UNIVERSITÀ DEGLI STUDI DI FERRARA
DIPARTIMENTO DI ECONOMIA ISTITUZIONI TERRITORIO
Corso Ercole I d'Este, 44 – 44100 Ferrara

Quaderno n. 17/2006

October 2006

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Municipal waste production, economic drivers, and 'new' waste policies: EKC evidence from Italian regional and provincial panel data

Massimiliano Mazzanti[♣], Anna Montini[♥] and Roberto Zoboli[♦]

Abstract

The paper provides empirical evidence on delinking and Environmental Kuznets Curve (EKC) for municipal waste production in Italy. First, methodological issues and literature on delinking and EKC for waste are critically re-examined. Secondly, we analyse two very disaggregated panel datasets on Italian Regions and Provinces (1996-2004 data for the 20 regions, 2000-2004 data for the 103 provinces) to estimate the extent delinking between waste production and economic drivers is taking place. The empirical analysis of different specifications show mixed evidence in favour of an EKC relationship. Evidence supporting an EKC hypothesis significantly arises at the provincial level, which presents a very high data heterogeneity. Nevertheless, the turning point is at very high levels of value added per capita (around 23,000-26,000€), which characterise a very limited number of wealthy (Northern) Italian provinces. The analysis does not bring to a similar evidence for the regional dataset: just a relative delinking dynamic emerges At the provincial level, we also note a positive relationship between waste production and the share of separated waste collection, which can be explained by the sharp difference in income and waste-policy performance between Northern and Southern Italy. Population density is never significant instead. Finally, the test on some policy proxies, i.e. the diffusion of the new waste tariff regime at the local-level and the ability of utilities to recover waste service cost, leads to the conclusion that they are not (yet) impacting waste production. To lower the turning points and to avoid an increasing gap between geographical areas, innovative (market based) and more effective policy instruments should be implemented. In particular, the weight of waste policies should be rebalanced towards waste prevention targets and instruments, in line with the priorities stated by the EU and Member Countries. In fact, the indirect feedback effect of good post-production waste management policies/practices on reducing wastes production at source can be weak and slow. In general, the results confirm that more geographically-disaggregated data may offer more insights with respect to cross-country datasets, also from the policy perspective.

Jel: C23, Q38, Q56

Keywords: Decoupling, Environmental Kuznets Curves, Environmental Efficiency, Waste Indicators, Waste Policy, Economic Drivers, Panel Data

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1. Introduction

Indicators of 'decoupling' or 'delinking' are becoming increasingly popular in detecting and measuring improvements of environmental/resource efficiency with respect to economic activity. An extensive work on decoupling indicators for reporting and policy-evaluation purposes is being done by the OECD (see OECD, 2002). Various decoupling or resource-efficiency indicators are included in the European Environment Agency's state-of-the-environment reports (EEA, 2003c), and they are part of the work by European Topic Centres[1] A few European countries started to include delinking-type indicators in official reporting on environmental performance (DEFRA/DTI, 2003). Some countries are considering delinking-based targets for major environmental policies, and the US adopted an 'emission-intensity' target, i.e. a reduction of the CO_2/GDP ratio, for its climate policy.

Delinking trends are under scrutiny since decades for industrial materials and energy[2]. In the 1990s, research on delinking extended to air pollution and GHG emissions[3]. The 'stylised fact' emerging from those analyses, i.e. an inverted U-shaped relationships between pollution and economic growth, is similar to the Kuznets' results (1955) on income distribution in the long-run, and became the well-known 'Environmental Kuznets Curve' (EKC) hypothesis, which is the natural extension of delinking analysis[4]. Despite increasing applied research efforts, empirical evidence for EKC on emissions is still ambiguous. Some regional/local pollutants seem to show a 'turning point' at certain levels of income, but it is a shared view that some critical externalities, like CO2 emissions and waste flows, are monotonically rising with income. At best, a 'relative delinking' is taking take place (Stern, 2004)[5].

Research on delinking and EKCs for materials and waste is actually less developed compared to pollution and GHG emissions. Although recent works, in particular those by the Wuppertal Institute[6], produced extensive evidence on material intensity indicators, the still limited research results for the waste sector may be a serious problem in a policy perspective. The EU policy 'thematic strategies' on both resources and waste entail the reference to 'absolute' and 'relative' delinking indicators (European Commission, 2003a,b). Since a decreasing ratio of a material input with respect to an economic driver would suggest a decreasing (future) production of waste, delinking at the various stages of the material-to-waste chain can be interpreted in terms of 'prevention'. The latter is the stated first priority of the EU waste policy strategy, also transposed in national waste legislations. Therefore, waste prevention activities and policies could be monitored and evaluated by addressing, in particular,

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[1] See eea.europa.eu, and the activities of the Topic Centre on Resource and Waste Management, waste.eionet.europa.eu.

[2] For a discussion of the evidence on materials and energy until the early 1990s see Zoboli (1995 and 1996). For recent analyses of the long-run trends for energy see Ayres et al. (2004), Gruebler et al. (1999) and other works carried out at IIASA, www.iiasa.ac.at.

[3] See Holtz-Eakin and Selden (1992), Ten Kate (1993), Selden and Song (1994), Grossman and Krueger (1994).

[4] The EKC hypothesis does not originally stems from a theoretical model, but recent contributions have started showing how it may be included in formalised economic models. See Andreoni and Levinson (2001), Chimeli and Braden (2005) and Kelly (2003), who finds that the EKC shape depends on the dynamic interplay between marginal costs and benefits of abatement.

[5] The empirical literature is too extended to be surveyed here. Summing up main results, water pollution seems to present a turning point between 5.000 and 17.000$ of per capita income depending on the specific pollutant. For air emissions, all main externalities, except CO2 and transport-related emissions, appear to have a turning point in the range of 10.000-20.000$ (Yandle et al., 2002).

[6] See Moll et al. (1999); Femia et al. (2001); Bringezu et al. (2003); Eurostat (2001, 2002).

the trends towards reduction of waste production at source and reuse (see also OECD 2002; 2003) and, at the macro level, through 'absolute' or 'relative' decoupling indicators, as well as by EKCs analysis[7].

This paper provides empirical evidence on delinking trends for municipal waste production in Italy. Firstly, methodological issues regarding the analysis of delinking are discussed and the related Environmental Kuznets Curves literature is critically re-examined (Sections 2). Secondly, two panel datasets concerning, respectively, Italian Regions and Italian Provinces are used to estimate delinking and EKC relationships between waste production and economic drivers (Sections 3 and 4). Thirdly, the policy implications of our empirical results are presented and discussed (conclusions in Section 5).

The possible value added of the paper is manifold. Empirical evidence on EKC dynamics for waste is still scarce, and analyses which exploit country-specific, highly disaggregated panel data are even scarcer with respect to cross-country analyses. We thus provide EKC evidence exploiting environmental-economic merged panel datasets at decentralised level (Regions and Provinces). The datasets cover the period 1996-2004 for the 20 Italian regions and 2000-2004 for the 103 Italian provinces. As economic drivers we exploit both value added/GDP and household expenditure, then testing the additional effect of socio-economic variables such as share of separately collected waste and population density. The analysis also includes decentralised policy-related variables: the share of municipalities passed from the tax on waste to the waste tariff; and the percentage of waste management costs covered by the tax/tariff. We also control for tourist-related flows, a crucial issue for local waste production in Italy. The results from international or even European level analyses are generally considered to be unsatisfactory; they produce only average elasticities for the environmental-economic relationship, and are unanimously considered to have a low information value for policy purposes. We think therefore that highly-disaggregated analyses at the country level, as the one presented in this paper, can represent a fruitful research direction.

