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Municipal waste generation, socio-economic drivers and waste management instruments
Evidence from Italy using provincial panel data

Massimiliano Mazzanti Anna Montini Roberto Zoboli

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Abstract

This paper provides original empirical evidence on the Environmental Kuznets Curve (EKC) hypothesis regarding municipal waste generation. The empirical analysis uses a disaggregated panel dataset based on Italian Provinces, and provides mixed evidence in favour of an EKC relationship. The turning point occurs at very high levels of value added per capita (in the range 22586-31611€ for preferred specifications), which characterise a very limited number of wealthy (Northern) Italian provinces. The tests on some recently adopted waste policy / management instruments, show that they are not (yet) impacting 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.

Jel: C23, Q58, Q53

Keywords: Decoupling, Environmental Kuznets Curves, Waste Indicators, Waste Policy, Economic Drivers, Decentralised Panel Data, waste management instruments

[1] University of Ferrara, University of Bologna, University of Milan respectively. Contact ma.maz@iol.it

1. Introduction

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 environmental Kuznets curves **(**EKC) framework extends the basic decoupling reasoning, and models a multivariate analysis of the environment-income relationship.

This paper provides empirical evidence on delinking trends for Municipal solid waste (MSW). The added value of this contribution is manifold. Firstly, empirical evidence on waste Kuznets curves (WKC, hereafter) dynamics for waste is still scarce. Research on delinking for materials and waste is far less developed than research into air pollution and greenhouse gas emissions. Although some recent works, particularly those by the Wuppertal Institute (Bringezu et al., 2003), have produced extensive evidence on material intensity indicators, the still limited research results for the waste sector may be a serious problem from a policy perspective. Secondly, analyses that exploit country-specific, highly disaggregated panel data on waste are even scarcer with respect to cross-country investigations

We provide WKC evidence exploiting environmental-economic merged panel datasets at a very decentralised level. The dataset covers the period 1999-2005 for the 103 Italian provinces, derived from official sources (Italian Environmental Agency) and are quantitatively and qualitatively detailed. Environmental data are merged with official economic data on economic drivers[2]. Third, our analysis includes decentralised policy-related variables: the share of municipalities that have progressed from taxing waste to applying waste tariffs; and the percentage of waste management costs covered by the tax/tariff[3]. We check for tourist-related flows, a crucial issue in local waste generation in Italy and also examine on socio economic drivers and waste management tools. Given the large gap between the southern and northern areas of Italy in terms of environmental and

[2] Value added is the (incremental) component of produced wealth which is attributed to the geographical area. Value added is the only available economic driver at province level. Other potential drivers are the usual GDP, or its components, consumption and investments.

[3] We are unable to use policy variables related to landfill taxation, since landfill taxes are implemented in Italy at the decentralised level and tax values are only available for the main northern regions. We exploit available information on waste management instruments.

economic performances, our analysis provides interesting insights within a development oriented perspective. National case studies may be the starting point for more extended regional analyses (EU, US) when sufficient data become available. To date, we believe that good national based data offer higher availability, reliability, and heterogeneity than even official sources, such as Eurostat (Eurostat, 2003) or the OECD. As far as waste is concerned, OECD data, in our opinion, are less reliable and less consistent for policy interpretation, given the very differentiated waste frameworks and statistical waste definitions across non-homogeneous countries.

Waste is a framework within which policies are implemented at a very decentralised level in many EU countries. We think, therefore, that highly-disaggregated analyses at country level, such as the one presented in this paper, are a fruitful research direction. The next section provides a short survey of the studies on waste and delinking. Section 3 presents the empirical model and the data. Section 4 is devoted to the empirical evidence. Section 5 concludes with policy implications and suggestions for further research.

2. Waste indicators and delinking analysis: recent empirical evidence

We refer to Cole et al. (1997), Dinda (2004), Stern (2004, 1998), Andreoni and Levinson (2001), Copeland and Taylor (2004), Brock and Taylor (2004, 2003), for major critical surveys and a discussion on the theoretical underpinnings of delinking and EKC, which mainly analyse air and water emissions, mainly CO_2, with a limited focus on waste streams. 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 (Pearce, 2004).

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.

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[4], 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.

