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REGIONAL AND PROVINCIAL PANEL DATA EVIDENCE FROM ITALY

MASSIMILIANO MAZZANTI, ANNA MONTINI & FRANCESCO NICOLLI

Embedding Landfill Diversion in Economic, Geographical and Policy Settings

Regional and provincial panel d  evidence from Italy

Massimiliano Mazzanti, Anna Montini & Francesco Nicolli [♣]

Abstract

This paper analyses the process of delinking for landfilling trends embedding the dynamics in a frame where economic, institutional, and geographical and policy variables enter the arena and play their role. On the basis of the recently observed decreasing path of landfilling occurring at EU level, we aim at investigating in depth what main drivers may be responsible for such a phenomenon, and whether differences may be observed focusing the lens on a decentralised provincial based setting. We exploit a rich panel dataset stemming from Official sources (APAT, Italian environmental agency) merged with other provincial and regional based information, covering all the 103 Italian provinces over 1999-2005. Such an extended, decentralised and recent source of data is of major interest for investigations dealing with waste processes and policy valuation, where evidence is typically scattered and rare, given paucity of high quality data. The case study on Italy is worth being considered provided that Italy is a main country in the EU, thus it offers important pieces on information on the evaluation of policies like the 1999 landfill Directive. Then, its problematic economic, institutional and environmental performance heterogeneity allows an interesting analysis of how economic and policy levers impact on the dynamics of landfilling in such settings. Finally, being waste management and landfill policies implemented at a much decentralised level, it provides food for thought for policy making processes that have operated or will operate along similar directions. Evidence shows that the observed decoupling between economic growth and landfilling is driven by a mix of structural factors, as population density and other waste management opportunity: local opportunity costs and landfill externalities matter in shaping waste policies and local commitment to landfill diversion. But not only structural factors are relevant. If on the one hand landfill taxation is not arising as a significant driver of the phenomenon, even at the more coherent regional level, where the tax is implemented, waste management instruments, when we exploit the provincial dataset, are associated to high significant negative effect on Landfilled waste. A good performance on managing waste according to economic rationales helps reducing the amount that is landfilled. In association to the features of the tariff system, we also underline the key role played by the share of separated collection: where it is higher. Both the evolution of collection and tariff system are joint factors that may drive a wedge between the comparative waste performances of northern and southern regions. We finally note that lock in effects linked to the intensity of incinerator sites in the area are relevant for landfilling: though quite obvious, past investments in incineration lock in the region in this technological path, which may be associated to less opportunity cost and lower external effects. The lock in effect driven by the number of landfill sites in the areas is instead significant, a bit counterintuitive perhaps, only when analysing regional data. Summing up, landfill diversion is stronger where the economic cost deriving from high population density, a structural factor, are higher, and waste management collection systems and economic instruments are associated to higher performances. The main economic driver is just weakly impacting, but this is plausible since is more distant to landfilling with respect to waste generation, and landfilling. We may affirm that just relying on the endogenous path characterised by landfilling and economic growth (the baseline Environmental Kuznets Curve scenario) is not assuring delinking. Some policy actions are needed to affect the shape of delinking.

JEL: C23, Q38, Q56

Keywords: Landfill policies, incineration, landfill tax, policy effectiveness, waste management, delinking, landfill trends, Kuznets curves

[♣] Respectively University of Ferrara, University of Bologna and University of Ferrara, Italy. Corresponding author Massimiliano Mazzanti (mzzmsm@unife.it).

Introduction

The aim of reducing landfilling is a primary aim of European environmental policies, as long as climate change. The effectiveness of European policies is to be achieved by a sound implementation at decentralised level, where waste is generated and disposed of and polices are implemented.
At European level efforts towards reducing landfilling have been a priority according to the waste hierarchy. As a consequence, one of the pillar of EU waste strategy is the 1999 Landfill Directive (EEA, 2007), that is then operatively implemented at decentralised member state level in association to national actions regarding waste management, such as separate collection, recycling, incineration, and pricing of waste uses and disposal. Such actions are devoted towards the aims of diverting waste from landfill and reducing waste generated at source, thus obtaining a decoupling at different stages of the waste production chain.
Indicators of 'decoupling' are becoming increasingly popular in detecting and measuring improvements in environmental/resource efficiency with respect to economic activity. Extensive research on decoupling indicators, for reporting and policy-evaluation purposes, is being carried out by the Organisation for Economic Cooperation and Development (OECD, 2003, 2002). Various decoupling or resource-efficiency indicators are included in the European Environment Agency's state-of-the-environment reports (EEA, 2003a,b,c). The EU policy 'thematic strategies' on both resources and waste, entail reference to 'absolute' and 'relative' delinking indicators (EC, 2003a,b; Jacobsen et al., 2004): the former being a negative relationship between economic growth and environmental impacts, the latter a positive but decreasing, in size, association. A positive lower than unity elasticity in economic terms.
As recognised by the EEA "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. It is also important because there is a growing interest in sharing best practice and exchanging national-level experience across Europe, with the common goal of achieving more cost-effective solutions to the various problems being faced" (EEA, 2007).
The EEA shows that countries can be categorised under three waste management 'groupings', according to the strategies for diversion of municipal waste away from landfill and the relative shares of landfilling, material recovery (mainly recycling and composting) and incineration. The first grouping comprises countries which maintain high levels of both material recovery and incineration, and which have relatively low landfill levels. The second grouping brings together countries with high material recovery rates and medium incineration levels and where there is a medium dependence on landfill. The third grouping contains those countries whose material recovery and incineration levels are both low and whose dependence on landfill is relatively high (EEA, 2007, 2008). Though northern Italy is rapidly evolving towards high level of recycling composting and incineration strategies, the average figure for the country is still dominated by landfilling as recent dramatic 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 stabilised, trend for waste generation.
This paper analyses the process of delinking for landfilling trends embedding the dynamics in a frame where economic, institutional, geographical and policy variables enter the arena and play their role. On the basis of the recently observed decreasing path of landfilling occulting at EU level, we aim at investigating in depth what main drivers may be responsible for such a phenomenon, and whether differences may be observed focusing the lens on a very decentralised provincial based setting. We exploit a rich panel dataset stemming from Official sources (APAT, Italian environmental agency) merged with other provincial and regional based information, covering all 103 Italian provinces over 1999-2005. Such an extended, decentralised and recent source of data is of major interest for investigations dealing with waste processes and policy valuation, where evidence is typically scattered and rare given paucity of high quality data. This evidence is complementary to EU level analyses (Mazzanti and Zoboli, 2008; Andersen et al 2007)[1] on driving forces of past and future waste trends, and is a consequence of recent studies on waste generation drivers in Italy, showing that Environmental Kuznets Curve (EKC) evidence is still far from being a real fact for all regions, and that waste strategies may play a role complementary to exogenous drivers as income (Mazzanti et al., 2008a,b).
The value added of this paper is manifold. Firstly, it offers unique evidence on landfill diversion trends. This is highly relevant to add food for thought in waste analyses, mainly suffering from lack of robust econometric panel based evidence. Secondly, in doing this it exploits a wide array of drivers related to economic, geographical

[1] See also EEA (2007, p.7, fig.1) that shows historical and projected (to 2020) generation and landfilling trends: the former is not associated to delinking, landfilling to weak delinking or just stabilization. Country heterogeneity still remains a problem as long as critical regional hot spots.

