quality of the tax reform' (e.g. how revenue is recycled: to fund sustainability projects, to abate labor costs etc..) is important in affecting landfill diversion. In any case, this is the only dataset we are aware of that shows detailed regional information on landfill taxes for a large country.
The research hypothesis is then the following. We aim at shedding light on whether the level of the landfill tax and its dynamics has been a significant driver of landfill diversion. In other words, whether landfill taxes where possibly a relevant omitted variable in past studies on landfill diversion.
Ancillary hypotheses are tested. First, whether the landfill taxes implemented in contiguous regions play a role in determining the region landfiling performance. Waste trade is costly, but we cannot rule out the presence of spatial effects associated to governmental actions (Mazzanti et al., 2012; D'Amato et al., 2012; Brueckner, 2003). A too high relative landfill tax for a region may incentive landfiling outside the boundary of the region. This is true for movements and provinces close to regional borders. We also check if the 'technological relative capacity', captured by relative incinerated waste per capita, affects landfiling in the region. Lack of technological installed capacity may either drive more landfiling or crate incentives to exploit the capacity of nearby regions.
Table 2 sums up the main research hypotheses.

(Figures 1-3 and tables 1-2 here)

The paper is organised as follows. Section 1 presents the dataset in depth and the empirical model we use for assessing landfill tax effects. Section 2 comments on main results. Section 3 concludes.

2. Empirical Evidence

2.1 Data and model

The analysis is based on an Italian regional waste dataset that includes observation for all 20 Italian regions over the period 1999-2008. Waste related data are taken from the Italian environmental agency (ISPRA waste report, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009), while economic data, with the exception of the landfill tax, are taken from the Italian national institute for statistics (ISTAT). Following to the Waste Kuznets Curve (WKC) literature (Mazzanti and Zoboli, 2009) we refer to the usual general specification:

$$\text{Log (landfilled Waste)}_{it} = \alpha_{it} + \beta_1 \text{ Log (GDP)}_{it} + \beta_2 \text{ Log (Landfill tax)}_{it} + \beta_3 \text{ Log (Z)}_{it} + \varepsilon_{it}$$

Where the first term is an intercept that control for country fixed effect, the dependent variable is measured as Kg of landfilled per capita, and the explanatory variables include GDP per capita (β_1), landfill (β_2), and a set of variables that control for the Regional waste management characteristic according to the research hypothesis summarised in Table 3. Z includes structural factors such population density. Descriptive statistics and a brief variable description are presented in table 3. All variables are expressed in logarithmic form in the analysis.

(Table 3 here)

2.2 Econometric evidence

The log-log model results are summarised in table 4 below. We performed both Fixed effect estimation and random effect estimations as common procedure with panel data. As evident from the comparison between model I (RE) and I (FE) however, Hausman tests strongly prefer FE models, suggesting a possible bias in RE coefficient. For this reason we only present FE estimations[2], which are nonetheless similar to RE ones, especially after accounting for waste management characteristics. A first relevant result, in line with previous evidence (EEA, 2009), is the un-significance of GDP per capita, which became even more evident when other factors are included in a multivariate analysis. For this reason Value added coefficient are not included in the regression table below[3]. A second result that confirms previous evidence is the prominent role played by population density in promoting landfill diversion. Economic and health related opportunity costs associated with an higher level of urbanization are confirmed as one main driver of landfill reduction, as previously found in similar studies at provincial level (Mazzanti et. al., 2012). More specifically, a 1% increase in population density through urbanization leads to a 6-8% decrease in the amount of waste landfilled. On the other side, model I (FE) underlines an important difference between this regional based study and previous provincial based evidence. Tourist flow is in fact in this context not significant, while in previous analysis it was able to amplify the effect of population density. If at provincial level the high economic dependency by touristic activities has been able to promote landfill diversion, due to the disamenities associated with landfill sites, this evidence is here more opaque. The provincial results could have been probably driven by some striking cases, such as Rimini, Venice among others as examples. In conclusion, the core specification shows that where opportunity costs and potential economies of scale are driven by populations density, landfilled waste is lower and probably other form of disposal are more relevant, while the effect of GDP and tourism is weak and not relevant.