Some evidence in favour of delinking has emerged. Leigh (2004) presents evidence for WKC concerning a waste/consumption indicator derived from the environmental sustainability indexes (ESI). Berrens et al. (1998) and Wang et al. (1998) also find evidence in favour of a negative elasticity, focusing on US stocks of hazardous waste as an environmental impact indicator, and exploiting a county-based cross sectional dataset.

A recent study by Johnstone and Labonne (2004) is of interest; they use a panel database of solid waste in the OECD countries to provide evidence on the economic and demographic determinants of rates of household solid waste generation, regressed over consumption expenditures, urbanisation and population density. They find positive elasticities, but lower than 1, in a range from 0.15 to 0.69[5]. 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). MSW increases monotonically with income. Urbanisation exerts even a stronger effect on waste generation, while the time-invariant policy index is not significant.

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

[4] Among the first studies, we also refer to the national case study on an OECD country, such as South Korea, by Lim (1997), which is of interest here given the focus at national level. Concu (2000) study on Sardinia (Italy) is interesting for its regional focus, but displays all the deficiencies and weaknesses of cross section analyses.

[5] Beede and Bloom (1995) use cross sectional data for 36 countries and find a MSW elasticity with respect to income of 0.34.

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.

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. In our study we try to bring together different pieces of the puzzle: WKC analyses, policy effectiveness studies, and an extensive evaluation of waste drivers.

The literature on waste determinants and WKC for waste referred to above, underlines that waste indicators generally tend to increase with income or other economic drivers, such as population and, in general, an inverted U-shape curve is still not in line with the data. A decreasing trend (negative elasticity) may be found in industrialised countries where waste management and policies are more developed. Nevertheless, the risk is that WKC trends (absolute delinking) are associated with a few rich countries or areas and can divide countries in terms of waste performance indicators. The underpinnings of such evidence might be many. Some authors have suggested that for stock pollution externalities, for example, waste to a greater extent, the pollution income relationship difficulty turns into a EKC shaped curve, with pollution stocks monotonically rising with income (Lieb, 2004). Another structural motivation concerning the lack of evidence on waste may be that the change in sign of the income elasticity of the environment/income function should occur at relatively lower income levels for pollutants whose production and consumption can be easily spatially separated, e.g. by exporting associated pollution or by relocating activities. This is likely to be more difficult for waste flows, especially biodegradable waste. The WKC literature, is slowly growing in general, and it still lacks, as noted, a more in depth investigation of driving forces and policy effects. We aim at bringing together different pieces of the puzzle: WKC analyses with policy effectiveness studies and an extensive evaluation of waste drivers.

3. Empirical analysis at provincial level for Italy

3.1 The data

The dataset includes data on municipal solid waste generated (collected) by Italian Provinces. We exploit all available yearly editions of the Environment Agency waste report (APAT, 2002, 2003, 2004, 2005). The dataset covers the period 1999-2005 for the 103 Italian provinces. The Italian Environmental Agency (APAT) works according to data collection guidelines of Eurostat and the European Environmental Agency (EEA, 2003a,b,c), and has achieved a massive effort in the waste-related area. We merged these data with official economic data on economic drivers. We use value added, the main indicator at provincial level. Although consumption is often indicated and used as a coherent driver when analysing waste trends (Andersen et al., 2007), data at province level were not available, making value added the only reliable and available economic driver. Additional socio-economic variables relevant for waste, such as share of separately collected waste and population density, are tested. The analysis also includes decentralised policy-related variables: the share of provincial municipalities and the provincial population covered by a tariff regime, in place of the previous 'waste tax'; and the percentage of waste management costs covered by the tariff[6]. Finally, we check for tourist-related flows, a crucial issue in waste generation and collection. Table 1 presents the dependent and independent variables and their descriptive statistics.

A note on the transition from a tax to a waste tariff is useful at this point. The waste management *tariff* was introduced by Italian bill no. 22/1997, which substitutes for the old waste management *tax*, although this latter still prevails in many Italian municipalities. The provisions of bill 22/1997 allow the transition phase to be quite gradual and slow. The tax was calculated merely on the size of household living spaces; the tariff is instead based on principles of full-cost pricing of waste management services and can be considered as an 'economic instrument', although it does not correlate to external environmental costs. It consists of 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 additional new element, to the number of people in the family. The tax was thus penalizing smaller families. Then further innovation, the variable part is associated to the (expected) amount of waste produced, which is calculated on the basis of past trends and local idiosyncratic features. This should favour waste reduction efforts finally, and probably more relevant as and incentive, the variable part is abated by

[6] We are unable to use policy variables related to landfill taxation, since landfill taxes are implemented in Italy on a decentralised level and tax values are available only for main northern regions. APAT does not survey tax level implementation at a region/province level.

around 10-20% if households adopt domestic composting and/or join garden waste door to door collection systems. Effective implementation of the tariff system nevertheless remains highly dependent on local policy decisions.