and policy factors. It thus presents outcomes useful for both ex post landfill policy evaluation and assessment of Kuznets delinking trends for landfilling. Policy levers are investigated both at the side of waste management level (collection) and at disposal final level (landfill tax, incineration regional strategies), in order to check direct and indirect effects along the waste management - disposal chain. Third, it relies on a much decentralised dataset, a level at which Kuznets shapes may be assessed more robustly since they exploit richer heterogeneity. The interest is even higher for Italy that presents a high structural diversification between northern and southern areas, differences that show their relevance especially in waste management and disposal performances. Fourth, the analysis is a complement to EU level panel based investigations on delinking and policy evaluation for waste generation, recycling and landfilling, and to analysis on waste generation delinking trends for Italy we have carried out in recent years. The whole set of evidence is an important source of information for policy makers and researchers on the set of dynamics operating in the waste sector.
The case study on Italy is worth being considered provided that Italy is a main country in the EU, thus it offers important pieces on information on the evaluation of policies like the 1999 landfill Directive. Then, its problematic economic, institutional and environmental performance heterogeneity allows an interesting analysis of how economic and policy levers impact on the dynamics of landfilling in such settings. Finally, being waste management and landfill policies implemented at a much decentralised level, it provides food for thought for policy making processes that have operated or will operate along similar directions.
The paper is structured as follows. Next section presents a short survey of the studies on waste and delinking, that highlights the lack of comprehensive empirical analyses on landfilling, compared to waste generation and in general to other environmental issues and other analyses regarding landfilling, evaluation of costs and benefits as one among the others. Section 2 presents the empirical model and the panel data source. Section 3 comments on the empirical evidence at both regional and provincial level. Section 4 concludes with policy implications and suggestions for further research.

1. Waste generation and disposal: the state of the art of empirical literature

We shortly survey the still scarce evidence on waste delinking and waste management and policy tools evaluations. The main aim of this short survey is to highlight the incremental value of our paper and suggest future yet unexplored, research directions. We group these works by the geographical area of analysis and focus (EKC, waste drivers, policy evaluation, etc.).
In spite of the significant environmental, policy and economic relevance of waste issues, there is very little empirical evidence on delinking even for major waste streams, such as municipal and packaging and other waste streams. Analyses of policy effectiveness are also scarce. Works oriented towards waste management optimization or evaluation of externalities largely prevail, regarding mainly landfill and also other waste disposal strategies. Some purely theoretical analyses on waste management and landfill management have also appeared (Calcott and Walls, 2005; Daskalopoulos et al., 2004; Andre and Cerda, 2004; Ozawa, 2005) The focus on cost benefit analyses and landfill siting decision has prevailed so far, partly due to the lack of reliable data at country level and within country level (Pearce, 2004)[2]. As said, only recently, as example, the EU (EUROSTAT data) and some countries provide detailed and reliable (panel) data that can provide robust empirical insights on diverse waste issues. The analysis of endogenous and exogenous drivers, including policies, is an important field, this paper belongs to, that bring together environmental Kuznets curves analyses (EKC, or WKC, Waste Kuznets Curve, for waste)[3] and ex post policy effectiveness studies.
Some evidence at the macro level, exploiting cross country regression analysis of data from the eighties, has been first presented in the international report which gave birth to the EKC literature (World Bank, 1992). Recent reports (DEFRA; 2003) present positive elasticities of waste generation to income, as a primary policy concern: in terms of CO_2, which nevertheless is associated with some evidence of a Turning Point (TP) in some recent studies, waste generation seems still to be characterised by a strict relationship between economic drivers and environmental pressures.

[2] We quote among the others Powell and Brisson (1995), Miranda et al (2000); Eshet et al (2004), Brisson and Pearce (1995), Dijkgraaf and Vollebergh (2004), Seok Lim and Missios (2007). Recently, Caplan et al (2007) offer an example of how economic evaluation techniques may inform landfill siting process.
[3] We refer to Cole et al. (1997), Dinda (2004), Stern (2004, 1998), for major critical surveys and a discussion on the theoretical underpinnings of delinking and EKC, which mainly analyze air and water emissions, mainly CO_2, with a limited focus on waste streams.

One of the first WKC studies is by Cole et al. (1997), who find no evidence of an inverted U-shape in relation to municipal waste. They use municipal waste data for the period 1975-90, for 13 OECD countries, but find no TP, with environmental indicators (municipal waste generation) monotonically increasing with income over the observed range. Over almost the same period (1970-1994), Seppala et al. (2001) also found no evidence of delinking regarding direct material flows, for five industrialised countries including Japan, the US and Germany. We can expect, therefore, that the evidence varies for waste generation and waste disposal. In fact, Fischer-Kowalski and Amann (2001) analyse the richest OECD countries and find that the intensity of material input with respect to GDP shows relative but not absolute delinking, with a material growing over 1975-1995 for all countries. They note that absolute delinking holds for landfilled waste but not for waste generated.

Few WKC studies include waste policy analyses. Karousakis (2006), which is not primarily focused on WKC, deals with policy evaluation, and presents evidence on the determinants of waste generation and the driving forces behind the proportions of paper/glass recycled, and the proportion of waste land-filled. The panel database is for 30 OECD countries (four years over 1980-2000, 120 observations). Municipal solid waste (MSW) increases monotonically with income. Urbanisation exerts even a stronger effect on waste generation, while the time-invariant policy index is not significant. This is one of the few studies that studies socio-economic and policy drivers for landfill diversion. The evidence is nevertheless undermined by the not always high quality of OECD data on waste indicators, given we pool together very different countries and different waste measurement systems. Then, the policy index is generally capturing environmental policy commitment of countries, not specific waste management and policy indicators. It is a first analysis to start with towards richer analyses.

For European countries, Mazzanti and Zoboli (2005) and Mazzanti (2007) find neither absolute nor relative delinking. There is not WKC evidence for municipal waste and packaging waste from European panel datasets respectively, from 1995 to 2000 and 1997 to 2000. Estimated elasticities of waste generation with respect to household consumption are close to unity. Andersen et al. (2007) recently estimated waste trends for EU15 and EU10 new entrants, and found that waste generation is linked to economic activities by non-constant trend ratios, which is in line with WKC reasoning. A somewhat descriptive analysis of delinking in EU countries provides forecasts in favour of relative delinking; it in any case does not confirm WKC evidence. Projections for 2005-2020 for the UK, France and Italy, show a growth in MSW of around 15-20%, which may, at least at first sight, be compatible with relative delinking with respect to GDP and consumption growth. Mazzanti and Zoboli (2008) is a new study that analyses Eu15 and Eu25 panel data for all waste trends (from generation to landfilling including recycling and incineration) over 1995-2005, finding some weak evidence of delinking and signals of policy effectiveness. It is one of the first study to provide robust empirical evidence on landfilling drivers at international level. Policy commitment seem to be an important pillar of landfill diversion.