2. Estimating EKCs: Key issues and evidence for waste

2.1. The econometrics of EKCs: Some key issues

At the econometric level, the aim of EKC analysis is to estimate a vector of coefficients, each linked to a single driver of the environmental index, by using a simple reduced form equation. EKC issues will be briefly commented referring to the extensive literature developed over the last decade[8]. The focus is twofold. First, we suggest that the EKC framework is, under certain circumstances, a necessary step forward of decoupling analysis. Multivariate investigations adds robustness to results. Second, the potential weaknesses of the EKC analysis will be thoroughly highlighted.

The EKC framework extends the basic decoupling reasoning, modelling a multivariate analysis of the environment-income relationship. Even if EKC does not rely on a specific economic model, many theoretical assumptions, on the consumption and production sides, are implicitly tested within the EKC empirical context. The main economic hypotheses underpinning the EKC setting are: (i) income increase has a 'negative scale

[7] For a discussion on the prevention meaning of delinking indicators for materials and waste, and their possible adoption in policy evaluation, see Jacobsen et al. (2004). Se also Mazzanti and Zoboli (2005) for a discussion on the meaning of delinking and EKC in the framework of an IPAT model, which includes population and income as scale factors.

[8] Good critical surveys are Stern (2004), Dinda (2004) and Dasgupta et al. (2002).

effects' on emissions, and (ii) the main 'positive effects' of income increase are: a composition effect of economic activities within GDP, a technological effect, a preference-drive effect (environment being a normal/luxury good), a possible policy effect driven by market-instruments.

We do not specifically focus on the more statistically oriented key issues (and potential weaknesses), like (i) differences in estimated coefficients between parametric and non parametric models; (ii) the degree of the polynomial used to proxy the environment income relationship; (iii) the econometric model specification used[9]. Less technical but critical issues are: (i) the environmental performance index and economic drivers investigated; (ii) the nature and quality of data. Both are crucial in this paper, which investigates EKC on a quite unexplored realm (waste), providing preliminary results grounded on disaggregated within country data, as opposed to cross country analysis.

EKC studies often use different environmental index (absolute, per capita, output based, input based, per unit of GDP). A general consensus over what indicators to use does not exist. Different measures have nevertheless different implications and interpretation. For example, if a measure on per capita basis in OECD countries faces few problems of understanding, and absolute measures could be avoided, if we measure intensity in the vertical axis the presence of a lower bound implies that total emissions are growing at the same rate of income, in a sort of 'steady state' equilibrium. It is obvious that the measures on the vertical and horizontal axis should be compatible to each other[10]. We also note that there is no consensus about the type and number of explanatory factors introduced as potential drivers of the environmental performance. Some studies use income variables only. Other studies include many socio-economic variables with the (correct) aim of extending the conceptual setting behind the EKC empirics (Harbaugh et al., 2000); a few include policy drivers (Markandya et al., 2004). The choice obviously depends on both data availability and research objectives.

The nature and quality of data are also crucial issues. In the first wave of the EKC literature, a large majority of contributions focussed on the analysis of cross-country datasets, generally taken from official OECD and World Bank sources. Nevertheless, the quality of macro data for some regions (non OECD countries) has been questioned, and even the exploitation of panel datasets does not allow the researcher to calculate specific country-level coefficients for the income-environment relationship[11]. The conceptual key fact is that not a single relationship, but many different, may apply to different (categories of) countries. Therefore, the policy relevance of world-wide cross country analyses seems to be limited. European countries, if compared to international datasets usually exploited for EKC analyses, represent a more homogeneous set of statistical units. Although the limited data variability is an intrinsic feature of such a dataset, the relevancy for policy-making purposes is higher. Future research, as it will be stressed in the conclusions, should then focus on delinking analysis that exploit

[9] We refer to Mazzanti, Montini and Zoboli (2006) for an updated critical survey of main literature streams.

[10] Some argue that the choice over the dependant variable could depend on the issue considered. The per capita option is probably more compatible with situations where the degradation is deriving from overexploitation linked to population growth, whereas emission intensity is more compatible with scenarios with externalities caused by industries.

[11] In fact, econometric panel studies usually provide information on mean-value coefficients since they usually rely on the assumption of different constant terms, but equal coefficients across units (fixed effects model). We note that the superiority of heterogeneous panel data models is questioned. Baltagi et al. (2002) offer evidence that simplicity and parsimony in model estimation often offer better forecasts. Thus, added value may be found in the usual "homogenous panel analysis", but concerning national/regional datasets.

datasets regarding environmental and economic indicators at a provincial/regional level (at national/European level). 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 of investigating effects additional to the usual income driver, which lies at the core of EKC reasoning but may hide latent and even more important, though somewhat income correlated, driving forces.

2.2 Empirical evidence on delinking and EKC for waste

As summarised by Cole at al. (1997) and Stern (1996, 2003), the evidence provided by the first wave of studies, relying on data until the late eighties, was generally that EKC existed only for local air and water pollutants, but not waste, while indicators with a more global or indirect effect were increasing more or less monotonically with income.

Empirical evidence of various nature in support of an EKC dynamics, or delinking between emission and income growths, has shown to be more limited and fragile for CO_2 compared to local emissions and water pollutants (Cole et al., 1997; Bruvoll and Medin, 2003). Decoupling between income growth and emissions of CO_2 is not (yet) apparent for many important countries (Vollebergh and Kemfert, 2005), and when delinking is observed, it is mostly of a relative and not of an absolute kind. (Fischer - Kowalski and Amann, 2001[12]).

For waste production/generation, empirical contributions are scarce and tend to point out that the EKC is not emerging, despite the local nature of waste-related externalities. We nevertheless must note the differences between delinking concerning waste production and the delinking potentially associated to disposal options, at which level policy efforts have been stronger since many years in developed countries (Karousakis, 2006).

There are few EKC analyses aimed at analysing the relation between material flows/waste and economic drivers. As noted by Karousakis (2006), most evidence on the determinants of waste production is based on US microeconomic studies carried out at the local community level. Johnstone e Labonne (2004) present an overview of such studies dealing with microeconomic individual or household data: income-elasticities of waste production is estimated in a range between 0.05 to 0.55, thus inelastic. They note that a microeconomic based study is problematic since it often relies on case studies and small datasets.

In our framework, this inelastic relationship may mean that a relative delinking is present, though no signal of an absolute delinking do emerge.