Early implementation, which is partly the choice of the municipality, may be a sign of policy commitment. We note that the implementation is heterogeneous even across areas with similar income and similar social economic variables. It thus adds some relevant heterogeneity. The shift from tax to tariff should also capture the incentive effect of the former, although we underline that the impact on waste generation, if significant, is not visible in the short term.

As far as tariff variables are concerned, we note that the number of municipalities applying a tariff is increasing each year despite its efficacy being uncertain.

The tariff scheme mainly applies to the Northern municipalities. It use increased from 564 municipalities in 2004 to 747 in 2005 and, at regional level, the largest use increase was in Veneto (212 municipalities in 2005) and Lombardy (160 municipalities). At regional level, Veneto is the region with the most municipalities (36.5%) applying the tariff system[7]. The published data for all provinces include the shares of the population and the number of municipalities covered by the tariff system.

3.2 The WKC empirical model

The first methodological problem related to our analysis is how to specify the WKC functional relationship. There is no consensus on this point[8]. Here, we test the hypothesis by specifying a proper reduced form, which is usual in the EKC field (Stern, 2004):

$$(1) \qquad \log(\text{MSW generation}^{9}) = \beta_{0i} + \alpha_t + \beta_1 \text{Log(value added)}_{it} + \beta_2 \text{Log(value added)}^2_{it} + \beta_4(Xi) + e_{it}$$

where the first two terms are intercept parameters that vary across provinces, and years.

[7] APAT datasets also contain a regional based dis-aggregation over 1996-2003, for the 20 Italian regions. A preliminary analysis was carried out and the results were found to be statistically less satisfactory in terms of overall fit and coefficient significance; thus, here we present only the provincial analysis. The provincial dataset in fact provides higher heterogeneity and is more suitable for analysing decentralised, local-level waste policies in our context.

[8] Some authors adopt second order polynomials, others estimate third and even fourth order polynomials, comparing different specifications for relative robustness. It is worth noting that neither the quadratic nor cubic function can be considered a fully realistic representation of the income-environment relationship: the cubic WKC specification implies that environmental degradation will tend towards a plus or minus infinity as income increases; the quadratic specification implies that environmental degradation could eventually tend towards zero. Third or fourth level polynomials could also lead to N rather than U shaped curves. The N shape would be justified by a non-linear effect of the scale of economic activity on the environment.

[9] MSW accounts for around 14% of total waste generated in the OECD countries and includes household and similar waste. It includes bulky waste, garden waste, waste originating from small businesses and institutions.

Different specifications are tested by including either waste per capita or waste in total terms as dependent variable[10]; accordingly, value added is either per capita or total[11].

The vector X refers to a set of other drivers, added to the core WKC specification as controls and possible additional significant drivers of waste generation[12]. In our model, it includes the percentage share of separately collected waste, population density and tourist flows, recovery capacity of waste service cost, and share of population subject to waste tariffs (rather than waste taxes) for the province-level analysis. The main research hypotheses associated with the examined explanatory factors are commented on below and summarised in Table 1.

Population density is included, in line with other studies (Johnstone and Labonne, 2004): the expected sign is ambiguous, since on the one hand economies of scale may help reduce average waste collection costs (reducing incentives for waste prevention), while on the other hand population density may imply greater scarcity of land resources and, thus, more pressure to preserve land dedicated to waste disposal.

The inclusion of policy proxies may be fruitful for valuing the effect of policies within the WKC framework and generally assessing ex post policy effectiveness. We then include decentralised policy variables which we can include within the *waste management instruments*[13] and which show strong geographical heterogeneity: (i) the share of municipalities which have already implemented the new regime based on the waste management tariff, (ii) the actual percentage of variable costs covered by the tax/tariff for each province, which is correlated to the level of the tax/tariff itself[14] and allows us to capture waste policy features and policy commitment at a decentralised level.