As already said, the economic analyses on landfilling have predominantly focused on cost benefit assessment of relative externalities. Some studies have appeared in relation to the evaluation of Eu landfill Directive and the widely known experience of the UK landfill tax implementation dated back to 1996 (informed, rare case, by a specific evaluation of externalities (Turner et al, 1998)). Such studies, given lack of data, present interesting but only qualitative assessments. During the first phase of the Uk landfill tax implementation, Morris et al (1998) offered 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) consequently update the analysis highlighting some operational weaknesses and debating some preliminary reviews at that period. The latter author links the Eu directive with national Uk implementation. Another interesting assessment, quite pessimistic in its conclusion, is offered by Martin and Scott (2003), who stress that tax has failed to significantly change the behavior of domestic waste producers. The landfill tax is intended to contribute to a transition away from landfilling of waste, towards recovery, recycling, re-use and waste minimization. They affirm that available evidence finds that there is reasonable data to monitor progress towards recycling, but not for re-use or waste minimization.

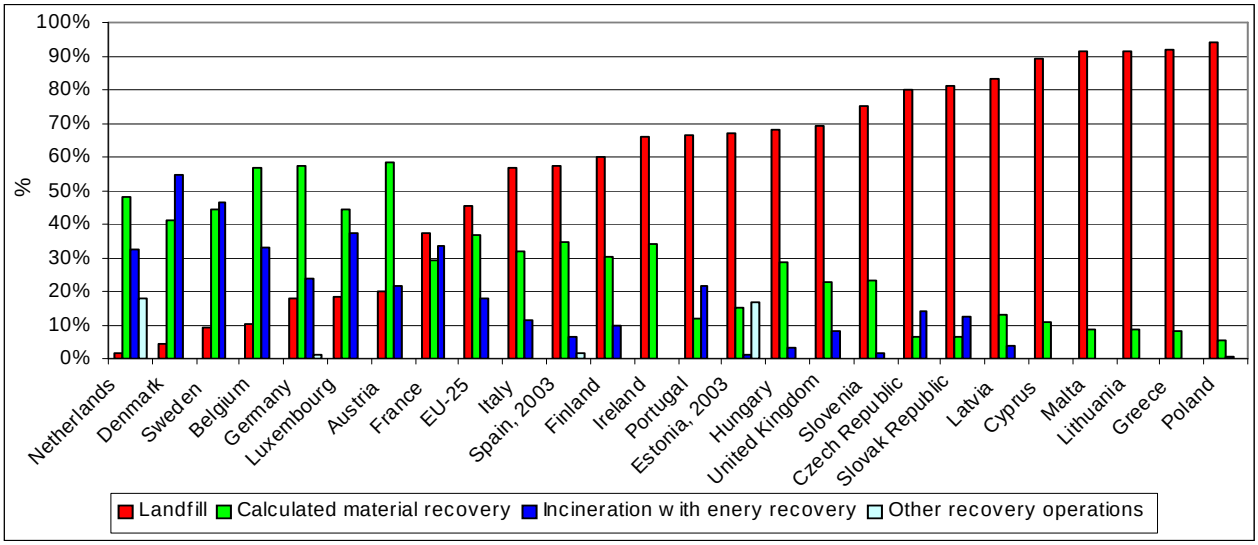
Among other more recent works, we refer the reader to Davies and Doble (2004), who survey the UK landfill tax from its introduction, offering insights on future evolutions, criticalities, and externality evaluation. Such works were by definition of qualitative nature given the lack of data and the aims of specific analyses.

Very recently, a UK specific regional assessment on waste strategies is offered by Phillips et al (2007). Regional based analyses are nevertheless a rarity, if any.

Outside UK, analyses are rare. Taseli (2007) recently presented an assessment of EU landfill directive on Turkey, a potential incoming country that may be compared to some eastern Eu newcomers. The study highlights the great difficulties of such countries in achieving the targets even in the long run, and shows a clear analysis of the EU framework. Though the analysis extensively uses data in support of arguments, statistical investigation is not the aim and a possibility.

This survey of the literature, which is still slowly developing even in the waste framework, lacks, as noted, in depth investigation of driving forces and policy effects, and case studies on a single country or a homogenous policy relevant over a sufficiently long period of time. Landfill oriented analyse are in addition the minority even within the waste realm. In our study we try to bring together different pieces of research interests: the analysis of exogenous and endogenous landfill diversion drivers, by exploiting the intrinsic higher heterogeneity of decentralised regional data. A specific focus is to be devoted to waste management and policy levers. It is worth noting, and we will comment on this point, that some waste management strategies may be to some extent endogenous, being driven by income and geographical differentiation. The different waste commitment and performance of northern and southern regions in Italy is a clear example.
Overall, to conclude the section, landfilling is still the predominant treatment option for the EU's municipal waste, and Italy is a country under pressure and constant monitoring and evaluation of performances. In 2004, about 45 percent of the total municipal waste was landfilled while 18 percent was incinerated. However, there are significant differences in how dependent countries are on landfilling. Figure 1 clearly shows that several countries – the Netherlands, Denmark, Sweden and Belgium – have already arrived at very low landfilling rates. Those countries not only have a substantial level of incineration; they also have a high level of material recovery. In general, there seems to be two strategies for diverting municipal waste from landfill: to aim for high material recovery combined with incineration, or to aim for material recovery which includes recycling, composting and mechanical biological treatment (EEA, 2007).

Figure 1. Use of landfilling, incineration and material recovery as treatment options in 2004



Source: EEA (2007), Eurostat Structural Indicators on municipal waste generated, incinerated and landfilled, supplemented with national statistics.

2. The Empirical framework

2.1 Data sources and research hypotheses

The analysis considers two datasets, a regional and a provincial one, that exploit the statistical information in all available yearly editions of the Italian Environment Agency's waste report (APAT, 2001, 2002, 2003, 2004, 2005, 2006). These reports which present a very rich set of waste data produced according to Eurostat and the European Environmental Agency guidelines (EEA, 2003a,b,c).

The provincial dataset includes data on MSW generated (collected) and landfilled in all the Italian Provinces (n=103) and covers the period 1999-2005. We merge these data with official data on economic drivers at provincial level. Although consumption is often indicated and used as a coherent driver when analysing waste trends (Andersen et al., 2007), consumption province level data were not available, making value added the only reliable and available economic driver. Additional socio-economic variables relevant for waste, such as MSW generated and incinerated, share of separately collected waste and population density, are tested. We also check for tourist-related flows, a crucial issue in waste generation and collection for many Italian provinces. The analysis finally includes decentralised policy-related variables and, in particular: (a) the share of provincial municipalities and the provincial population covered by the new 'waste tariff' regime, which substitutes for the

old 'waste tax' regime; and (b) the percentage of waste management costs covered by the tariff. With respect to the policy-related variables, the waste management *tariff* was introduced by Italian law no. 22/1997, which substitutes for the old waste management *tax*; the latter, however, still prevails in many Italian municipalities because the provisions of law 22/1997 allow the transition phase to be quite gradual and slow. The old tax was calculated on the size of household living spaces, while the tariff is based on principles of full-cost pricing of waste management services[4]. Effective implementation of the tariff system nevertheless remains highly dependent on local policy decisions and practices and is partly based on the choice of the municipality. Early implementation of the new tariff-based system may be a sign of policy commitment. We note that implementation is heterogeneous even across areas with similar incomes and similar social 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, is not visible in the short term.
The regional dataset includes all the information of the provincial dataset plus data about yearly household consumption expenditure per component and landfill tax (both the variable are available only at regional level) Tables 1 and 2 present the dependent and independent variables, their descriptive statistics and the related research hypothesis according to the provincial and regional dataset respectively.