[12] The paper, which is strictly linked and refer to Matthews et al. (2000) presents descriptive quantitative evidence on material, waste and emission flows, from a perspective of material input-ouput accounting. Richer OECD countries are taken as examples. For material input, the intensity with respect to GDP shows relative but not absolute delinking, with material growing over 1975-1995 (the period considered) for all countries. As far as outflows (air emission and waste disposed into the environment) are concerned, evidence support relative but not absolute delinking as well. Outflows are then broken down by the environmental media they enter. Looking at CO2, air emission and landfilled waste, they note that absolute delinking holds for waste landfilled (not produced!) and air emissions, but not for CO2. This confirms that absolute delinking, more strongly associated with the EKC hypothesis, is likely to hold (sooner over the development path) for local and regional externalities (Bruvoll and Medin, 2003). A similar perspective is presented by Canas et al (2003), who find EKC evidence for direct material input concerning 16 industrialised countries, but with income ranges observed mostly on the rising pattern of the curve (relative delinking).

Concerning the intrinsically macroeconomic framework of the EKC, the international report which gave rise to the EKC literature (World Bank, 1992; Shafik and Bandyopadhyay, 1992) did not find evidence of delinking for waste by exploiting cross-country regression analysis of data from the eighties. The elasticity is positive and equal to 0.38, showing actually a relative delinking trend. Recent reports like the UK DEFRA (DEFRA; 2003) presents the positive elasticity of waste generation to income as a primary policy concern: as long as CO2, waste production seems to have still a strict relationship with economic drivers.

Cole et al. (1997) find no evidence for an inverted U-shape EKC curve concerning municipal waste. They use municipal waste data for the period 1975-90 in 13 OECD countries, finding no turning point, with environmental indicators (per capita municipal waste) monotonically increasing with income over the observed range. Leigh (2004) presents evidence for EKC concerning a waste/consumption indicator deriving from the environmental sustainability indexes (ESI). The analysis faces two potential problems: data only exists for 2001-2002 and the index is based on a comparative rather than on an absolute scale. Wang et al. (1998) also find evidence in favour of a negative elasticity, by focussing on US stock of hazardous waste as environmental impact indicator and exploiting a county-based cross sectional dataset. The nature of the pollution effect (stock/flow, hazardous/non-hazardous) seems to matter: non-hazardous and flow externalities appear to be less likely associated with a negative elasticity, even in industrialised countries. Recent works is nevertheless emerging for waste, though always limited by data availability. A macroeconomic based study is by Johnstone and Labonne (2004) who use a panel database of solid waste in OECD to provide evidence on the economic and demographic determinants of generation rates of household solid waste, regressed over consumption expenditures, urbanization and population density. With respect to economic activity and population density, the results are largely consistent with results found in previous studies: they find positive elasticities, but lower than one, in a range from 0.15 to 0.69, evidence of relative delinking. Population density is also positively related to waste generated, while a negative effect is found for population age[13].

Karousakis (2006) also focuses on municipal solid waste generation for OECD countries. She presents evidence both on the determinants of waste generation and the driving forces behind the proportion of paper/glass recycled, and the proportion of waste landfilled. A panel database from 30 OCED countries over 1980-2000 (four period data, thus observations are 120) is exploited. Although not explicitly dealing with EKC, it shows that MSW increases monotonically with income, with an elasticity around 0.42-0.45. Urbanisation exert even a stronger effect on waste generation, while population density is not significant, as the policy index[14]. This is one of the first studies to explicitly deal with the drivers of waste management and disposal options, in addition to waste generation. Though thus extensions re relevant, we argue that as far sustainability arguments and waste policies are concerned, the investigation of the relationship between waste and its economic and non economic drivers is of primary relevance. The production of waste is the more relevant environmental pressure indicator: more waste means more disposals loads, more management costs, and more environmental externalities. Reduction at source is, without ambiguity, at the first level of the EU waste hierarchy, while some doubts are

[13] A previous similar study is by Beede and Bloom (1995) who use cross section data for 36 countries finding an elasticity of MSW with respect to income of 0.34 and with respect to population of 1.04. When using time series data for the US (1970-1988), income elasticity is 0.88 while population is not significant as driver.

[14] The latter two variables are instead significant in a final attempted FGLS model, both with expected negative signs.

now cast on the relative social costs and benefits of recovery and landfilling options. The added value of waste recovery routes (recycling, incineration with energy recovery, composting, etc.) are to be demonstrated case by case, compared to (new) landfills with energy recovery and long run full cost potentially internalised (Pearce, 2004; Diikgraaf and Vollebergh, 2004). However, the amount of waste produced depends on highly resilient, structural features of processes and products at industrial and distribution levels. Therefore, it is the level at which waste policies should be stronger, and, at the same time, the level at which policies face more difficulties, due to the visibility of their costs for economic agents. On the other hand, policies at the level of waste management and disposal can hardly exert strong and direct incentives backward to waste generation at source. We will further discuss these policy issues in our conclusions.

As far as Europe is concerned, Mazzanti and Zoboli (2005) find no delinking and EKC evidence exploiting municipal waste and packaging waste European panel datasets respectively from 1995 to 2000 and 1997 to 2000; estimated elasticities of waste production with respect to household expenditure are close to unity. The European waste sector emerges as an area for further exploration of the EKC hypothesis. Given (i) the relative homogeneity across those countries in terms of structural characteristics, and (ii) the panel framing which helps dropping off non observed fixed factors, the results, though preliminary, could be considered robust and of policy interest for the European framework.

The literature thus underlines that waste indicators generally tend to increase with income or other economic drivers, and, in general, an inverted U-shape curve is still not fitting data[15]. Some authors have recently suggested that for stock pollution externalities the pollution income relationship hardly turn into an EKC shaped curve, with pollution stocks monotonically rising with income (Lieb, 2004). Another structural motivation for the lacking evidence for 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 (Khanna and Plassmann, 2004)[16].

Both the literature on the determinants of waste production and the EKC literature converge to the same point: to date, macroeconomic evidence on EKC relationship for waste is still very scarce[17]. Furthermore, policy

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[15] Rothman (1998) argues that delinking is less likely to occur when we tackle "consumption-based" measures. Evidence in this direction, explained by trade patterns between richer and developing states (within a country) or countries, is provided by Aldy (2006) on CO_2. See also Roca (2003), who stresses the relevancy of distributional issues, as long as EKC is possible explained by the possibility of displacing environmental costs to other areas or to the future; Gawande et al. (2001), who attempts to develop a consumption side model of EKC, and Bagliani et al., (2006), who empirically test an ecological footprint framework, finding no evidence of absolute delinking.

[16] Outside the waste framework, evidence has been increasingly developing over the last ten years. We refer to Ekins (1997), Dinda (2004, 2005), Cole et al. (1997), Cole (2003), Fonkych and Lempert (2005), Stern at al. (1996), Stern (2003, 2004), Managi (2005) and Yandle et al. (2002) for critical surveys of the literature, which is not an explicit aim of this paper.

