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The dynamics of Landfill diversion: economic drivers, policy factors and spatial issues

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The dynamics of Landfill diversion: economic drivers, policy factors and spatial issues

Evidence from Italy using provincial panel data

Massimiliano Mazzanti, Anna Montini & Francesco Nicolli[1]

Abstract

Waste disposal is an issue that is becoming increasingly important in policy terms in the European Union, and in Italy, case study of this article. This paper analyses the process of delinking for landfilling trends with the inclusion of economic, and geographical elements, also focusing on spatial issues. 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 tools: 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, waste management instruments, such as separate collection, and the associated tariff-based evolution of services cost financing, are associated to significant negative effect on landfilled waste.
Regarding the analysis of spatial interrelations, we note that the presence of incinerators in nearby provinces increase landfill diversion in a given area, due to free riding behaviour or intra provinces 'agreements' on waste management, while this is not true for landfill sites, that cause for a given province a string lock in effect.

Jel Classification: C23, Q38, Q56

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

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Introduction

Reducing, landfilling and promoting other form of waste disposal is a primary objective of European environmental policies. 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.

Very recently, for example, some areas in Southern Italy have being experiencing a collapse in waste management performances that has still to be resolved, mainly due to a set of different factors such as low separated collection, absence of serious alternatives to landfill siting, increasing scarcity of land in a densely populated area, failures in local policy implementation and property right enforcement. The problem with waste management and correlated externalities that arise at landfill stages is that waste stock accumulates and is difficult to reverse the process when the sustainability balance between inflows of waste generated and outflows of waste treated is broken at some time.

Waste generation and waste disposal are issues that are becoming increasingly prominent in the environmental arena both from a policy perspective and in the context of delinking analysis. Waste generation is in fact still increasing more or less proportionally with income, and economic and environmental costs associated to landfilling are also increasing. We thus may affirm that waste management, from production to disposal, is an environmental issue not less relevant than and potentially critical as water scarcity or climate change. It also presents some interlinks with an issue like climate change, since incineration, recycling and landfill possess diverse greenhouse gas potentials. Diversion of waste away from landfill (landfill diversion) is one option to reduce greenhouse gas (GHG) emissions

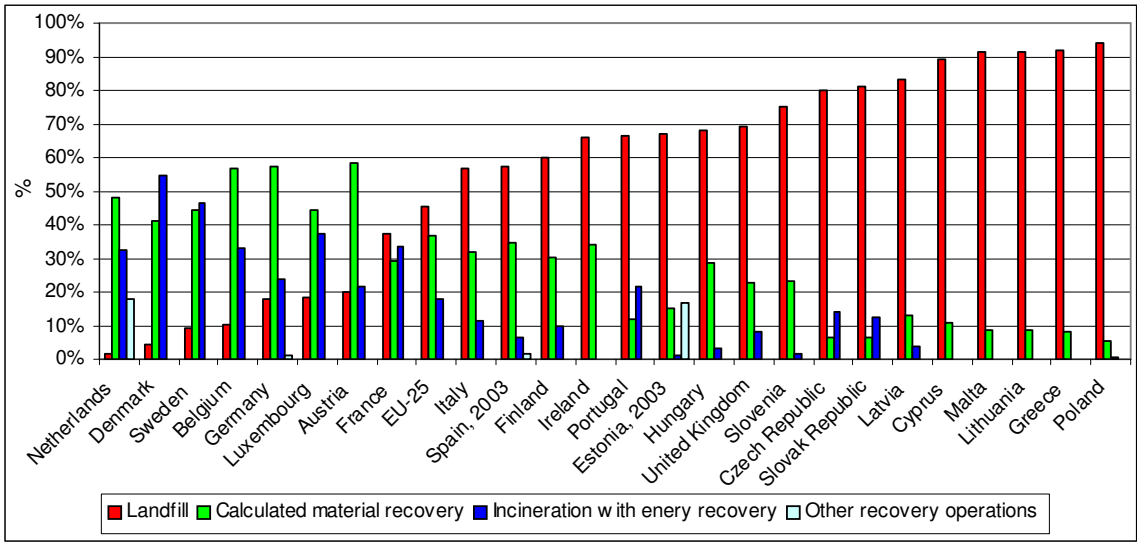
In this context indicators of 'decoupling' are becoming increasingly popular in detecting and measuring improvements in environmental/resource efficiency with respect to economic activity. Extensive research on decoupling indicators, for reporting and policy-evaluation purposes, is being carried out 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, 2003). The EU policy 'thematic strategies' on both resources and waste, entail reference to 'absolute' and 'relative' delinking indicators (EC, 2003): 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.