An added value of our work is that these policy variables are continuous and time variant, unlike the synthetic indexes or time-invariant dummies used in many existing studies. They should capture, on the one hand, the implementation of an instrument that is more market based: the tariff is correlated to socio-economic indicators, unlike the former waste tax, which was unrelated to waste generation and household income. On the

[10] We should stress that our municipal waste generation includes a variety of waste sources in addition to household waste, such as commercial and public administration waste generated at the municipal level.
[11] Cubic specifications are, as expected, not significant.
[12] As stated by Fonkych and Lempert (2005, p. 29), "different EKCs are likely to exist for different countries and pollutants, and explanatory variables other than per capita income may be better determinants of emission trajectories". This confirms the need to investigate additional effects to the usual income driver.
[13] Economic, legislative, informative tools used by countries to achieve the goals set in waste management plans. The main types of waste management instruments are incentives (deposit systems, tax refunds) and preventive economic tools (taxes, charges and fees).
[14] The exact tax/tariff level is information that is not readily available, since it is determined by the individual (private or public) utility company that manages the waste flows at municipal or provincial level.

other hand, they should capture cost recovery, for both public and private waste management companies, as a proxy for the degree of subsidisation (the higher the cost of recovery, the lower the subsidy). We should expect that both policy proxies should be (significantly) negatively related to waste generation: the more 'market based' the system, the more waste generation should be discouraged. Nevertheless, in the short term, their influence will not be significant, provided that changes in production and consumption behaviour take time and waste generation is less dependent compared to waste disposal/recovery/recycling, on price-based instruments and management approaches. Policy instruments could also present endogeneity with regard to income levels. This is a new issue addressed mainly within the realm of ex post environmental policy evaluation. Some recent studies have analysed the drivers of environmental regulation, and defined endogenous factors (Cole et al., 2006). Consistent with EKC reasoning, policies may be endogenous to economic development, and may be correlated to income factors at both supply and demand levels (Cagatay and Mihci, 2006). Finally, in order to correct for "tourist hot spot areas" (e.g. Rimini, Rome, Venice, Florence), we check whether the introduction of tourist flows at provincial level affects the estimates.

For each combination of the dependent and independent variables, different specifications are estimated, including: linear regressors only (baseline case), or linear and squared terms (WKC usual case). We observe that the dataset is a typical panel that captures more cross-sectional heterogeneity than time-series dynamics, though we recall that 7 years is e long series for waste indicators. Even more important, baseline panel specifications are tested against first order serial correlation and heteroskedasticity. In case null hypotheses were rejected, corrected estimates would be presented.

4. Empirical evidence

4.1 WKC: socio-economic drivers

This section describes the results concerning the WKC hypothesis, across different specifications. We first comment on the core specifications focusing on economic drivers only, and then highlight the role of factors such as tourist flows and waste management instruments when included as additional drivers.

Preliminary tests on serial correlation and heteroskedasticity signals the only the latter is a problematic issue in this data context. Thus, all specifications are estimated using the Prais-Winsten correction technique[15].

The results of the econometric estimates of logarithmic[16] forms are summarised in Table 2. In linear form, the elasticity of waste generation to value added is around 0.35. Contrary to non corrected specifications, a (very high) TP arises, at around 36000€, outside the range of observed values[17].

When separated waste collection and population density are included as additional variables, the estimated elasticity increases to 0.43 in linear forms, while the TP decreases to 31600€, which is close to the maximum observed value (e.g. Province of Milan). Confirming most usual hypotheses, population density is positively impacting waste generation: economies of scale in waste management do not seem to outweigh scale effects. More densely populated urban areas produce relatively more waste. This result has implications, among other things, for forecasting future waste trends driven by population flows. The share of separated collection also presents a negative expected coefficient. Stronger commitments towards waste flow separation and recycling seem to have impact on the amount of waste generated. Possible endogeneity (the higher the amount of waste, the higher separated collection) is not found here, though is worth being checked. Waste management performances somewhat impact backwards on waste generation along the filiere.

The inclusion of geographical dummies (south, north-east, north-west, and centre) slightly reduces the elasticity (0.333) and WKC is found. Central Italy, South and North-west are the most significant, with a positive coefficient attached to the former (geographical dummies are not shown in Table 2). Negative coefficients apply to the Northern regions dummies, confirming expected insights on north-south structural differences, but also to southern regions, at least with respect the baseline of islands (Sardinia and Sicily).