[17] This is true for all the EKC literature. Concerning air emissions, we quote List and Gallet (1999) who present evidence on the US using state level SO2 and NOx emissions from 1929 to 1994. In summary, the large majority of states follow an EKC shape, predominantly in quadratic rather than cubic form, and with a larger share of states for NOx. Then, turning points predicted by the traditional panel model are lower than the peaks observed state by state. Most countries though associated to an EKC shape witness higher than the average turning points. Thus, traditional panel analysis may lead to overly optimistic conclusions, driven by the result which represents the average picture, hiding specific EKC dynamics by states or regions within countries. Aldy (2005, 2006) explores relationships among economic development, energy consumption and CO2, using EIA data for US States over 1960-1999. he finds that the energy consumption income elasticity is positive but decreasing in income, though energy production takes an inverted U shape, peaking at 21500$

implications from international cross-country studies may be weak: 'average' elasticities stemming from international panel datasets are difficult to interpret, since elasticities should be calculated at the more decentralised level as possible, in order to be informative for policy makers. Macroeconomic analysis at a relatively disaggregated geographical level may be the good compromise and the best choice between microeconomic based studies, difficult to generalise, and macroeconomic investigations based on cross-country datasets.

Nevertheless, the literature still lacks single-country case studies using data at regional, provincial or municipal level. This is potentially a fruitful line of research, both for the methodological reasons mentioned above, and, not least important, for the quality of data. As Johnstone and Labonne (2004) observe, OECD and EU datasets may be affected by differences in waste classifications used by different countries. Care must be taken mainly when dealing with data reported before the 1990s. National official datasets provide a better and more reliable basis, offering in addition the possibility of exploiting geographically disaggregated datasets.. Nevertheless, regional or provincial statistics help providing cross sectional heterogeneity and a sufficient number of observations to the panel matrix[18]. In this paper, we pursue this task of developing a very disaggregated, within country analysis.

3. Empirical analysis on regional and provincial data for Italy

3.1 The datasets

The two datasets includes data on the Italian Regions and the Italian provinces' waste production published in the yearly editions of the APAT (Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici) "Rapporto Rifiuti". The APAT data[19] contain information on the waste production, the separately collected waste, the energy and materials recovery and the urban waste disposal of all the Italian regions from 1996 to 2004 and from 2000 to 2004 for the Italian provinces. Every year the published data contain (or can contain) revisions of the previous published data; so, for every year we have considered the data of the last available publication.

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reflecting energy imports for richer states. The standard CO2 measure, corresponding to energy production, peaks and follow EKC dynamics, while when adjusting mission for inter states electricity trade, an N shape emerges. This is a key point: interstate electricity trade can affect estimated emission income relationship. The use of production based rather than consumption based statistics affect the estimation of EKCs curves, possibly yielding downward relationships which under estimate the real environmental impact. The carbon intensity of energy declines in income or total energy consumption and for industrial, residential and commercials sectors.

[18] Regarding Italy, Concu (2000) focuses on Sardinia, exploiting cross section data on municipal waste generation for 322 municipalities: he does not find evidence supporting EKC; he finds an exponential shape for its logarithmic specification. The analysis is nevertheless limited by the cross section nature of data. As noted, we argues that though rather complex, the new research line is one exploiting panel data at regional, provincial or municipal level, for assessing EKC evidence at national level. Heterogeneity may exist in EKC shapes across countries, as noted in the literature, and the heterogeneity associated to disaggregated data help producing better estimates for EKC functional forms.

[19] APAT collects data through questionnaires mailed to public and private organisations (Regional and Provincial Agencies for the environment protection - ARPA and APPA - Regions, Provinces, Provincial observatory on the waste and in same cases the municipal firm for the management of urban hygiene services) that collect information about the waste management for different purposes. APAT collects several other information through questionnaires mailed to other organisations like the Authority for the waste emergency, the CONAI and other consortia (steel, aluminium, paper, wood, plastic material and glass) for the production and collection of specific waste.

The provincial dataset includes a variable related to the share of the provincial municipalities and the provincial population covered by a tariff regime substituting the old 'waste tax'[20]; this information derives from the APAT Rapporto Rifiuti too and is related to the monitoring of the experimental application of the tariff and to the economic analysis of the management costs of the urban waste cycle. Generally, the municipalities' number that applies the tariff system increases every year despite the normative uncertainty[21]. The published data refer, for every province, to the number of the municipalities with a tariff, the corresponding population and includes the covering share calculated on the 2000 population and the 2000 municipalities number[22].

The application of the tariff scheme mainly affects the Northern municipalities. It increased from 564 municipalities in the 2004 to 747 in the 2005 and, at regional level, the biggest increases happened in Veneto (212 municipalities in 2005) and Lombardy (160). At regional level, the Veneto region has the biggest share (36.5%) of the municipalities that applies the tariff out of the total; Trentino Alto Adige, with a share of 35,4%, Emilia-Romagna (about 32%) and Lombardy (10,3%) follow. For the same regions the population shares covered by the tariff are 66% in Veneto, 64% in Trentino Alto Adige, 49% in Emilia-Romagna e 19% in Lombardy.

Data on the percentage of recovery of the total waste management cost that waste-management utilities have been able to achieve are available for years 2002 and 2003; so this variable can be used only by considering one year (i.e. the last one), repeated for every year in the database.

The population data used for the calculation of per capita waste production and the provincial inhabitants density refer to the 31 December of every year (the source is ISTAT, the National Institute of Statistics). The source of per capita value added at constant prices 1995 (Italian regions dataset) and at constant prices 2000 (Italian provinces dataset) is ISTAT; per capita yearly expenditure at constant prices derives from the yearly Italian Household Budget survey (from 1996 to 2003 due to data availability). Finally, the data on the yearly provincial tourist presence (total, Italian and foreign) are drawn from the yearly ISTAT volumes "Statistiche del turismo".

3.2 The EKC empirical model

The first methodological problem for the applied analysis is how to specify the EKC functional relationship. There is no consensus on this point. Some authors adopt second order polynomial, others have estimated third and even forth order polynomials, comparing different specifications for relative robustness. It is worth noting that neither the quadratic nor cubic function can be considered a full realistic representation of the income-environment relationship: the cubic one implies that environmental degradation will tend to plus or minus

[20] The decision related to the tariff application is up to the single municipal administration. The D.Lgs. 22/97 – Art. 49 introduced the tariff and abrogated the previous regime (tax scheme). The tariff regime application was then postponed by the 'Legge Finanziaria 2005', n. 311, 30/12/2004: all the municipalities with a cover of the tax service costs at least equal to the 55% out of the total have to apply the tariff scheme from the 1st January 2006; all the municipalities with a cover of the tax service costs below the 55% out of the total have to apply the tariff scheme from the 1st January 2008. The 'Legge Finanziaria 2006' postponed again the introduction of the tariff scheme of the first group of municipalities.

[21] Considering the 2005, year not included in the database, about the 9% of the communal administrations uses a tariff scheme that corresponds to the 23% of the Italian population.

[22] The number of municipalities with tariff has been compared to the 2000 number; the same has been done with the population in the APAT volumes.

infinity as income increases; the quadratic one implies that environmental degradation could eventually tend to zero. Third or forth level polynomial could also lead to N rather than U shaped curves, opening new problematic issues in understanding the income-environment relationship for policymaking. The N shape would be justified by a non-linear effect by the scale of economic activity on the environment, which is difficulty to prove[23]. Finally, the use of the income factor only, without quadratic and cubic terms, would collapse the EKC analysis to the basic decoupling analysis.

We here test the hypothesis by specifying a proper reduced form usual in the EKC field (Stern, 2004):

$$(1) \qquad \log(\text{Waste}) = \beta_{0i} + \alpha_t + \beta_1 \text{Log}(\text{Economic driver})_{it} + \beta_2 \text{Log}(\text{economic driver})^2_{it} + \beta_4(\text{Xi}) + e_{it}$$

where the first two terms are intercept parameters, which vary across provinces or regions, and years[24].