2.2 The model

We then estimate a model by specifying our research hypothesis with the following general panel based reduced form (Dijkgraaf and Gradus, 2004, Stern, 2004):

(1) $\log(\text{landfilled MSW per capita}) = \beta_{0i} + \alpha_t + \beta_1 \log(\text{economic driver})_{it} + \beta_2 \log(\text{socio-economic factors})_{it} + \beta_3(\text{environmental policy}) + \varepsilon_{it}$

where the first two terms are intercept parameters that vary across regions or provinces, and years.
Different specifications are tested by including either landfilled waste per capita (or per area) or landfilled waste in total terms as dependent variable; accordingly, value added is either per capita or total.
Other socio-economic factors are added to the core specification as controls and possible additional significant drivers of waste generation. In our model, they include the population density, the percentage share of separately collected waste, the incinerated waste per capita, the tourist attendance, and related to the environmental policy, the recovery capacity of waste service cost, and the share of population (or municipalities) subject to waste tariffs (rather than waste taxes). The main research hypotheses associated with the examined explanatory factors are commented on below and are summarised in Tables 1 and 2.

[4] There is a part covering fixed costs and a part aimed at covering 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 to 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 systems.

Table 1. Descriptive statistics and research hypothesis (*provincial* dataset): dependent and independent variables

Acronym	Variable description	Mean	min	max	Research hypothesis
LAND-WASTE	MSW yearly generated and landfilled (kg per capita)	326,38	0	1133,78	Dependent variable
VA	Provincial yearly value added per capita (€2000)	17653.6	9369.12	28796.07	Positively correlated with income, the objective is assessing whether relative or absolute delinking is present
DENS	Population/surface (inhabitants/km2)	244.10	36.43	2640.92	Positive and negative correlations may emerge depending on the role of factors like economies of scale and land opportunity costs occurring in urban and densely inhabited areas
COLLEC	Share of separated collection (%)	18.40	0.03	67.57	Negatively affecting landfilled waste per capita
INC-WASTE	MSW yearly generated and incinerated (kg per capita)	49.93	0	581.81	Negatively affecting landfilled waste per capita
TAR POP	Share of population living in municipalities that introduced a waste tariff substituting the former waste tax (%)	9.00	0	99.72	Possibly reducing MSW generation through indirect feed back effects, though the direct effect is at waste management level. Possible endogeneity given the positive correlation with respect to income.
TAR MUN	Share of municipalities that introduced a waste tariff substituting the former waste tax (%)	5.03	0	100.00	
COST-REC	Cost recovery of waste management services (tax/tariff revenues on variable service costs, only one data for 2004) (%)	85.61	53.3	104.2	
TOURIST	Tourist yearly attendance (per capita)	7.18	0.40	58.83	Positively affecting landfilled waste per capita

Table 2. Descriptive statistics and research hypothesis (*regional* dataset): dependent and independent variables

Acronym	Variable description	Mean	Min	max	Research hypothesis
LAND-WASTE	MSW generated and landfilled (kg per capita)	358.07	80.00	620.00	Dependent variable
GDP	Gross domestic product per capita (€2000)	20331.3	12740.92	27904.56	Positively correlated with income, the objective is assessing whether relative or absolute delinking is present
CONS	Household consumption expenditure (per component)	9716.78	6504.48	13423.56	Positively correlated with income
DENS	Population/surface (inhabitants/km2)	176.12	36.43	426.11	Positive and negative correlations may emerge depending on the role of factors like economies of scale and land opportunity costs occurring in urban and densely inhabited areas
COLLEC	Share of separated collection (%)	15.85	0.70	47.76	Negatively affecting landfilled waste per capita
INC-WASTE	MSW generated and incinerated (kg per capita)	36.00	0	170.00	Negatively affecting landfilled waste per capita
LAND-TAX	Landfill tax (€/kg, only one data for 2004-2005)	0.015	0.005	0.023	Negatively affecting landfilled waste per capita
TAR POP	Share of population living in municipalities that introduced a waste tariff substituting the former waste tax (%)	8.91	0	65.68	Possibly reducing MSW generation through indirect feed back effects, though the direct effect is at waste management level. Possible endogeneity given the positive correlation with respect to income.
TAR MUN	Share of municipalities that introduced a waste tariff substituting the former waste tax (%)	4.19	0	36.49	
COST-REC	Cost recovery of waste management services (tax/tariff revenues on variable service costs, only one data for 2004) (%)	63.40	47.05	72.03	
TOURIST	Tourist yearly attendance (per capita)	8.44	1.72	41.26	Positively affecting landfilled waste per capita

Only with provincial data, a semi-logarithmic model is also estimated to deal with the zero values that correspond to the absence of landfilling site[5]. Spatial econometric analyses are definitely a future extension that investigates the role of flows between provinces by analysing contiguity and distance.

3. Empirical evidence

3.1 Regional analysis

The analysis on the regional dataset grounds on a panel of 140 observations (20 regions observed over 7 years: 1999-2005). Most variables are time variant, thus we can compare REM and FEM through the usual Hausman test. We subdivide the empirical investigation and comments in three different but consequential steps: the analyses of baseline specifications, the assessment of additional structural & socio-economic factors, the effects of policy elements. Regarding the latter, some capture both cross regions and time heterogeneity/dynamics, others (the landfill tax) do not vary over time due to data availability. Nevertheless, landfill tax are not usually adjusted frequently year by year so that this lack of variance is a minor problem compared to the value of having a fully decentralised information on landfill tax for all regions of a country like Italy. This analysis is properly fitting the assessment of landfill tax implementation given that this levy is managed by the regional authorities.
The model of reference in the regional analysis is

(2) $\log(\text{landfilled MSW per capita}) = \beta_{0i} + \alpha_t + \beta_1 \log(\text{gross domestic product})_{it} + \beta_2 \log(\text{socio-economic factors})_{it} + \beta_3(\text{environmental policy})_{it} + \varepsilon_{it}$

where the first two terms are intercept parameters that vary across regions, and years.
All variables are in logarithmic forms unless they present 0 values. This is not the case, differently from the provincial level analysis (as we will see), for the dependent variable. At regional level, landfilling is not and probably will never be zero for some regions, even if facing decreasing landfill of waste.

First, we comment on the baseline specifications. Linear forms are not significant, though the coefficient associated to GDP shows an expected negative sign (Tables 3 and 4). This negative relationship becomes significant when introducing the squared term: the U shape shows a potential up turn of the relationship. Nevertheless, this is currently only a potential threat: in fact the observed turning point is around 19000€ per capita, and the average is around 20000€. It signals that, without corrections, becoming richer may increase once again the amount of waste landfilled per capita[6].