The effect of regional landfill tax, included in model II below, is negative and highly significant. To our knowledge this is the first study that includes a continuous variable able to account for the stringency of such policy instruments, and its statistical significance across all the difference specifications presented underlines the important role that such instruments had in promoting landfill diversion and more generally in contributes at the overall transformation that the Italian waste sector experienced in the last ten years (See Mazzanti et al., 2012). This result is especially interesting if we consider that the average rate of the Italian landfill tax (15 euro per tonne of MSW in 2008) is still much lower than in other European countries like for example UK, in which the tax was of about 40 pound per tonne in the same year. Italy presents lower than average landfill taxes and higher than average gate fees.

Moving to the characteristics of the local waste management two different elements emerge. First of all, the presence of incineration plants at regional level contributes to the process of landfill diversion, as evident by the negative and statistically significant coefficient of the incineration variable in model IV. Conversely, the share of recycling is not a significant driver of landfill diversion (see model VI). Both landfill sites and incineration plants are long term investment decisions which bind municipalities to a technology for ages, and the choice of opening a new incineration is often to the detriment of the construction of new landfill sites. On the other side, more flexible recycling schemes does not seem to overlap to landfill capacity, and more probably

[2] RE results are available upon request.

[3] In line with previous WKC studies also the squared value of GDP has been tested, but given its general non-significance, results are not included in the text.

have been implemented to increase the overall disposal capacity, and not as a direct substitute of total landfilling. On the other side, CONTtax and CONTinc, which reflect respectively the average level of the tax and the average level of incineration in contiguous regions do not seem able to influence the regional choices of waste management. These variables were meant to correct for the potential 'attractiveness' and spillovers related to actions of adjacent regions, but the eventual presence of waste trade flow is apparently not influenced by such elements. Concluding, regional waste management choices are influenced by a mix of factors, including the level or urban concentration, the landfill tax and the installing capacity of incineration plants.

These results however can be biased by the potential presence of endogeneity between the policy variable and the dependent variable. It is in fact reasonable to presume that regions with an higher dependence from landfill activities may tend to enact stricter regulation in order to fill the gap with relative more efficient regions. For this reason this analysis is also conducted using a two stage model (IV-2SLS) in which in a first stage we regress the policy against some of it possible determinants, and in a second stage we use the first stage results to correct from the potential bias caused by the presence of endogeneity. In particular, we candidate as possible instruments for the first stage two 'social polarization' related variables and GDP. The link between 'social polarization' and policy stability has been stressed in many contributions. Following Easterly et al. (2006), and Keefer and Knack (2002) it is possible to argue that politicians might not be able to enhance good policies if the community in which they live experiences significant social constraints or, in other terms, that the absence of social cohesion and the presence of social polarisation can make the policy environment less secure and less stable. These elements have a direct consequence on environmental policies, which in turn may have important effects on waste management choices. Consequently, the presence of Social polarisation may affect waste management choices through the lever of environmental policies. Following this considerations we used the employment rate and the share of Electoral participation as proxy social stability and social capital, which are expected to be be valid instruments (expected to be correlated with the policy effort and exogenous to the main relationship). Moreover, being environmental quality generally considered as a normal good, is it possible to assume that richer regions may ask for more stringent regulations (Arrow et al. 1995, Diekmann and Franzen 1999, Dasgupta et al. 2001, Esty and Porter 2002). This suggest GDP, which is we note not significant in explaining landfill per capita, as another natural candidate for instrumenting the landfill tax. Fixed effect IV estimation are presented in model VII and generally confirm previous results. The bias is particularly evident, and instrumental variable estimations increase the effect of the landfill tax of four times. General test of overidentification strongly support the set of instruments chosen. Taking the estimated coefficient, it suggests that an increase in the tax by 10% (say a jump to 16.5€ from the 15 level) shrinks the landfill disposal of MSW to 316 (from 344 kg per capita). The more conservative FE estimates would suggest a reduction to around 337 kg.

Concluding, this analysis confirms the relevant role played by landfill tax in the promotion of landfill diversion, in a study relative to the 20 Italian regions observed over the periods 1999-2008. We reconstruct for the first time a dataset on the history of the tax which is currently unavailable from official sources, and also for the first time we present evidence of landfill tax effectiveness through a wide and relevant panel dataset.