Different specifications are tested by including: (i) as dependant variable: waste per capita, log waste per capita and waste in absolute terms[25], and (ii) different economic drivers: provincial value added per capita (provincial level) and regional GDP and per capita expenditure (regional level).

The vector X refers to other drivers, added to the core EKC specification as controls for the base income only specification and possible other significant drivers of waste generation, and it may include population density, policy factors, legislations, socio economic factors like household size and population age, environmental public expenditures. In our model, it includes the percentage share of separately collected waste, population density (for both provincial and regional analysis) 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 (see Section 3.1).

Population density is included as a control variable, following other studies, for instance Johnstone and Labonne (2004) and Kaurosakis (2006): the expected sign is ambiguous, since on the one hand economies of scale may help reducing average waste collection costs (reducing incentives for waste prevention), while on the other hand population density may imply higher scarcity of land resources, thus more pressure to preserve land dedicated to waste disposal.

As suggested by other studies, the inclusion of policy proxies may be a fruitful addition for valuing the effect of policies within the EKC framework and in general assessing ex post policy effectiveness (Markandya and Golub, 2004; Kaurosakis, 2006; Millock and Nauges, 2006). We then include decentralised policy variables showing a strong geographical heterogeneity: (i) the share of municipalities (in the province and the region) which already implemented the new regime based on the waste management tariff, introduced by law ….., which substitute for the old waste management tax, the latter however still prevailed in many Italian municipalities until 2006[26]; the tariff is based on principles of full-cost pricing of waste management services

[23] Shobee (2004) suggests a third order polynomial specification as more realistic relationship between environmental degradation and income per capita. The issue still remains unresolved, with the EKC hypothesis relying mainly on empirical evidence.

[24] Cubic specification are preliminary tested but they are not deemed relevant for waste.

[25] We stress that our municipal waste production includes a variety of waste sources other than household waste, such as commercial and public administration waste, generated at the municipal level (see also Johnstone and Labonne, 2000).

[26] Given the provisions of law D.Lgs. 22/97 – Art. 49, the transition phase is quite gradual and slow. Early implementation, which is partly at the choice of the municipality, may be a signal of policy commitment. We note that such implementation is heterogeneous even across areas similar by income and by social economic variables. It thus add relevant heterogeneity. The shift from tax to tariff should also captures the incentive effect of the former, though we underline (see below) that the

and can be considered as an 'economic instrument', although it odes not include external environmental costs (see below); (ii) the actual percentage of variable costs covered by the tax/tariff for each province and region, which is correlated to the level of the tax/tariff itself[27].

Such policy variables are continuous and time variant, differently from the synthetic indexes of time-invariant dummies used in most studies, which prevent from estimating them in a panel fixed effect model. They should capture, on the one hand, the implementation of an instrument which is more market –based. The tariff is correlated to socio-economic indicators, differently from the old Italian waste tax that was independent from waste production and household income. On the other hand, they should capture cost recovery, for both public and private waste management companies, as a proxy of the degree of subsidisation (the higher cost recovery, the lower subsidisation). We should expect that both policy proxies should be (significantly) negatively related to waste generation: the more the system is 'market based', the more waste production should be discouraged. Nevertheless, in the short term, their influence cold be non significant, provided that changes in production and consumption behaviour take time and waste production is less dependant, compared to waste disposal/recovery/recycling, on price-based instruments and management approaches (see below).

Finally, in order to correct for "tourist hot spot areas", we check whether the introduction of tourist numbers at regional and provincial level affect the estimates.

The last three mentioned variables are specified only for the provincial dataset, which provides higher heterogeneity and it is more suitable to analyse decentralised, local-level waste policies.

Table 1 sums up all dependant and independent variables, showing descriptive statistics. For each combination of the dependant and independent variables, different specifications are estimated, including: the linear regressors only (delinking baseline case), linear and squared terms (EKC most usual case), and finally a specification with linear, squared and, only as an ancillary test, cubic terms. Then, the additional covariates are introduced and tested. Given the panel data framework, the relative fit of fixed effect and random effect models is compared by the Hausman statistic.

Though the logarithmic specification model is used as preferred specification, there is no clear evidence of its advantages over a non logarithmic model, which has the disadvantage of presenting non smoothed data Despite the fact that the coefficients, at least in the log linear case, are easily associated to elasticity values, we also estimate the non logarithmic specifications. Another check is carried out by estimating a LSDV model with time period effects, which may be relevant for the regional dataset covering 9 years. In any case, our panel datasets capture more cross-sectional heterogeneity than time-series dynamics, and, by exploiting this higher cross-section heterogeneity, we can have the advantage of improving estimates reliability and controlling for both individual heterogeneity and unobservable missing values.

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impact on waste generation, if significant, is not quite visible in the short term. The variable is more a way to capture waste policy features and policy commitment at decentralised level.

[27] The exact tax/tariff level is an information not easily available, since its is determined by the single (private or public) utility company which manages waste flows at municipal or provincial level. We then use two policy/management proxies derived from official APAT annual databases.

4. Results

4.1 Provincial level: 2000-2004, 103 Provinces

The results of econometric estimates on the provincial dataset, for different specifications of equation (1), are summarised in Table 2. We first estimate the model in non-logarithmic form. Results show evidence in support of an EKC. The random effect specification[28] is preferred following Hausman tests, though results are basically the same in terms of coefficient level and significance. The fit is highest when both the linear and squared value-added variable are included. The specification is also estimated correcting for first order serial correlation[29]: the outcome nevertheless does not change, apart a slight decrease in the turning point (TP)[30]. When including time effects, the overall fit decreases.

When the share of separate waste collection is introduced as an additional covariate, it is associated to a positive and significant coefficient (see below). When adding this variable, only the AR-corrected specification (column 4 in Table 2) leads to a significant quadratic term. The population density factor (population/surface) is positive in sign, but not significant in all specifications. Elasticities of waste production to value added in squared models 1-4 are estimated in a range between 1.29 and 2.23. Cubic specifications do not perform well in term of overall significance and single coefficient significance. This result is somewhat expected.

Considering all specifications (column 1-4, table 2), estimated turning points are in between 22.815€ and 25.917€ value added per capita. These values are strongly higher than the median and mean values for added value in the period considered, and quite close to the maximum value added observed. Only a few provinces out of 103 overcomes or are close to this fence, which is in any case close at the highest value added observed. In fact, taking the low level in the range, the following provinces present a value added higher than the estimated in 2004: Rome, Mantua, Firenze, Bologna, Modena, Milano, Bolzano, Parma, and Aosta and Bergamo very close; while taking the highest level in the range Bologna and Modena are slightly lower, and only Milan and Bolzano are strictly higher than the estimated turning point. Many other Northern provinces are very close, in their 2003-2004 levels, to the lower estimated turning point[31].