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.

For what concerns Italy, our case study, 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. A clear map of the current situation in Italy is well shown in figure 2, 3 and 4, representing the differences in waste management across Italian provinces.

Figure 2: landfilled waste per capita in Italian provinces (kg, 2005)

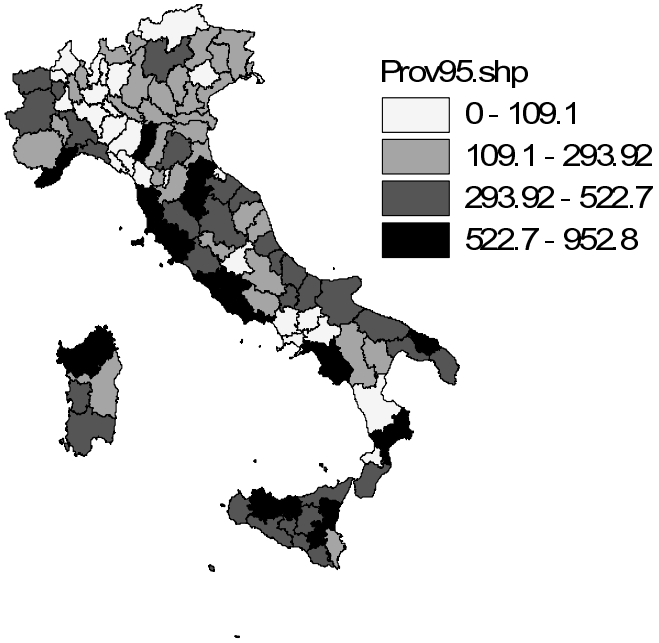


Figure 3: Incinerated waste per capita in Italian provinces (kg, 2005)

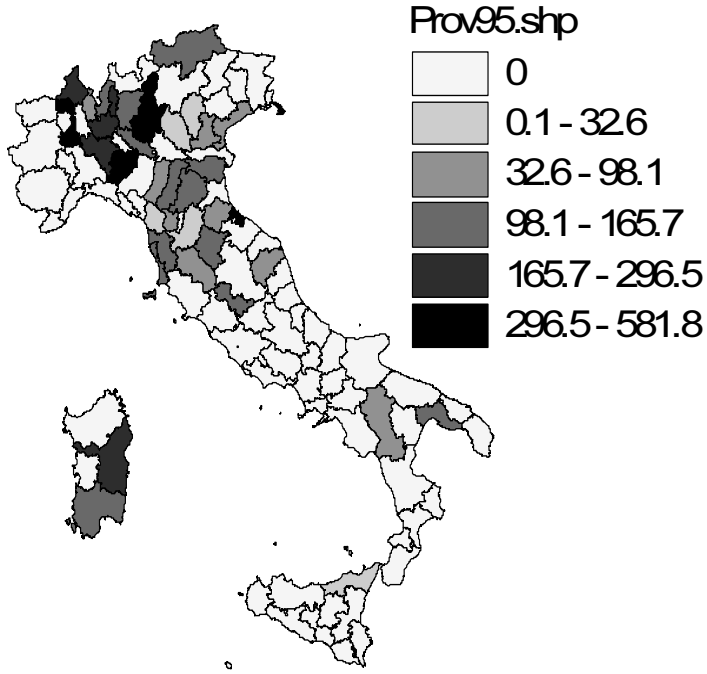
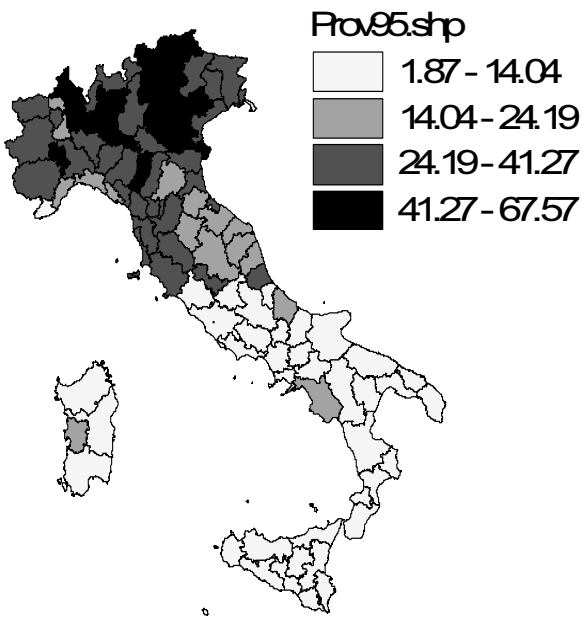