3. Conclusions

We analyze the effect of a landfill tax in context of decentralized regional implementation. As far as we know this is the first time that a landfill tax is empirically evaluated taking into account both cross section heterogeneity and time dynamics. This is possible on the basis of the Italian landfill tax that goes back to 1996. We have originally recovered the panel regional dataset covering 1999-2008 through direct interviews to regional officers. The heterogeneous implementation – in its levels and time variation- influences landfill diversion in accordance with our research hypothesis. The hypothesis that both an higher level of and an increasing – over time - landfill taxation drives down landfilling per capita of municipal waste cannot be rejected. Fixed effect models that capture any kind of regional idiosyncratic effects show that increasing landfill taxation significantly reduces landfilling. Economic and statistical significance are both large. In addition, we find that population density is the 'market' factor that drives down landfilling through the action of land opportunity costs and health costs. The intensity of Incineration in the region also drives down landfilling. Thus, policy, economic and technological factors all play a role. It is worth noting from a spatial management and policy perspective that instead the actions of nearby regions in terms of landfilling and incineration do not influence the regional performance. Each region has acted alone without interaction effects.

This evidence, which for the first time soundly demonstrate the effectiveness of landfill taxes on the basis of a large, long relevant dataset, calls for further – coordinated – increases in landfill taxation, complemented by stricter waste management strategies, in order to reach EU targets regarding management and disposal of municipal waste.

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Table 1 – Landfill taxes in Italy by Region 1999-2008 (€ per tonne)

Region	**Tax range 1999 2008**
Piemonte	10.33-25.00
Valle d'Aosta	5.17
Lombardia	12.91-15.49
Trentino Alto Adige	11.36
Veneto	25.82
Friuli Venezia Giulia	15.49
Liguria	10.33
Emilia Romagna	18.08
Toscana	15.49-16.98
Umbria	25.82
Marche	15.49
Lazio	12.91
Abruzzo	20.52
Molise	10.50
Campania	5.17
Basilicata	11-25
Puglia	11-15.50
Calabria	10.33
Sicilia	12.36
Sardegna	15.50

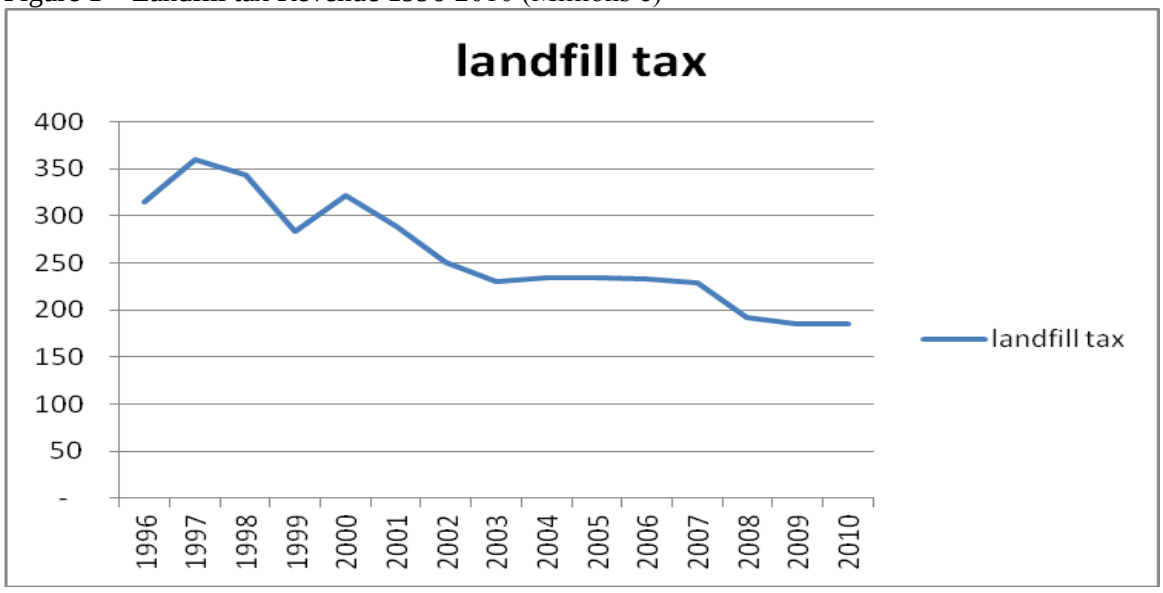
*Data over 2010-2012 are available upon request