Finally, the introduction of a tourist-flow factor, aimed at further correcting estimates for omitted variables bias, shows that the total provincial tourist presence positively influences per capita waste generation with high significance, as expected. In addition, it is not highly correlated to value added (VA). The TP is further

[15] Diagnostic tests here indicate the presence of heteroskedasticity but not serial correlation (tab.2). Thus, the models are estimated using Prais-Winsten feasible generalized least squares, assuming panel heteroskedasticity but not serial correlation. It gets parameter estimates along with panel-corrected variance estimates. Johnstone and Labonne (2004) recognise the necessity of testing both correlation and heteroskedasticity, but note problems in coping with both given missing values in their OECD data.

[16] Logarithmic transformations are preferred because from a theoretical standpoint it is more correct to implement significance tests on logarithmic data. The assumptions of the most common significance tests (z tests, t-tests, and F tests) is that variables are normally distributed. W note that per capita waste values are right-skewed, and the log transformation generates a more symmetrical distribution.

[17] A general note. WKC evidence emerges across specifications only in corrected regressions. We here present only heteroskedastic corrected estimates since serial correlation tests do not seem to highlight this as a problem for our data.

decreasing with respect to above regressions: 25,227€, now within the range of observed value added. The elasticity of waste generation to tourist attendance is 0.0758[18].

As an additional exercise, we tested a model for the total level of waste generated (not per capita), where the dependent variable is waste generation, and explanatory variables are value added, population and share of separated collection (estimates are not shown). Value added, population, and separated-collection share are positively (the latter negative) and significantly linked to waste generation. Elasticities of waste generation to value added and population are estimated respectively as within the ranges 0.43-0.93 and 0.56-0.59. These elasticities confirm previous results in the literature (Johnstone and Labonne, 2004).

To sum up, the analysis shows some evidence of a WKC shape, although the results need further confirmation given the very high TP, which nevertheless is, we note, within the range in the most comprehensive specifications including tourist flows. Graphical plots support (weak) WKC evidence. Some might argue that, instead of a real first sign of absolute delinking, we are observing a stabilization of waste generation for some richer areas[19]. Neither separated collection share nor population density, though significant, affect the evidence concerning the relationship between waste and income. This evidence may be the first sign, emerging from a very detailed and heterogeneous provincial dataset, of a process where the structural feature are reversing, from a positive to a negative elasticity of waste generation, with respect to income/value added drivers. Further empirical evidence is needed to confirm these results. All in all, if not absolute, there is strong evidence of a relative delinking, with elasticities that are much lower than those estimated in previous studies on the EU (Mazzanti and Zoboli, 2005)[20]. If not a clear EKC, at least a levelling off of MSW trends is appearing. We stress the value of provincial data, which allows more in depth investigation of income-environment trends by exploiting more (latent) heterogeneity.

4.2 The role of waste management instruments

With regard to waste management instruments, we can specifically test, at provincial level, two covariates that act as proxies for the policy shift towards more 'market-oriented' approaches: (i) share of total population living in municipalities that introduced the 'waste tariff' in place of the old 'waste tax' (TARIFF); an interesting 'policy

[18] Splitting tourist flows into national and foreign attendances (0,73 correlation) the aforementioned regression is still significant. National tourist flows are associated to a relatively higher positive elasticity.
[19] A similar picture is arising for Europe, when analysing EU15 and Eu25 samples. Some richer countries are stabilizing or reverting the trend.
[20] In other words, a diminishing marginal effect, but not a negative marginal effect.

proxy' since it captures the speed of local waste utilities in moving towards the 'full-cost pricing' approach provided by the Italian waste laws; (ii) the percentage of total waste management cost recovered by waste-management utilities (COST-REC); this variable should capture the way waste management is moving towards a "private enterprise approach", even within the sphere of public ownership/management[21]. We use only 2004 data, which is reliable, because, in this case, the time trend is less relevant than cross-section heterogeneity. The two variables, as expected, are positively correlated. However, the correlation is not high (0.18), since they capture different economic and institutional trends[22].

In including the two above mentioned variables, WKC evidence still remains, with TP estimated in a range between €23,500-26000. Thus, the inclusion of policy variables further reduces the TP level. It still remains a high income level, but some provinces exceed it[23].

TARIFF is positively and significantly correlated to waste generation, showing a possible signal of the above commented endogeneity of policy cycles with regard to income: richer areas may show stronger environmental policy commitment. This is of crucial relevancy in decentralised policy environments.