Table 3. Landfilled waste per capita: regional data, period 1999-2005 (fixed effects model, FEM, and random effects model, REM)

Specification / Variables	1	2	3	4
Constant	-	2.225 (0.420)	-	148.78 (0.188)
GDP/POP	-0.2819 (0.737)	-0.3350 (0.229)	-85.93 (0.006)***	-30.11 (0.189)
(GDP/POP)^2	…	…	4.35 (0.006)***	1.512 (0.194)
N	140	140	140	140
Model§	FEM	REM	FEM	REM
Hausman test (p-value)ϛ	0.9464		0.0207	

Note: Coefficients and significance are shown (10%*; 5%**; 1%***). § FEM=fixed effects model, REM=random effects model. ϛ p-value < 0.10 favour FEM.

[5] Five provinces have, in the observed period, no landfill site. A few observations more present zero values due to the closure of landfilling sites or a previous absence of landfilling sites during the years 1999-2005.
[6] We also show, in Table 4, estimates when using landfilled waste per regional area, not per capita, as dependant variable. Estimates do not substantially differ, so we do not comment on further. We just notice that, according to landfill external and market costs, per capita measures better capture the intensity of the problem in a given area.

Table 4. Landfilled waste per area: regional data, period 1999-2005 (fixed effects model, FEM, and random effects model, REM)

Specification / Variables	1	2	3	4
Constant	-	2.084 (0.661)	-	345.61 (0.010)**
GDP/POP	-0.2781 (0.732)	-0.2826 (0.557)	-84.30 (0.005)***	-70.14 (0.010)**
$(GDP/POP)^2$	…	…	4.276 (0.005)***	3.549 (0.010)**
N	140	140	140	140
Model§	FEM	REM	FEM	REM
Hausman test (p-value)ϛ	0.9946		0.4768	

Note: Coefficients and significance are shown (10%*; 5%**; 1%***). § FEM=fixed effects model, REM=random effects model. ϛ p-value < 0.10 favour FEM.

In addition, this baseline model may be deficient in explaining the landfilling trend. In fact, when including the most relevant control structural factor, population density, it arises highly significant, while GDP loses its explanatory power (Table 5). It seems that structural factors matter more than pure economic drivers. It is not signalling that waste are not economically driven: the significance of density, well expected, shows that where opportunity costs are higher (in urban areas, densely populated areas) and disamenity effects influence more people, landfill diversion is stronger. As an example, landfill studies have flourished in far east situations where the value of land is especially high and population density reaches world peaks (Lang, 2005, Ozawa, 2005). The size of the coefficient is high, as well its statistical significance.

More than GDP, that instead explains waste generation (Mazzanti et al., 2008), other factors impacts on the last stage of waste disposal. GDP is not, coherently, a direct factor of impact. It may act as indirect lever, as it will be clear below. A bit counterintuitive for a country like Italy, instead, geographical dummies are not significant. This will be confirmed at provincial level. Also tourist flows do not affect landfilling trends, where they instead had an impact on waste generation (Mazzanti et al., 2008).

Secondly, going on with our discussion, we observe that other socio-economic levers also are relevant. One factor, which is hybrid between policy, institutional and local cultural factors, is the share of separated collected waste. As expected, it turns out very significant. It is significant both in a regression together with GDP, and, better, included alone only with density: both the variables are highly significant. All in all, it seems to outweigh the previous mentioned economic effect, being more directly linked to landfill diversion chances. Its coefficients signal that 1% of more separated waste reduces landfill diversion by 0.08-0.2%. This may indicate problems in transforming collection performances in landfill diversion. Some separated collection increases could not (in the short term) automatically generate more innovative waste management, in case the entire filiere is not structured on landfill diversion options and technologies.

It is worth noting that adding relevant socio economic factors generate regressions where the FEM is plausibly chosen as preferred specification, given that we are reasoning around the all population, not a sample of regions.

Table 5. Other specifications with landfilled waste per capita (20 regions, 1999-2005)

Variables	Specification									
	1	2	3	4	5	6	7	8	9	10
Costant	-	2.278	-	3.133	2.29	-	2.924	1.929	-	-
GDP	-0.6829	-0.348	2.362**	-0.4361	-0.255	-.04208	-0.3151	0.4106	-0.7430	-0.5296
Density	-7.34***				-0.166*	-6.93**	-0.2277	-0.2397	-7.74***	-5.89***
North west		0.126								
North east		-0.104								
Centre		0.290								
South										
Islands		0.225								
Separated collection			-0.22***							
Tourist flows				0.0516						
N. incen/area					-25314.2					
N. land sites/area						3449***				
Land tax							-.0554			
Cover cost								-1.430		
TARPOP									0.0007	
TARMUN										-.0062*
N	140	140	140	140	140	140	140	100	140	140
Model§	FEM	REM	FEM	REM	REM	FEM	REM	REM	FEM	FEM
Hausman test (p-value)ᶜ	0.000	-	0.0002	0.3973	-	0.0000	-	-	0.0000	0.0000

Note: Coefficients and significance are shown (10%*; 5%**; 1%***). Empty cells mean the variable is not included in the regression. § FEM=fixed effects model, REM=random effects model. ᶜ p-value < 0.10 favour FEM.

Other waste related structural factors, which we deem exogenous (driven by institutional, policy and geographical factors in the short run), are the ratio of incinerators and landfill sites on both per capita and per area terms. We see that the first factor (incinerators) is not significant, while the number of landfill sites per area drives up the amount of waste that is landfilled. This seems a tautological result; nonetheless it signals and proves the existence of lock in effects due to past investments in disposal sites. Lock in effects may charities any technology, even recycling and incineration options. The decision to invest in a landfill strategy locks in the region for the time on which the investment is carried out, typically not a short term fully reversible phenomenon.

Finally, we test the relevancy of (i) waste management related factors and (ii) regional landfill taxes. It turns out that the latter is not effective. It seems that is not the direct cost of landfill taxes to drive landfill diversion but other opportunity costs (density), and to some extent waste management innovation that increases the financing and the performance of collection and separated collection. The not significant impact of landfill taxes may be due to a quite recent implementation, and more to the relatively low level of the tax, compared to other countries. Nevertheless, we have above noted that even in leading countries as UK, some authors have cast doubt on the effectiveness of its instrument. Waste management may matter more given its centrality in the waste chain. Landfill pricing is only the last option at the end of the waste production filieres. Diversion is driven more by actions taken before the landfill stage is reached.

As far as waste management dynamic are concerned, we check the evolution towards a waste tariff system, from a tax based one, and the share of variable cost covered by the tax. Both elements proxy dynamics of privatisation of the system, intended as moving towards tariffs that are linked to waste produced, and with a full cost recovery strategy in mind. From a pure public good provision to a user oriented approach. Wherein even public utilities may go "private" by changing their objectives and behaviour. Most utilities in Italy are in fact still public owned, or with shared participation: it is the management that changes more than the property of assets.

Though all signs are negative as expected, we only observe a significant coefficient for the variable that captures the share of municipalities, within a region, linked to a tariff. This share is steadily increasing. It shows that more than the share of population, driven by the introduction of the tariff in large municipalities, it is the number of local authorities that matters. In other words, it seems that the joint transition of many municipalities matter

more than that of big cities. Given the high relevancy of governance interconnections between local authorities in waste management in local/regional areas, this is not unexpected.
We will compare such results with the province based analysis that exploits originally provincial data that were aggregated to carry out the regional oriented investigation.