Figure 4: Share of separate collection among Italian provinces (2005)



The value added of this paper is manifold. Firstly, it offers unique evidence on landfill diversion trends. Secondly, in doing this it exploits a wide array of drivers related to economic, geographical and policy factors, with a focus on spatial issues that is allowed by the province based nature of the dataset. It thus presents outcomes useful for both ex post landfill policy evaluation and assessment of Kuznets delinking trends for landfilling. Third, it relies on a much decentralised dataset, a level at which Kuznets shapes may be assessed more robustly since they exploit richer heterogeneity. Fourth, such an extended, decentralised and recent source of data is unique, given paucity of high quality information in this field, and allow for a long series of reasoning. 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.

Given that the EU and even Italy as a member country show quite developed waste policies, their experience may feed both other EU members, newcomers or even countries all over the world that want either to reshape current strategies or to set up ex novo a waste policies starting from zero. As recognised by the EEA (2007), it is important to know if we are on track of meeting the Landfill Directive's targets, and which policies work well and which play a less significant role. This will be helpful for designing and refining policies in the future development of EU policies. Using a more specific reference, the Sixth Environment Action Programme of the European Community poses emphasis on '*ex-post* evaluation of the effectiveness of current policy measures in terms of their environmental objectives'.

The paper is structured as follows. Section 1 presents the state of the art of the literature on the 'economics of waste', that highlights the relative scarcity of the type of study we here present. Section 2 defines the empirical model, presents the original source of data and comments on the main Research hypotheses. Section 3 summarises and comments on empirical outcomes deriving from econometric analysis. Section 4 concludes offering policy making insights.

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. 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 between waste management strategies, economic evaluation of disposal externalities and landfill siting decision procedures has prevailed so far (Pearce, 2004)[i], partly due to the lack of reliable data for carrying out EKC type of analysis in the field. The analysis of endogenous and exogenous drivers, including policies, is an important field (at which this paper belongs to) that bring together environmental Kuznets curves analyses (EKC, or WKC, Waste Kuznets Curve, for waste)[ii] 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 CO2, 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.

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.

For European countries Mazzanti (2008) 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 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. At country level, evidence is also rare. Mazzanti, Montini and Zoboli (2008) use a disaggregated panel dataset based on Italian Provinces, and provides mixed evidence in favour of an EKC relationship for waste generation. The turning point occurs at very high levels of value added per capita which characterise a very limited number of wealthy (Northern) Italian provinces. The tests on some recently adopted waste policy / management instruments, show that there is some policy driven effect on waste generation at source, and that they present some endogeneity with respect to socio economic drivers. To achieve delinking and to avoid an increasing gap between Northern and Southern areas, more effective policy instruments should be implemented and the weight of waste policies should be rebalanced towards waste prevention targets and instruments, in line with the stated priorities of the EU and Member Countries.

Some studies have appeared in relation to the evaluation of the Eu landfill directive, and the UK experience, one of the first country with an own landfilled tax dated back to 1996. The Landfill tax in UK, as in EU, has the aim to contribute to a transition away from landfilling of waste, towards recovery, recycling, re-use and waste minimization. Such studies highlighted some criticalities, operational weakness and future evolutions on this instruments. We refer the reader to main relevant studies in the field such as Morris et al (1998), Morris and Read (2001) and Burnley (2001), Davies and Doble (2004). Besides the high level of interest of the results, all these 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.

This survey of the literature, 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 analyses 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 to 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. Moreover, as some recent studies confirmed, also in the waste disposal context trade may be very important. The analysis of Ley et al., (2002) for example, underlines how policies proposed to restrict interstate waste trade in the US can reduce the aggregate social welfare.

2. The Empirical analysis on landfill diversion

2.1 The model, data sources and research hypotheses

The analysis considers a provincial data set, based on data taken from the Italian Environment Agency's waste report (APAT, 2001, 2002, 2003, 2004, 2005, 2006), that is produced according to Eurostat and the European Environmental Agency guidelines (EEA, 2003). The provincial dataset includes data on MSW generated (collected) and landfilled in all the Italian Provinces (n=103) and covers the period 1999-2005 (1999-2005 for landfilled waste). Landfilled waste per capita is the dependent variable or our model, the environmental pressure.