Table 2 – Main Research Hypotheses

Landfill taxation in the region	*Higher/increasing taxes negatively correlate to landfilled waste per capita since they incentive dynamic reallocation of disposal towards incineration and possibly more recovery of materials in waste management.*
Landfill taxation in contiguous regions	*The higher the value, the more likely waste is not 'exported' to other nearby regions.*
Incinerated waste per capita in the region	*The higher the value, the more likely waste is not landfilled due to technological installed capacity*
share of separated collection of waste	*The higher the value, the more likely waste is not landfilled in the coming year*
Incinerated waste per capita in contiguous regions	*The higher the value, the more likely waste disposal is 'exported' to other nearby regions due to nearby technological installed capacity.*

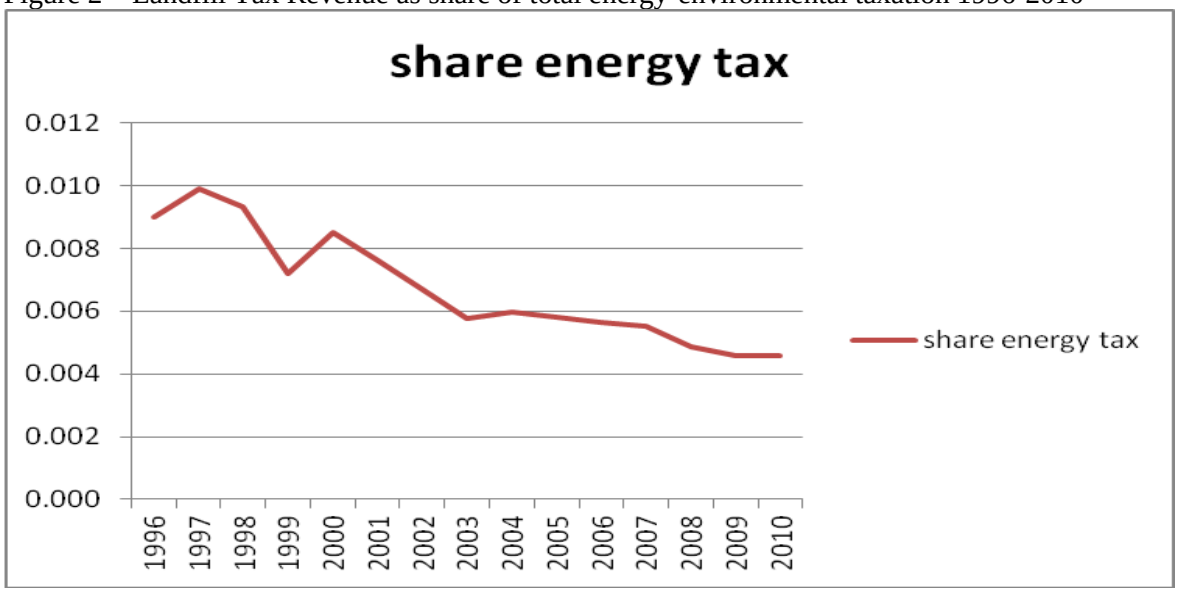
All variables used for testing implications show cross section and time related variation.

Figure 1 – Landfill tax Revenue 1996-2010 (Millions €)