3.2 Provincial analysis

We here present the analysis on province based data. Such dataset offers an higher possibility of investigating landfill diversion determinants by exploiting a much richer heterogeneity and a larger collection of data than the regional one. Thus, it constitutes a robustness test for the regional analysis, and new insights may also come out. Though the two are complement investigations, we may affirm that, besides exception (landfill tax assessment), the province analysis is overall stronger. We nevertheless will see that differences are not many and the two levels of analysis are coherent with each other.
The main methodological problem is the nature of the dependent variable, the landfilled MSW per capita, that, at province level, presents zero values: some (5, as previously noted) of the 103 provinces observed over 1999-2005 have no landfill sites for MSW, and thus no landfilling. Others (e.g. Milan) close landfill sites at a given time, thus the series witnesses zero values after a certain year.
We present and compare outcomes for three specifications of the dependant variable: a semi log model where only the dependant variable is in non logarithmic form, an unbalanced panel where zero values are omitted, narrowing down the units to 658 from 721, and as third best way of coping with the problem, a fully logarithmic specification where we had previously substitute very low values tending to zero in place of 0. This is plausible if we assume that the statistical zeros are in reality very low values of landfilling.
Further investigations could take as object the test and analysis of autocorrelation and heteroskedasticity, and, more important, the eventual specifications of a two stage heckman model, which poses higher complexity, but addresses the eventual selection associated to the 5 provinces which witness no landfill sites over the period for maybe political or idiosyncratic motivations.
The models of reference for the semi-log (balanced panel) and the log-log (unbalanced panel) specifications respectively are then:

(3) landfilled MSW per capita= $\beta_{0i} + \alpha_t + \beta_1 \text{Log(Value added per capita)}_{it} + \beta_2 \text{Log(socio-economic factors)}^2_{it} + \beta_3(\text{environmental policy}) + e_{it}$

(4) $\log(\text{landfilled MSW per capita}) = \beta_{0i} + \alpha_t + \beta_1 \text{Log(Value added per capita)}_{it} + \beta_2 \text{Log(Value added per capita)}^2_{it} + \beta_3(\text{socio-economic factors}) + \beta_4(\text{environmental policy}) + e_{it}$

where the first two terms are intercept parameters that vary across provinces and years.
Added to the core specification as controls and additional drivers of landfilled waste are a set of other socio-economic and policy related factors. Let us comment on main findings.

3.2.1 Semi logarithmic balanced specifications

Semi-log specifications attached to model (3) show the following results. We consequently include, in addition to the baseline speciation with VA and density, one factor at a time, to avoid collinearity problem. Thus, our specifications witness three variables, two of which, VA and density, always present as pillars of the model.
First, though the significance is opposite in the REM model, for the baseline specification (value added as economic driver, and density as structural control factor) in the FEM (strongly preferred by the Hausman test here and in all regressions, which is a plausible result) both show a negative sign, with respectively a 10% and 1% significance (Table 6)[7]. This evidence confirms that delinking relatively with income growth is relevant, but mostly structural factors are impacting and should be included to account for landfill diversion drivers. This confirms regional based analysis.

[7] Quadratic specifications do not arise significant when other controls like density are included.

Table 6. Specifications with landfilled waste per capita (semi-log model, balanced panel), province analysis (N=721, 103 provinces, 1999-2005)

	Specificaton								
Variables	1	2	3	4	5	6	7	8	9
Constant						2.78***	2.92***		
Value added	-0.191*	-0.169	-0.011	-0.20*	-1.59***	-0.21***	-0.164**	-0.142	-0.139
Population density	-1.403***	-1.423***	-1.269***	-1.41***	-0.03***	-0.034	-0.037	-0.809**	-0.726**
Tourist flows		-0.036							
Separated collection			-0.026***						
N. incen/area^				-1492.00					
N. land sites/area^					197.40				
Landfill tax						0.043			
Cover cost							-0.179		
TARPOP^								-0.001***	
TARMUN^									-0.003***
F test (prob)	0.0000	0.0000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Model[§]	FEM	FEM	FEM	FEM	FEM	REM	REM	FEM	FEM
Hausman test (p-value)[ç]	0.000001	0.000001	0.000048	0.00000	0.00000	-	-	0.0227	0.0143

Note: Coefficients and significance are shown (10%*; 5%**; 1%***). Empty cells mean the variable is not included in the regression. Covariate are separately added to the baseline model in order to mitigate collinearity. ^not logarithmic covariates. § FEM=fixed effects model, REM=random effects model. ç p-value < 0.10 favour FEM.

Moving on, when including tourist flows per capita, we observe that the significance of VA decrease under 10%: the only impacting factor is the density of population, related to the aforementioned (see the regional analysis) opportunity costs and environmental impacts, higher and more critical in densely populated areas. Also confirming regional analysis, the macro geographical dummies linked to North, south and centre regions do not seem to explain landfill diversion, a bit counterintuitive.

Instead, a variable that is somewhat related to north-south strong differences regarding performances, the share of separated collection, as above shows its key role in the explanation of the phenomenon. If we look at regression 3 in the table, we observe that VA completely loses its statistical power. The other two are highly significant. If we consider the quite high correlation between VA and the share of separated collection, motivated by the north-south different performances in waste management, that share-related variables maintain a very high significance, as expected. If we instead specify (not shown) a two stage model to address 'policy endogeneity'[8], where in the first step we get the predicted values of separated collection regressed over density and VA, and in the second step we test density (which must be present in both steps) and such predictions as drivers of landfill diversion, the significance of separated collection, in the FEM preferred model, is just 10% (1% in pooled OLS and REM). Overall, the separated collection is a very significant driver of landfill diversion. Observing estimated elasticity values, this means that for a 1% increase in separated collection, the decrease of landfilling is between 0.03-0.05%; not much to some extent, but it may be consistent with the fact that though significant, the decrease in landfill trends is of an order of magnitude less than the increase in recycling, which has dominated so far in Italy as primary strategy to address waste criticalities. CHECK senso On the other hand,

[8] Recent studies have focused on analysing the drivers of environmental regulation, defining endogenous factors (Cole et al., 2006; Alpay et al., 2006). Efforts aimed at setting up environmental policy indexes for climate change, waste and other areas show that developed countries' environmental regulations are more stringent. Consistent with EKC reasoning, policies may result endogenous especially if correlated with income factors at both supply and demand levels (Cagatay and Mihci, 2006). Regarding (paper) waste, evidence is supporting higher demand for waste management and environmental policies in more developed richer countries (Berglund and Soderholm, 2003). At micro level Callan and Thomas (1999), who study the drivers of unit pricing adoption at municipal level, provide evidence for policy (economic instrument) endogeneity with regard demographics, fiscal capacity and socio-economci determinants.

it may signify that waste management strategies are not so effective: a part of separated collection could still be disposed of in landfill sites, if recovery options are not well implemented. Even well performing waste management systems at collection level may be ineffective if disposal options and disposal markets are not developed. Landfilling then remains the last easy resort and solution to any failure occurring in earlier stages of the waste system.
We consequentially test the effect of (i) the number of incinerators per capita and per area, (ii) the number of landfill sites per capita and per area. We recall that the former variables are not in log forms given they present zero values. We note that though the coefficient linked to incinerators is as expected negative, it turns out to be not significant, and similarly the positive sign attached to landfill sites per head and per area is positive and not significant. Lock in effects are here not arsing relevant. Some different insights will be commented on below when addressing the unbalanced model.
At the final level of waste management instruments and landfill tax assessment, some new insights emerge here. If the non significance of landfill taxation is confirmed, the tariff-based variables capturing some features of the transition to a full cost recovery and privately managed (not necessarily privately owned) waste managements system show different insights.
The coverage of variable cost of waste management, not available for all years, is tested on the year 2004 value. Heterogeneity is high across provinces; the coefficient is negative as expected but not sufficiently high in significance[9]. Future analyses could try to exploit full panel data even for this variable[10].
Instead, giving some more relative robustness to the provincial analysis, we find that both the share of population and municipalities covered by a waste tariff instead than a tax impact negatively on landfill diversion. The coefficient is not of large size but significance is at 1% level. This is a signal, emerging coherently more at a decentralised provincial level that waste management instruments may have some indirect impact on landfilling, recalling what we discussed above for the factor of separated collection.