In order to test the core WKC shape, we merge these data with official data on economic drivers, value added, at provincial level. Then, to embed landfill diversion

dynamics in socio-economic, geographic and policy issues we add other explanatory variables to the empirical model.

First, additional socio-economic and structural variables relevant for waste, such as MSW generated and incinerated, share of separately collected waste and population density, are tested. We also check for decentralised policy-related variables. These are 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[iii]. 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. We note that implementation is heterogeneous even across areas with similar incomes and similar social economic variables, and may depend by the different level of policy commitment. 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. Though only a time invariant data is available, we test the effect of the main environmental tax in the waste realm, the landfill tax, which is implemented at regional level. We observe a moderate heterogeneity across regions in the level of the tax, which is lower in level with respect to other EU countries.

Finally, two spatial-related variables are included in the analysis, to take in to account for proximity and 'trade' effects, due intentional cooperation strategies between neighbouring provinces or free riding behaviour. The aim in this case is to test if the proximity to a Province can generate waste diversion through waste trade. Tables 1 presents the dependent and independent variables, their descriptive statistics and summarises the related research hypothesis we test by consequent econometric analysis.

Table 1. Descriptive statistics and research hypothesis: 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	9369.12	28796.07	Positively correlated with income, the objective is assessing whether relative or absolute delinking is present
DENS	Population/surface (inhabitants/km2)	244.1	36.43	2640.92	Positive and negative correlations may emerge depending on factors such as economies of scale and land opportunity costs in urban and densely inhabited areas
COLLEC	Share of separated collection (%)	18.40	0.03	67.57	Negatively affecting landfilled waste per capita
INC-AREA	Number of incinerators in the province / area of the province	0.0000026	0	0.000094	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, 2004 data only) (%)	85.61	53.3	104.2	
LANDFILL TAX	Regional Landfill Tax (€/kg)	0.015	0.01	0.03	Possibly reducing MSW generation, incrementing the relative cost of landfilling.
INCclose	Number of incineration plants in the adjacent provinces	1.992	0	11	The presence of incineration plants in the adjacent provinces can stimulate waste trade and promote diversion through formal or informal agreements or just free riding and exploiting nearby incinerators
LANDout LANDin	Ratio between landfill sites within the province and sites in the adjacent provinces	0.283	0	3.67	A small ratio may be related with an high level of 'export' to the adjacent provinces

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

(1) landfilled MSW per capita $= a_t + \beta_1$ *(landfilled MSW per capita)*$_{t-1} + \beta_2$*log(economic driver)*$_{it} + \beta_2$*log(socio-economic & geographic factors)*$_{it} + \beta_3$*(environmental policy)*$+ \varepsilon_{it}$

We believe that the process is dynamic, with current realizations of the dependent variable influenced by past ones. For this reason we estimated with a GMM-sys technique[iv], that allow us to include the first lag of the dependent variable among the regressor in a dynamic context (the coefficient β_1).

Considering that the data set presents zero values (5 of the 103 provinces observed over 1999-2005 have no landfill sites for MSW, and thus no landfilling; others like Milan, closed landfill sites at a given time, thus the series witnesses zero values after a certain year) the model has a linear-log specification, and not a more traditional log-log one, that drops all the observations equal to zero.

The coefficient β2, refers to socio-economic and geographic factors that are added to the core specification and possible additional significant drivers of waste generation, while β3 refers to environmental policies index tested in the analysis.

2 Empirical evidence on landfill diversion drivers

Main results are presented in table 2. The analysis is conducted by adding explanatory variables one by one on the core WKC model including value added and population density, the main economic and structural/geographical factors to avoid collinearity problem. Thus, our specifications witness three variables, two of which, VA and density, are always present as pillars of the model.

The baseline specification, presented in column 1, underlines the basic elements of our analysis. First, a negative and significant relationship between VA and landfilled waste emerges. This is plausible given that since 1995 Italy and the Eu have experienced on average a decrease in waste being landfilled. We recall this does not automatically assure neither sustainability nor the achievement of EU policy targets. We also note that 2006, not included here, witnessed a slight recoupling with a moderate increase in landfilled waste. Recoupling is always a possible future scenario to have in mind.

Secondly, the sign of population density, as expected, shows that where opportunity costs associated to land values are higher (in urban areas, densely populated areas) and disamenities effects influence more people, landfill diversion is stronger, possibly even without policies, just through 'market' forces[v]. 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. Moreover, waste generation and waste disposal, as well as the location of landfilled site for both municipal and special waste, may be correlated to some characteristic of the population, like density, average-income and ethnic group (Atlas, 2002; Jenkins et al., 2004). This is scope for further quantitative research in this field as soon as data are available.