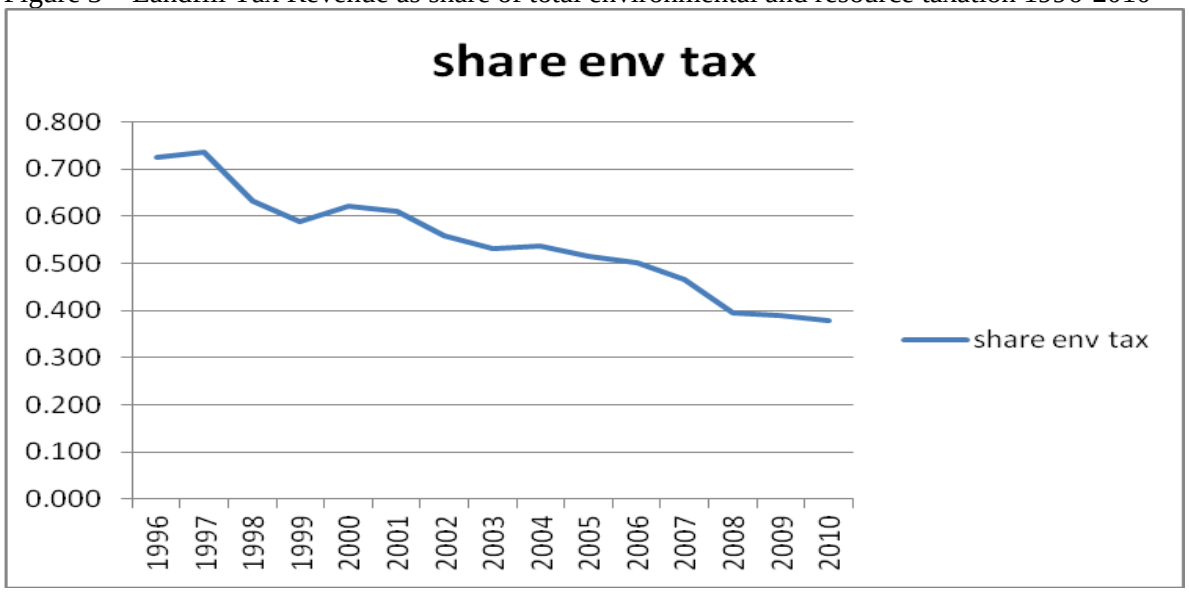
Source: ISTAT Rome

Figure 2 – Landfill Tax Revenue as share of total energy-environmental taxation 1996-2010



Source: ISTAT Rome

Figure 3 – Landfill Tax Revenue as share of total environmental and resource taxation 1996-2010



Source: ISTAT Rome

Table 3. Descriptives and Data sources

Acronim	Variable Description	Obs	Mean	St. Dev.	Min.	Max.	Source
Landfilled	Landfill waste, Kg per capita. (log in the analysis)	200	344.8817	120.4124	41.9154	618.2991	APAT/ISPRA
GDP	GDP per capita, 1999 thousand Euro. (log in the analysis)	200	22687.84	5866.67	12423.5	34154.6	ISTAT
Popdens	Population density, inhabitants/Km2. (log in the analysis)	200	177.6093	106.1145	36.43	427.7	ISTAT
Turism	Total touristic presences. (log in the analysis)	200	17525640	14885240	554459	6.15e+07	ISTAT
Incinerated	Incinerated waste, Kg per capita. (log in the analysis)	200	35.8279	48.0735	0	185.7825	APAT/ISPRA
Recycling	Share of Recycling on total waste management (log in the analysis)	200	18.8507	13.8835	0.7	56.8	APAT/ISPRA
Landfill tax	Landfill tax, euro per Kg (log in the analysis)	200	0.0149	0.0059	0.0051	0.0258	Direct survey / web sites / official documents
CONTtax	Landfill taxation in contiguous regions (log in the analysis)	200	0.0148	0.0056	0	0.0258	
CONTinc	Average Incinerated waste, Kg per capita in contiguous regions (log in the analysis)	200	31.1150	32.1241	0	126.258	APAT/ISPRA
Soccap	Electoral turnover Share (At provincial Level, %)	200	82.0263	4.6901	70.085	89.275	Home Ministry
Employment	Employment/inhabitants.	200	0.40	0.065	0.2716	0.4960	ISTAT

Table 4. Estimation Results

	I (RE)	**I (FE)**	**II**	**III**	**IV**	**V**	**VI**	**VII**
GDP	-1.1670***	-0.5177						
Popdens	-0.3698	-4.9285**	-6.4743***	-5.8986***	-8.7874***	-9.1953***	-6.7671**	-8.0673***
Tourism	0.1285	0.0012						
Landfill tax			-0.17391**	-0.1754***	-0.20544***	-0.1889***	-0.1717**	-0.8464**
CONTtax				-0.2247				
Incinerated					-0.2015***	-0.2232***	-0.2243***	-0.2152**
CONTinc						0.1130		
Recycling (t-1)							-0.0077	
Region fixed effect	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hausman		22.49 (0.0001)						
Instruments								GDP, Social capital, Employment
Overid test								0.689
N	200	200	200	200	200	200	180	200

Cluster-robust standard error, Cluster unit: Region. **,*** indicate significance at respectively 5% and 1% level.