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[28] We estimate the model by NLogit 3.0, using a least square dummy variable specification (fixed effect). The Hausman test generally provides evidence in favour of the FE model; nevertheless, results do not differ sharply when the random effect model is estimated. We use a LSDV model since we are not specifically interested in estimating individual fixed effects, which may be inconsistently estimated when N increases. On the other hand, the alternative within effect model does not present an intercept. Since no dummy is used, this model has a larger degree of freedom for error, resulting in incorrect (smaller) standard errors for the parameter of interest.

[29] Following the procedure in Wooldridge (2002, p.176), which tests serial first order correlation by a t test on the coefficient of the lagged fitted residual term in a regression which sees as dependant variable the fitted residual in time T and the vector of explanatory factors. Lagged residuals are significant in both FEM and REM models, thus the correction model, which does not consider time T for estimation, is indicated. As noted by Wooldridge (2002, p.176), one interpretation of serial correlation in the errors of a panel data model is that the error in each time period contains a time constant omitted factor. Serial correlation may be verified by a test on the residuals (Wooldridge, 2002, p.176). If the null hypothesis of no correlation is not rejected, the model is definable as dynamically complete in the conditional mean. In any case, the loss of efficiency in presence of correlation, in models that involve relatively slowly changing variables, like consumption and output, is not so severe (Greene, 1997, p.589-590). In addition, we note that if the stationarity assumption holds, autocorrelation fades over time, but correlation have to be dealt with since it may cause more or less severe losses of efficiency. We recall that the corrected correlation model reduces the number of observations since it is based on T-1 periods, unlike the time period effect model.

[30] See Johnstone and Labonne (2000, p.535), who estimate a model correcting both for AR1 and heteroskedasticity.

[31] Other richest provinces of the North are close to the turning point, since they present average added value in the period from 23,000 to 25,000€ per capita (at constant prices 2000). We may say that some other Northern provinces could have

By using a logarithmic form, the squared term is not significant in the base specification: elasticity of waste production to value added is 0.36. Nevertheless, AR correction leads to a significant turning point of 25,310€. The inclusion of population density does not affect results. Instead, when separated waste collection is included, the estimated elasticity of waste production to value added is around 0.28-0.31 (FEM/REM), leading to an evidence of 'relative delinking'[32]. The EKC shape emerges only when correcting for serial correlation, though FEM and REM results slightly differ, with a Hausman statistics of 7.77. Thus, the REM-corrected specification show EKC evidence with a turning point at 25,196€, and the waste collection variable loses significance. Logarithmic specifications thus present an EKC TP only in AR-corrected estimates: TP nevertheless do not differ from the ones estimated for non-log specifications.

We also tested a logarithmic model in the absolute level of the variables (not per capita), where the dependant variable is waste production, and explanatory variables are the value added terms, population and share of separated collection (estimates not shown). The EKC shape is not emerging as significant in this case, but value added, population, and separated-collection share are all positively and significantly linked to waste production. Elasticities of waste generation to value added and population are respectively estimated within ranges 0.28-0.34 and 0.64-1.00, depending on the inclusion of separated collection or not. Such elasticities confirm previous literature outcomes (Johnstone and Labonne, 2002).

The introduction of a tourist flows factor, aimed at further correcting estimates for omitted variables biases, shows that the total provincial tourist presence positively influences the per capita waste production with high significance, as expected. In addition, it is not highly correlated to VA. As above, the logarithmic base specification is associated to low significance. The AR1 corrected specification consistently provide two VA terms significant at 5%, and a total tourist flow per capita at 1%. The TP is 25232€ in the REM preferred model (output similar to the FEM). The elasticity of waste generation to tourist attendance is 0.059 in the base model and 0.062 in the AR1 corrected one[33].

Summing up, the provincial level analysis shows some evidence supporting an EKC shape, though results are somewhat dependant on the specifications used. Separated collection share, though significant, and population density, do not affect results concerning the relationship between waste and income. This is the first evidence, as far as we know, in favour of EKC in the waste environment. Turning points, as expected, occur at very high income level, close to the highest value added levels observed in the sample. They characterise some of the richest provinces of Northern Italy. It could be the first signal, emerging from a very detailed and heterogeneous provincial dataset, of a process which are reversing its structural feature from a positive elasticity to a negative elasticity of waste production with respect to income/value added. Given the non conclusive evidence and the high turning point, which leave on the right side only some rich provinces, further empirical evidence is needed to confirm there results.

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reached the estimated range in the period 2004-2006. A rough calculation suggests that 14 out of 103 provinces lie within this range: except Rome they are all Northern provinces.

[32] In this case, the test for serial correlation shows the presence of correlation only for the REM model, which is nevertheless not preferred to the FEM.

[33] Splitting tourist flows into national and foreign attendances (0,73 correlation) the aforementioned regressions is still significant, with respectively elasticities of 0.060 and 0.043, and EKC TP of 26353 and 24577€.

It is worth discussing the emerging positive and significant sign of the variable 'share of separated collection'. The interpretation may be the following: the separately-collected share of total waste produced is sharply higher in Northern and richer areas of Italy. Waste management is easier where public institutions are more committed to waste collection and recovery/recycling, where European and national policies are better and more fully implemented, and when funding possibilities are higher, also as a consequence of the introduction of the waste management tariff. Thus, the higher waste generation, as is the case in Northern provinces, the higher separate waste collection, and both are driven by and correlated to provincial economic welfare indexes (value added, GNP, household expenditure). It might be expected that a better performing and more effective collection/management system (i.e. a high share of separate collection) can be also a factor possibly contributing to reduce the still positive correlation between waste production and economic drivers. However, this 'waste prevention effect' of the collection systems is far from being sure and it is not emerging in practice. Therefore, the establishment of policy targets at the of source, i.e. waste production, would be needed. This should help the waste-value added relationship to reverse into a negative elasticity, with a potential process of 'tunnelling through' the exogenously determined EKC[34]. We will further discuss this point in the conclusions.

With regard to policies, the APAT dataset allows us to specifically test, at the provincial level, two covariates that can represent proxies of the policy shift towards 'market-oriented' approaches (Table 1): (i) Share of total population living in municipalities that introduced a 'waste tariff' substituting the old 'waste tax' (TARIFF); it is an interesting 'policy proxy' since it captures the speed of local waste utilities in moving towards the 'full-cost pricing' approach provided for by the Italian waste policy laws (a long implementation period is allowed for); data are available for the five years 2000-2004 and they are highly heterogeneous, even within Northern regions and over time; (ii) the percentage of recovery of the total waste management cost that waste-management utilities have been able to achieve (COST-REC); this variable should capture the way waste management is moving towards a private-enterprise approach, even within the public ownership/management sphere[35]; we use only the data for 2003, which have a reasonable reliability, because, in this case, the time trend is less relevant than cross-section heterogeneity[36]. The two variables are positively correlated, as expected. However, the correlation is not so high (0.18), and they capture different economic and institutional trends. Therefore, they can be included jointly in the regression[37].

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[34] As we noted above, the share of separated waste collection is generally positively correlated with value added. We have exploited the variable as a control factor, since it may capture relevant heterogeneity concerning institutional, policy and other unobserved socio economic factors. We have also tested a two stages procedure, estimating in the first step the usual specification, then using the predicted values for waste generation, included in the second step in a regression where the dependant variable is COLLECT and the two covariates those predicted values and population density: both emerges with a very significant and positive coefficient (estimates not shown).