A third important element underlined by the basic specification, is the highly significance of the lagged dependent variable, that proves the existence of lock in effects due to past investments in disposal sites. 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[vi].

Having commented on the pillars of the empirical relationship we test here, we move to the analysis of additional factors that enriches our investigation.
A variable that is somewhat related to north-south strong differences regarding performances, the share of separated collection, shows its key role in the explanation of the phenomenon. In this regression (column 2) VA is not included because of its high correlation with the share of separated collection, which is in this sense endogenous, motivated by the north-south different performances in waste management (fig.4)[vii]. This means that for a given increase in separated collection, there is a decrease of landfilling. On the other hand, 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. Overall, in any case, separated collection is the main, partly income driven, waste management scheme of a waste system aimed at reducing waste being landfilled.

We consequentially (column 3) test the effect of the number of incinerators, in per capita and per area terms (fig.3), finding mostly the latter as another high significant element in explaining landfill diversion. This may seem a tautological result; nonetheless it confirms the existence of lock in effects due to past investments in disposal options: whether a province invest relatively more in a defined strategy is relevant for the dynamic evolution of the waste strategy, provided high fixed costs are borne in the initial time. Lock in effects may characterise any technology, even recycling and incineration options.
We also test the relevancy of 'waste management related factors' and regional landfill taxes, to account for explicit waste policy factors which are implemented in Italy at a much decentralised level. It turns out that the landfill tax is not effective (column 4). The not significant impact of landfill taxes may be due, more than to a recent implementation (the tax was formally introduced in 1996), to a relatively low level of the tax in comparison to other EU experiences, and to a 'weak enforcement' and not stringent implementation in some regions. This is nevertheless scope for further more detailed research. 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 at local level. Landfill pricing is only the last option at the end of the waste production 'filiere'. Diversion is driven more by actions taken before the landfill stage is reached.

As far as waste management related factors dynamics are concerned, we in fact check the extent to which both the evolution towards a waste tariff system, from a tax based one, and the share of variable cost covered by the tax, influence landfill diversion performances. Both elements proxy dynamics of 'privatisation' of the system, intended as moving towards a system of 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: such waste tariffs are aimed at representing a sort of 'environmental economic instrument' that both change relative prices impacting household behaviour and fully recover cost of services. Most utilities in Italy are actually still public owned, or with shared public-private participation: it is the management that changes more than the property of assets.

As far as the coverage of variable cost of waste management (COST-REC), the heterogeneity is high across provinces: the coefficient is negative and as expected and shows high significance (column 5). For what concern the other policy indicators, e.g. share of population and share of municipalities that introduced a waste tariff substituting the former waste tax, though all signs are negative as expected, we only observe a significant coefficient for the variable that captures the share of municipalities linked to a tariff (TAR-MUN, column 7). This share has been steadily increasing. It shows that more than the share of population covered, driven by the introduction of the tariff in larger

municipalities, it is the number of local authorities within a province 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. Anyway also in this case the static analysis show slightly different results. Estimating with a fixed effect model in fact both the variables are significant and negatively correlated with the amount of waste sent to landfill.

As a last but main relevant point in this analysis, the two spatial related variables show statistically significant effects on landfill diversion, as we can see in columns 8-9. The presence of incineration plants in the adjacent provinces may improve landfill diversion inside the province, by means of (formally agreed) trade relationships between provinces. Given the high cost of transporting waste, this phenomenon mainly concerns nearby provinces. The coefficient of INCclose is in fact highly significant and negatively correlated to the amount of waste landfilled. On the other side, column 9 tell us that the variable which is created as the ratio between the number of landfill sites within the Province and landfill sites in the adjacent provinces shows a positive and significant coefficient (relatively more abundant are landfill sites in the province, the lower is the landfill diversion inside a province)[viii]. From this result we can argue that provinces with incinerator or landfill sites are attracting waste from the other provinces. If on one side this can be view as a normal trade process consequent to some formal inter-provincial agreements, on the other side, in the medium and long run it can generate free riding and dependence from nearby (more efficient) provinces.