3.2.2 Unbalanced panel analyses

Unbalanced panel estimations related to model (4) show the following results (Table 7). A first difference we note is the significance, as it occurred in the log models at regional level, of the quadratic term. The related turning point is estimated at 19440€, similarly to the above case (regions). It is thus the logarithmic specification that originates a U shape, that seems to suggest, observing the TP, that richer areas could (re) experience a positive relationship between economic growth and waste landfilled.
Population density is confirmed as a main driver of landfill diversion: the sign of the coefficient even in the quadratic specification is negative, and highly significant.
Tourist flows are in this case a significant factor: the negative sign points out that landfill activities are mitigated by the presence of high tourist flows. Opportunity costs of land exploitation and negative externalities are elements that may undermine the profitability of tourist activities. Venice and Rimini are two examples of highly tourist-dense provinces with waste management strategies biased towards recycling and incineration, and away from landfilling. The business of tourism crowds out the "business" of landfill. This is a new interesting result stemming from unbalanced panel estimations.

[9] It is also not significant the interaction term between cost coverage and landfill tax, a variable that captures economic instrument impacts for different levels of waste management.
[10] If we run the analysis just on 2002-2004 for which panel data related to the coverage of variable cost of waste management are available, the variable is still not significant even in FEM model. We note that VA and density coefficients somewhat change signs and significance, highlighting the value added of having a quite long time series instead of an usual short term panel. This proves the value and robustness of our dataset, which exploits a sufficiently long time series and in-depth regional heterogeneity.

Table 7. Specifications with landfilled waste per capita (log-log model, unbalanced panel) province analysis (N=658, 98 provinces, 1999-2005)

Variables	Specificaton										
	1	2	3	4	5	6	7	8	9	10	11
Constant							145.83	144.81			
VA	-51.09**	-52.97**	-24.947	-49.65**	-63.75***	-45.076*	-29.04	-28.46	-60.81**	-66.00***	-78.89***
VA^2	2.587**	2.713**	1.282	2.511**	3.263***	2.284*	1.448	1.439	3.101**	3.374***	4.080***
Population density	-6.28***	-6.96***	-5.20***	-6.53***	-6.321***	-6.03***	-0.036	-0.072	-4.152**	-3.789**	-4.341**
Tourist flows		-0.88***									-0.607***
Separated collection			-0.128**								
N. incen/area^				-18696.2							
Incinerated waste per capita					-5.777***						-5.409***
N. land sites/area						0.058					
Landfill tax							0.393				
Cover cost								-1.157			
TARPOP^									-0.005**		
TARMUN^										-0.011***	-0.011***
F test (prob)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Model§	FEM	FEM	FEM	FEM	FEM	FEM	REM	REM	FEM	FEM	FEM
Hausman test (p- value)ᶜ	0.0007	0.0000	0.0478	0.0015	0.0001	0.0052	…	…	0.0652	0.0739	0.0000

Note: Coefficients and significance are shown (10%*; 5%**; 1%***). Empty cells mean the variable is not included in the regression. Covariate are separately added to the baseline model in order to mitigate collinearity. ^not logarithmic covariates. § FEM=fixed effects model, REM=random effects model. ᶜ p-value < 0.10 favour FEM.

As far as separated collection is concerned, we show as above that the variable is significant. It is worth noting that the fitted values arise here with an increased (at 5%) significance, and more evidently in the unbalanced specification.

Incinerator sites per capita, not per area, turn out to be respectively significant, differently from above: the latter is significant only in the non quadratic model, at 5%, while the former in both linear and non linear specifications, at 1%. In addition, the variable 'incinerated waste per capita is significant, with a strong 1% significance.

This new result gives more robustness to our comments on the relevancy of lock in effects in local waste management strategies. The (increasing) weight of incineration drives down landfilling. Methodologically speaking, it poses the necessity of further investigating selection models that account for "zero" values in data.

The density of landfill sites in provincial areas is instead not significant, tough with a positive coefficient: lock in effects related to landfill site investments emerge at provincial level weak (we recall a significant effect at regional level), while incinerators investments arise as diversion drivers, at least in the unbalanced version of the model.

Focusing on waste management-policy covariates, landfill taxes and cost coverage confirm their meaninglessness in explaining landfill diversion[11]. Finally, the coverage regarding the evolution towards the waste tariff system, both factors (population coverage and municipality's coverage) respectively present a 1% and 5% statistical significance in a quadratic specification.

Overall, the fully logarithmic unbalanced model confirms our previously commented outcomes[12]. Many differences are the statistical significance, depending on the log form, of the quadratic specifications, which raises some warnings of income-landfilling links above a certain threshold. Additional evidence regards the role of tourist flows, which shows to impact negatively on landfill diversion trends, and the role of incineration investments. This variable also increases the model robustness. Policy and waste management factors present unchanged significances with respect to the semi log specifications.

[11] Quadratic models show how such time invariant variables reduce model performances. We note that if we estimate a linear model the above noted 10% VA significance appears.

[12] In terms of model robustness, the higher R^2 (within) performance is the quadratic form with density, tourist flows, population tariff coverage and incinerated waste per capita (column 11 in table 6).

Summing up all outcomes, landfill diversion is stronger where the economic cost deriving from high population density, a structural factor, are higher, and waste management collection systems and economic instruments are associated to higher performances. The main economic driver is just weakly impacting, but this is plausible since is more distant to landfilling with respect to waste generation[13].
The decoupling is then driven by a mix of structural factors, density, but linked to economic issues, and management actions. We may affirm that just relying on the endogenous path characterised by landfilling and economic growth (the baseline EKC scenario) is not assuring delinking. Some policy actions are needed to affect the shape of delinking. Future analyses may provide more insights on landfill tax effectiveness, which nevertheless has been debated even in countries with high taxes, like UK.