[35] For both waste and water management, Italy currently witnesses 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 give rise to a variety of utilities configurations. In some of the latter, also private entities are involved and, in any case, the service must be tendered on the market. Therefore, the trend is one of an increasing capacity of full-cost recovery, also based on the shift from tax to tariff (waste), at least for the variable part of costs.

[36] We cannot take logs given the high number of "0".

[37] A high correlation with value added is also expected since the trends represented by the two variables are spreading more in Northern areas. Given their high correlation also with COLLECT, we omit the latter term in the present analysis. The quite high correlation with value added opens the way to reasoning around the possible endogeneity of policy elements with respect to value added. This is a crucial issue within the realm of ex post environmental policy evaluation (Mazzanti,

Results are summarised in Table 4. When omitting COLLECT and including the two variables, EKC shapes remains, with TP at around 22,500-22,600€, on the lower bound. Nevertheless, TARIFF is positively and significantly correlated with waste production, but this is not true for COST-REC, which results to be insignificant[38]. Including them jointly does not change the result. The interaction term is also significant at 10%, driven by the TARIFF effect. Looking at logarithmic specifications, nothing changes on relative terms. The TARIFF significance is nevertheless lower, at 10%. Estimated TP is 24,427€[39].

4.2 Regional level: 1996-2004, 20 Regions

The results of the analysis at the regional level are summarised in Table 3. We use two alternative economic drivers: GDP and household expenditure. The latter (not available at provincial level) could emerge as a closer driver of waste production (Mazzanti and Zoboli, 2005). FEM model is overwhelmingly preferred.

When using regional GDP (non logarithmic specifications), the base specification with income terms only does not show EKC evidence. An AR corrected model leads instead to some (very weak[40]) EKC evidence (TP in any case is outside of the income range), with and without the variable COLELCT (share of separate collection) and population density.

In the estimates of the linear forms, the two significant covariates, both with a positive sign, are value added (GDP) and COLLECT, whose inclusion does not affect the significance of value added We find positive coefficients for some dummies associated to Southern regions, while negative signs on Northern ones, confirming what commented above As far as GDP, estimated elasticities in linear specifications are in a range between 0.36 and 1.31, showing a high variability depending on the specifications. Elasticities are 1.31, 1.15 and 0.71 in linear models, corrected and not corrected for serial correlation[41] and heteroskedasticity. The latter model lowers the value of the elasticity. The inclusion of separated collection lowers elasticity from 1.31 to 1.01 in the non-corrected model, and from 1.15 to 0.79 in the corrected one, and from 0.41 to 0.36 in a LSDV with time period effects.

The logarithmic specification confirms the higher plausibility of the linear specification: the elasticity is in this case estimated across different specifications (only GDP, with separated collection, with correlation correction; specifications 4-6) in a range between 0.87 and 1.15 (lower when additional factors are estimated). Those values are higher than at provincial level, and also higher than the evidence shown in international contributions.

The squared model generates non significant terms when adding COLLECT and using the more proper correlation corrected model. Without correction, coefficients are significant but with reverse signs. This confirms that EKC evidence remains, as noted in the literature, quite dependant on the specification used.

Simeone and Zoboli, 2004; Mazzanti and Zoboli, 2006b). Nevertheless, the existence and the level of a TP are not affected by the inclusion of such set of covariates correlated with VA.

[38] Alternatively to TARIFF, we verify whether the share of municipalities (number, not population) that introduced a tariff (TARIFF2), leads to a diverse evidence (see Table 1). This variable is independent from effects deriving from huge urban areas opting for tariffs, since each municipality within a Province has the same weight.

[39] TARIFF endogeneity is tested by estimating predicted values in a first step (covariates density and value added) and the carrying out a Wu-Hausman test. Predicted values are significant in the test regression, and are then exploited alternatively to TARIFF. In this case, nevertheless, the variable is not significant in the waste regression, thus lowering the relevance of previous outcomes if we assume endogeneity a key problem here.

[40] Squared term is very close to 10% significance.

[41] The test (not shown) confirms this hypothesis, both in the base LSDV model and in the LSDV with time effects.

Summing up, elasticity to GDP ranges between 0.41 to 1.31 across different log and non-log specifications. When using household expenditure as economic driver (we lose one year due to data availability), we note that non logarithmic specifications do not provide robust regression results. Neither economic driver, in linear and squared terms, emerges significant. The logarithmic specification instead confirms the significance of the linear term and waste separated collection: the estimated elasticity is nevertheless lower than above, estimated in a range (across specifications) between 0.10 and 0.35[42].

Population density is significant: using a logarithmic factor, its elasticity is negative and equal to 2.38: economies of scale inherent to urban areas seem to count, maybe capturing more effective waste management in some more urbanized regional environments (see more below). This is partially counterintuitive, since we would have expected a greater role of this variable in the provincial dataset. The better fir of the provincial dataset with respect to income terms could be the reason why this variable emerges with more strength in the regional framework. All in all, given the higher fit of the provincial data, population density appears not to affect waste trends.

As for provinces, we also test a model using variables in absolute (not per capita) terms, but adding population LEVEL as explanatory factor. Opposite to above, population is emerging a regional level as a driving force only when the share of separated collection, which is as usual found positively significant, is omitted[43]. Confirming international evidence, population elasticity is at both regional and provincial level higher than income elasticity. Our regional dataset, which exploits GDP data instead of value added, provides higher elasticities for both driving factors[44].

All in all, the regional dataset seems to provide relatively less robust empirical evidence compared to province-level analysis. We argue that the main cause is the higher heterogeneity which enriches the provincial dataset[45].

5. Conclusions and policy implications

The paper provides a methodological perspective and econometric estimates on delinking for waste indicators in Italy. Environmental Kuznets curves are addressed as a natural extension of delinking analysis. The results provide evidence in favour an EKC for waste, with turning points within the observed income range, but such evidence is emerging mainly from province-level data. **For the specifications showing the EKC shape the estimated turning point is between 22,815€ and 25,917€ value added per capita. These values are** higher than the median and mean values for added value in the period considered, and quite close to the maximum value added observed. Only a few provinces out of 103 overcomes or are close to this fence, which is in any case close at the highest observed value-added per capita.

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[42] AR correction reduces the significance of the consumption term. Overall, the regional dataset seems to produce less robust result, and quite unexpectedly the model with consumption rather than GDP does not perform better. Provincial heterogeneity may be indicated as the main statistical added value.

43 With included separated collection, added value is significant in its linear terms with an associated elasticity of 0.37. When excluded, this elasticities increases to 0.60, while the elasticity of waste generation with respect to population is 1.22.

[44] As for provinces, we also test a two stages model, estimating first predicted values for waste generation, for including it as explanatory factor of separated waste collection: results are the same observed for provinces.

[45] We argue that the AR and time-period effect models are more compatible with the regional data set, which is characterised by a stronger weight of the times series component with respect to the cross section heterogeneity.

Regional based evidence weakly supports EKC-like relationships, and at this level a linear relationship between waste production and income emerges with more strength. At the regional level, the waste production estimated elasticity with respect to income drivers is estimated across specifications between 0.17 and 0.35 when using household expenditure as driver, and between 0.45 and 1.31 when using GDP. Then, results somewhat depend on the model specification we use, and the province-based analysis tends to be more robust to changes in specifications.