As far as COST-REC is concerned, a negative effect is instead found[24]. Including them jointly does not change the result, as table 2 shows. The more waste utilities adopt market behaviour, by covering at least the variable cost of the service through tariffs, the higher the local performance in terms of waste generated, regardless of the private/public/mixed kind of ownership. This is core policy evidence: though the transition from the tax to the tariff system is slow and endogenously driven, the full cost pricing mechanism impacts on waste trends even in the early implementation phase.

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[21] For both waste and water management, Italy is currently undergoing a long-run shift towards an institutional setting in which, even when remaining the owner and the manager of the service, the local public agents take on a variety of utility configurations. These can include private entities and, in any case, the service must be put out to tender in the market. Therefore, the trend is towards increasing full-cost recovery, based on the shift from tax to tariff, at least for the variable part of costs.

[22] It is true that the outcomes of policy analysis may be flawed by the short term nature of data. Nevertheless, we exploit time variant indexes, unlike most studies. Then, and this is a core point in our study, environmental and waste policies, especially in the initial phase, are characterised by endogeneity with regard to other features. Policies are not exogenous as theory might prescribe, but are often related to income and institutional features. We believe that this is worthy of further research.

[23] Summing up, TP across specifications are quite close to the maximum value observed. Only a few of the 103 provinces exceed the estimated lower bound of the range of estimated TP across regressions, i.e. Rome, Mantua, Florence, Bologna, Modena, Milan, Bolzano, Parma. Taking the highest level in the range, only Milan and Bolzano are strictly higher than the estimated turning point.

[24] As an alternative to TARIFF, we confirmed whether the share of municipalities within a province (not the population) that introduced the tariff (TARIFF2), leads to different evidence. This variable is independent from effects deriving from huge urban areas opting for tariffs, since each municipality within a province has the same weight. It is nevertheless not significant, with a negative coefficient.

Our work quantitatively assesses that at least the initial phase of policy implementation may be associated with endogeneity and consequently will increase differences between richer and poorer areas of a country. Nevertheless, we also confirm the hypotheses that instruments implemented at the level of difficulty of waste management (recycling, collection, and disposal), generate feedback effects on waste prevention, in reducing the amount of generated waste. Evaluating policy process in their initial phases can be useful for reshaping tools and processes[25].

5. Conclusions and policy implications

The paper provides empirical evidence on delinking, for waste indicators. Results provide evidence in favour of WKC for waste, with somewhat high turning points, but within the observed income range, at least for most comprehensive specifications. The estimated turning point is estimated as being in the range between 22586-31611€ (with baseline specifications showing a TP at 36518€, while those including socio-economic drivers and policy factors reducing it to around 23-26000€) of value added per capita. These values are higher than the median and mean values for value added in the period considered, and quite close to the maximum value added observed. Only a few of the 103 Italian provinces either exceed or come close to this threshold, which in any case is close to the highest observed value added per capita. All additional drivers, such as population density, separated waste collection, tourist flows, and policy factors, are significant, with expected signs. Policy factors highlight both the possibility of endogenous policy transition in the early implementation phase, but also the effectiveness of full cost covering pricing. The two policies related variables do not affect the core WKC evidence. What emerges is that the richest provinces in Northern Italy tend to be more innovative in terms of new institutional/policy approaches (market-oriented management settings, introduction of market-based instruments, better enforcement of waste policies), but they produce more waste per capita. The innovative approaches to waste policies adopted by the richer Italian provinces are expected to have an *indirect* negative feedback on waste generation at source (prevention). Though they are still characterised, even ex ante, by a greater emphasis on the recovery of waste-management costs and, both ex ante and ex post, by little incentive

[25] If waste management and waste policies are income driven, early implementation may affect the dynamic. Poorer regions with poor policy performance may undermine the future possibilities of reversing the relationship. Though the optimal dynamic of environmental investments for a region over dynamic development, is difficult to assess, the recent EKC literature shows that if defined threshold are exceed at an early stage, then irreversible or very high costs may emerge, making environmental management more difficult and costly at the (income) stage society values the environment.

to reduce waste at source, we here find that cost recovery schemes aimed at full cost pricing of waste management is impacting local waste generation performances.