Table 2. Specifications for landfilled waste per capita (semi-log model, balanced panel, GMM-Sys estimation), province analysis (N=721, 103 provinces, 1999-2005)

	Specificaton								
Variables	1	2	3	4	5	6	7	8	9
LAND WASTE t-1	0.642***	0.557***	0.651***	0.644***	0.510***	0.632***	0.479***	0.565***	0.633***
VA	-66.237***		-48.339**	-69.007***	-43.812*	-60.049***	-72.695***	-39.392*	-61.739***
DENS	-13.279**	-11.394*	-4.124	-12.819**	-18.376***	-13.626**	-17.910**	-12.002**	-12.370*
COLLEC		-34.572***							
INC-AREA^			-2711***						
LANDFILL TAX				8.657					
COST-REC					-147.521***				
TARPOP^						-0.211			
TARMUN^							-0.739**		
INCclose								-8.340***	
LANDout/LANDin									35.353**
Sargan test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Coefficients and significance are shown (10%*; 5%**; 1%***). Empty cells mean the variable is not included in the regression. ^not logarithmic covariates.

3. Conclusions

This paper has analysed the process of delinking in relation to landfill diversion by embedding the dynamics in a framework that simultaneously includes economic, geographical / spatial and policy variables. 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.

Overall, we observe a significant delinking between economic growth and landfilling of waste. Nevertheless, we cannot rely merely on economic growth to reverse the income-environment relationship. 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 tools: local opportunity costs and landfill externalities matter in shaping waste policies and local commitment to landfill diversion.

Structural factors, like population density, linked to economic and environmental opportunity costs, highly matter. This means that other things being equal the geographical embedding and the economic (market and non market) costs of landfill investments are important drivers of 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, probably given its low level and fable enforcement in most regions, waste management instruments, such as an economic instrument minded waste tariff, are associated to high significant negative effect on landfilled waste. A good performance on managing waste according to economic rationales (influencing prices) also 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 at the very heart of the waste chain: where it is higher, landfill diversion is higher. Both the evolution of separated collection and of the tariff system are joint factors that may drive a wedge between the comparative waste performances of northern and southern regions, provided they are quite correlated to the main economci drivers, highlighting some endogeneity which is relevant to considered as food for thought when structuring future policies.

We finally note that lock in effects linked to the presence of incinerator sites in the area are relevant for explaining landfill diversion: though quite obvious, past investments in incineration lock in the region in this technological path, as 'investing' in landfill sites also create lock in situations from an evolutionary perspective. This is evidence we find from various factors in the analysis.
Regarding the analysis of spatial interrelations, we note that the relative abundance of incinerators, and also landfill sites, in nearby provinces increase landfill diversion in a given area, due to free riding behaviour or intra provinces 'agreements' on waste management.

We may affirm that economic growth alone is not enough to achieve delinking and policy actions, and more advanced waste management measures, are needed to accelerate and to enhance the performances for achieving EU targets and avoiding a widening gap between Northern and Southern regions. Future research should intensify the analysis of spatial interrelations at al level of the waste filiere, waste generation, landfilling, and incineration, recycling and separated collection. In addition, further tests on the future evolution of both waste management instruments and landfill taxes are needed to provide updated evidence on policy making effectiveness.

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[i] Miranda et al (2000); Eshet et al (2004), Dijkgraaf and Vollebergh (2004), Seok Lim and Missios (2007). Caplan et al (2007) offer an example of how economic evaluation techniques may inform landfill siting process.

[ii] We refer to Cole et al. (1997), Stern (2004), for major critical surveys and a discussion on the theoretical underpinnings of delinking and EKC, which mainly analyze air and water emissions, mainly CO2, with a limited focus on waste streams.

[iii] 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.

[iv] The GMM-SYS estimator contains both first-differenced and levels equations. In addition to using instruments in levels for equations in first differences, it uses instruments in first differences for equations in levels (Arellano and Bover 1995). The GMM-SYS estimator is an alternative to the standard first-differenced GMM estimator. In dynamic panel data settings, the GMM-SYS estimator eliminates the unobserved unit-specific effects by means of first differences. The GMM-SYS estimator also controls for the endogeneity.

[v] Policy makers could also be willing to reduce negative political effects of disamenities affecting their electors / citizens.

[vi] This element has been tested also in the static model, with the inclusion in the regression of a variable related to the number of landfill sites per area, which is found significant, and able to drive up the amount of waste that is landfilled.

[vii] Two stage regressions estimating first COLLEC as dependent on VA and then including 'fitted' COLLEC values in the second stage di not alter results.

[viii] We are forced to set up such a ratio, instead of the more intuitive opposite, given that some provinces show 0 landfill sites. The variable 'number of landfill sites in the adjacent provinces', not shown here, is moderately significant with a negative sign.