3.2.3 The 'decision' of not having a landfill site: verifying the relevancy of sample biases

As already noted, a methodological issue that we should address given the nature of our data, witnessing '0' values for some provinces over some or all observed years, is the possibility of a sample bias. We have dealt above with it by either specifying a semi log model that allowed an inclusion of all observations, or an unbalanced logarithmic model that drops '0' values (68 cells out of 721). We here present as robustness check a two stage Heckman-like estimator that explicitly takes into account this 'sample bias'. Table 8 sums up results that do not present striking differences and thus confirm that the aforementioned commented evidence is robust to the eventual sample bias depending on provinces that do not witness landfill sites in their territory or have closed down all sites in a certain year.
The preliminary probit regression shows that all the three included covariates – VA, DENS, TOURIST – are significant in explaining the dichotomous decision having/not having a landfill in the provincial area. We only note the positive sign in this case of the tourist related variable: while tourist flows negatively impact on the amount of Landfilled waste, presumably to reduce disamenities, landfill siting is necessary where tourist flows are higher, with exceptions in this regularity (e.g. Rimini). Fit measures (Estrella and Mc Fadden fit measures show good performances, and more important the correct prediction performance is high, with a 90.7% of actual '1s and 0s' correctly predicted.
The basic unbalanced specification which now includes the inverse Mills ratio (IMR), confirms the results we obtained above for the unbalanced model, and the IMR is significant at 10%, highlighting the relevancy of introducing the two stage procedure.
The statistical significance of the IMR increases to 1% in all other regressions that present significant effects for COLLEC, TAR-MUN, TAR-POP, and finally COST-REC. the landfill tax is nevertheless not significant. Overall, the two stage heckman procedure does not alter our evidence but shows the relevancy of investigating the 1/0 binary decision, which seems to depend on socio-economic and structural factors, with some signs that are possibly reverted (TOURIST) compared to the analysis on landfill diversion strategies.

[13] If we include the amount of waste generation per capita as explanatory variable, the variable is highly not significant in a simple model, and significant at 10% when using a two stage procedures with VA as driver of waste generation in the first step. The sign is also counter intuitively negative, but this may arise given the correlation between VA and waste generated. The insignificance of waste generation is plausible if we reason around the fact that the direct link is between economic drivers and waste generation, that then indirectly bring about effects downstream at landfill level. Given separated collection and other waste recovery options drive a wedge between waste generation and landfill, this results is coherent with a waste system associated to quite good performances, though heterogeneous across regions.

Table 8. Heckman two stage regressions (probit + unbalanced panel)

	Specification								
Variables	1	2	3	4	5	6	7		
Constant	13.98***			184.097*	190.049**				
Value added	-1.039***	-2.607**	-2.847**	-38.609**	-38.969**	-4.406***	-4.282***		
Value added^2				1.981**	2.023**				
Population density	-0.495***	-7.641***	-7.322***	0.424*	0.421*	-6.565***	-6.199***		
Tourist flows	0.125*	-0.658**							
Separated collection			-0.116**						
Landfill tax				0.335					
Cover cost					-1.238*				
TARPOP^						-0.004**			
TARMUN^							-0.010***		
IMR	/	8.642§	12.894***	-3.177***	-3.397***	16.777***	16.349***		
N	721	653	653	653	653	653	653		
F test (prob)	0.0000	0.0000	0.00000	0.0000	0.0000	0.0000	0.0000		
Model	Probit	FEM	FEM	REM	REM	REM	REM		

Note: Coefficients and significance are shown (10%*; 5%**; 1%***). Empty cells mean the variable is not included in the regression. Covariate are separately added to the baseline model in order to mitigate collinearity. ^not logarithmic covariates. IMR=Inverse Mills Ratio (§20% significance); regression 1 specifies as dependent variable the dummy equal to one if the province witnesses a positive amount of land-filled waste. Results are not affected by the linear or quadratic specifications on value added, though quadratic ones present on average more robust outcomes in REM, linear ones in FEM.

4. Conclusions

The paper has analysed the process of delinking regarding landfilling trends by embedding the dynamics in a frame where economic, institutional, and geographical and policy variables jointly enter the arena. On the basis of the recently observed decreasing path of landfilling occurring at EU level, we aim at investigating in depth what main drivers may be responsible for such a phenomenon, and whether differences may be observed focusing the lens on a very decentralised provincial based setting.

We exploit a rich panel dataset stemming from Official sources (Italian environmental agency) merged with other provincial and regional based information, covering all 103 Italian provinces over 1999-2005. Such an extended, decentralised and recent source of data is of major interest for investigations dealing with waste processes and policy valuation, where evidence is typically scattered and rare given paucity of high quality data.

The case study on Italy is worth being considered provided that Italy is a main country in the EU, thus it offers important pieces on information on the evaluation of policies like the 1999 landfill Directive. Then, its problematic economic, institutional and environmental performance heterogeneity allows an interesting analysis of how economic and policy levers impact on the dynamics of landfilling in such settings. Finally, being waste management and landfill policies implemented at a much decentralised level, it provides food for thought for policy making processes that have operated or will operate along similar directions.

Econometric investigations have focused on both regional and provincial disaggregation. The two set of results are consistent to each other, with some minor differences.

Overall, we observe a significant delinking between economic growth and landfilling of waste. Nevertheless, the case study shows how the baseline EKC relationship between income and environmental pressure may be not sufficient to explain landfill diversion. Other factors impact on environmental performances. We cannot rely merely on economic growth to reverse the income-environment relationship. In fact, if it is confirmed that the sign of the income-landfill diversion trend is negative, since we already observe a descending path in terms of waste landfilling, this link turns out to be not the key one. Structural factors, like population density, highly matter[14]. This means that other things being equal the geographical embedding and the economic (market and non market) costs of landfill investments are drivers of landfill diversion. Then, some specifications also

[14] A logarithmic model that estimates the impact of population on landfill diversion also shows a negative and significant effect. Both higher density and higher population drive down landfilling.

highlight the role of tourism: local systems relying on tourism tend to avoid landfilling as a waste management strategy, as additional opportunity costs may arise and negative externalities could affect the business.
But not only structural factors are relevant. If on the one hand landfill taxation is not arising as a significant driver of the phenomenon, even at the more coherent regional level, where the tax is implemented, waste management instruments, when we exploit the provincial dataset, are associated to high significant negative effect on Landfilled waste. A good performance on managing waste according to economic rationales helps reducing the amount that is landfilled. In association to the features of the tariff system, we also underline the key role played by the share of separated collection: where it is higher
Both the evolution of collection and tariff system are joint factors that may drive a wedge between the comparative waste performances of northern and southern regions.
We note the importance of having panel data for management variables, that captures both the time evolution and the cross section heterogeneity of the waste management evolution towards market based management systems, based on tariffs rather than taxes, and full cost recovery principles.
We finally note that lock in effects linked to the intensity of incinerator sites in the area are relevant for landfilling: though quite obvious, past investments in incineration lock in the region in this technological path, which may be associated to less opportunity cost and lower external effects. The lock in effect driven by the number of landfill sites in the areas is instead significant, a bit counterintuitive perhaps, only when analysing regional data.
Summing up, landfill diversion is stronger where the economic costs deriving from high population density, a structural factor, are higher, and waste management collection systems and economic instruments are associated to higher performances. The main economic driver is just weakly impacting, but this is plausible since is more distant to landfilling with respect to waste generation, and landfilling.
The decoupling is then driven by a mix of structural factors, density, but linked to economic issues, and management actions. We may affirm that just relying on the endogenous path characterised by landfilling and economic growth (the baseline EKC scenario) is not assuring delinking. Some policy actions are needed to affect the shape of delinking. Future analyses may provide more insights on landfill tax effectiveness, which nevertheless has been debated even in countries with high landfill taxes.

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