Results presented are, to our knowledge, the first, although to some extent not conclusive given the high TP, evidence supporting WKC for waste generation. In the present analysis, we claim that the emergence of a WKC for waste largely depends on the availability of in-country highly disaggregated data. By exploiting a more disaggregated dataset at provincial level, we find that the relationship between waste generation and economic drivers is associated with a conventional WKC shape. This result also points out that international cross-country analyses may capture only the cross country average effects. A disaggregated, within-country analysis is more useful in economic terms, and also provides a more robust statistical framework. When exploiting the within-country heterogeneity, different relationships between environmental pressures and economic drivers may arise, calling for different policy interventions.

If national/local situations differ with respect to 'abatement costs' and with respect to the point at which the country/region lies along the WKC development dynamic, the case for more heterogeneity in national/local waste policies is called for (Pearce, 2004). Our investigation is specific to Italy, a country where the role of decentralised environmental policies is structurally and increasingly relevant, and allows interesting considerations on North-South differences. Nevertheless, national case studies may be a complement to (EU) cross country analyses, and results for Italy can be to some extent interesting for other EU countries where a "decentralised" policy implementation prevails and that within country heterogeneity is crucial, especially in important countries, such as Germany and Spain. The US is another country which, along with some differences, shares similarities in this context.

Finally, though our result may suggest a somewhat weak reversal of the waste-income relationship, they show that we cannot rely only on the expected endogenous effects of economic growth, and more effective waste prevention policies, able to decouple waste generation from its income-related drivers, are needed.

The existence of waste-prevention effects might be better detected by long time series at much disaggregated even sub-provincial, local level (e.g. towns). For the present, similar to what is been emerging at European level, our results for Italy seem to confirm that waste policies are more successful in developing waste recovery/recycling and new disposal routes, rather than in promoting waste prevention. The problem of a lack of incentives for prevention is common to other environmental policies, but it seems to be exacerbated in the case of waste policies.

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Table 1. Descriptive statistics: dependent and independent variables

Acronym	Variable description	mean	min	max	Research hypothesis
WASTE	MSW generated (kg per capita)	516.26	251.91	893.24	Dependent variable
VA	Provincial value added per capita (€2000)	17,653.64	9,369.12	28,796.07	Positively correlated with income, the objective is assessing whether relative or absolute delinking are present
DENS	Population/surface (inhabitants/km2)	244.095	36.43	2,640.92	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	Possibly reducing MSW generation through indirect feed back effects, though the direct effect is at waste management level. Possible endogeneity given positive correlation with respect to income.
TARIFF	Share of population living in municipalities that introduced a waste tariff substituting the former waste tax (%)	9.00	0	99.72	
TARIFF2	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	98.2	104.2	
TOURIST	Tourist yearly attendance (per capita)	7.18	0.40	58.83	Positively affecting waste generation per capita

Table 2. Base estimations and additional specifications

	Model								
Variable	1	2	3	4	5	6	7	8	9
Cons	***	*	***	***	***	***	***	***	***
logVA	0.3494***	4.5554**	0.4315***	6.6850***	6.3136***	8.7775***	7.3668***	9.4415***	7.8275***
$(logVA)^2$	…	-0.2168**	…	-0.3226***	-0.3115***	-0.4360***	-0.3674***	-0.4639***	-0.3873***
logDENS	…	…	0.0355***	0.0415***	0.0619***	0.0387***	0.0596***	0.0454***	0.0625***
COLLEC	…	…	-0.0026***	-0.0026***	-0.0015**	…	…	-0.0035***	-0.0021***
TARIFF	…	…	…	…	…	0.0019***	0.0011**	0.0024***	0.0014***
COST-REC (2004)	…	…	…	…	…	-0.0024***	-0.0027***	-0.0023***	-0.0027***
logTOURIST	…	…	…	…	0.0758***	…	0.0759***	…	0.0721***
Turning point	/	36.518	/	31.611	25.227	23.515	22.586	26.246	24.494
Baltagi-Wu LBI	1.5257	1.5266	1.5458	1.5494	1.6052	1.5395	1.6061	1.5485	1.6048
Panel-level heteroskedasticity LRtest	544.91***	544.86***	571.60***	563.69***	546.91***	614.13***	591.21***	622.79***	587.20***
Chi-sq prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N	721	721	721	721	721	721	721	721	721

Coefficients are shown in cells.
* 10% significance level, ** 5% significance level, * % significance level.