Among the other covariates, population density has but it is never significant. The two opposite hypotheses on the sign of the relationship may both be valid, as the positive and negative effects of population are probably balancing the one another. This is in line with other recent empirical evidence.

We also estimate a model with variables in absolute levels (not per capita) at both regional and provincial level: elasticity with respect to value added and population are respectively estimated within ranges 0.28-0.34 and 0.64-1.00 for provinces, and 0.37-0.60 and 1.22 for the regional case.

To sum-up, the results presented here are, to our knowledge, the first evidence supporting EKC for waste. This result differs from that by Mazzanti and Zoboli (2005) for municipal and packaging waste at the European level, who did not find evidence for EKCs. In the present analysis, the emergence of an EKC for waste largely depends on the availability of highly disaggregated data. By exploiting more disaggregated dataset at regional and provincial level, we find that, at least for Italy, the relationship between waste generation and economic drivers is associated to a conventional EKC shape. This result confirms that international cross-country analyses, even if focused on regionally homogenous areas, may be misleading since they capture only the average effect. A disaggregated, within-country analysis is more plausible in economic terms, and also provides more robust statistical pitch. When exploiting the within-country heterogeneity different relationships between the environmental pressure and the economic driver may arise, also calling for differentiated policy interventions. In this regard, our result is exploiting more the cross section regional/provincial heterogeneity rather than the time series related trend, given data availability. This is partially different from the usual EKC framework, but it is a relevant perspective for quantitative analysis because it is, we think, more informative for policy making at the national level.

The nation-specific situation remains a crucial issue at the European level, where policies are often implemented assuming that single countries situations are similar regarding the environmental issue. If national situations differ with respect to 'abatement costs' and with respect to the point at which the country lies along the EKC development dynamic, more heterogeneity in national/local policies could be claimed. Empirical analysis on single countries could provide more information to policy makers on those directions.

Moe in general, although our result may be a first signal of a reversal of the waste-income relationships, we are far from a general reversal of the positive relationships between waste and economic drivers. We cannot rely only on the expected endogenous effects of economic growth, and more focused, stringent and effective waste prevention policies, able to decouple waste production from its income-related drivers, are needed.

We estimated the possible effect of two policy proxies: (1) the share of separately collected waste and (2) the shift from the tax waste collection to the tariff on waste management, which represent in Italy the (still evolving) move towards market-oriented management/policy approaches. The two variables do not affect the EKC

evidence (province level). The only significant effect is positive: waste production is higher where the share of population experiencing the new tariff-based system is higher. Similar results emerge for the share of separate collection on total waste production, which is always significantly and positively related to waste production across different regressions. Richer provinces in Northern Italy tend to be more innovative in terms of new institutional/policy approaches (i.e. market-oriented management settings, introduction of market-based instruments, better enforcement of waste policies), but they produce more waste per capita. The analyses of material recycling in Kaurosakis (2006) gives support to this argument of positive correlation between income, waste production and waste management capacity. The 'income effect' still tends to prevail, and the endogenous dynamics linking waste and income is not (yet) influenced by the new (evolving) institutional/policy setting.

Even if tariffs/taxes and collection systems should, in theory, stimulate a behavioural change by waste producers (i.e. consumers, households) towards producing less waste (prevention), their actual ex post role is mainly that of covering the costs of produced waste management. The innovative approaches to waste policies adopted by richer Italian provinces are expected to have an *indirect* negative feedback on waste production at source (prevention), but they nevertheless 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 incentives to reduce waste production at source (i.e. waste prevention). Indirect effects of this latter kind cannot be ruled out, but they are, at best, very slow as they depend on a systemic reaction of the whole system at the different stages (good production, waste production, waste recovery, recycling, disposal, etc.). Furthermore, the existence of waste-prevention effects might be better detected on long time series at very disaggregated, even sub-provincial, local level (e.g. towns), and the short length of our province-level time series do not allow us to perform such a detailed case-by-case analysis over time. For the moment, similarly to what suggested by Mazzanti and Zoboli (2005) at the 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 lacking incentives to prevention is common to other environmental policies, but it seems to be exacerbated in the case of waste policies.

The main policy implication that, in order to reduce the costs and increase effectiveness of major waste policies (e.g.. landfill, packaging waste), also based on important European directives, a reduction at source of waste production must be explicitly pursued instead of relying on the hypothetical indirect feedbacks on waste production at source that might stem from improving waste management/disposal in the post-production phase. Waste policy instruments are not yet giving their desired/expected 'prevention effect', which remain nonetheless the first priority of European and Member States' waste policy. Our empirical evidence suggests that waste policy efforts should be strengthened towards prevention and they should rely on a greater use of policy schemes aimed at changing agents' behaviour at the level of waste production. Otherwise, and Italy is a clear example, an increasing gap, fuelled by the income-driven, endogenous dynamics of delinking and EKC, will emerge between low- and high-income areas. The latter could achieve a sustainable path in the near future - may be even an absolute delinking in spite of their high production of waste- whereas low income area risk to get stuck in the jam of relatively lower (but increasing) waste generation and no reversal of the its link with income growth (ascending EKC curve). The role of prevention-oriented policy could then be differentiated from area to area.

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Table 1. descriptive statistics: dependant and independent variables

acronym	Variable description	mean	min	max
Provinces				
WASTE	MSW generated in tons per capita	517.13	289.61	893.23
VA	Provincial value added per capita (€2000)	17742.52	9704	28796
DENS	Population/surface (inhabitants/km2)	243.73	36.55	2640.91
COLLEC	% Share of separated collection	18.52	0.4	64.9
TARIFF	Share of population living in municipalities that introduced a waste tariff substituting the former waste tax (%)	8.42	0	99.72
TARIFF2	Share of municipalities that introduced a waste tariff substituting the former waste tax (%)		0	
COST-REC	Cost recovery of waste management services (tax/tariff revenues on variable service costs, only one data for 2003) (%)	84.05	0	105
TOURIST	TOURIST yearly Attendance (per capita)	7,.27	0.43	58.3
Regions				
WASTE	MSW generated in tons per capita	491.11	335.60	692.55
GDP	GDP per capita (€1995)	17141	9885.3	24091.33
C	Household consumption per capita (€1995)	735.18	412.47	1030.03
DENS	Population/surface (km2)	175.8	36.42	426.54
COLLEC	% Share of separated collection	12.31%	0.6%	44%

Mean, min and max are calculated across provinces and over time

Table 2. Provincial level: base estimations and additional specifications

€	1	2	3	4	5	6	7	8
Cons	*	*	*	/	***	**		**
VA	0.032***	0.0335***	0.047***	0.0425***				
VA^2	-0.000000627**	-0.000000659***	-0.00000103***	-0.00000091**				
logVA					0.3627***	8.17**	0.283***	8.29**
$(logVA)^2$						-0.402**		-0.409**
DENS		0.20	0.25	-0.211			-0.0003	0.000044
COLLEC				1.304***			0.002***	0.00073
Turning point	25917€	25417€	22815€	23351€		25311€		25196€
FEM/REM	REM	REM	REM (AR1)	FEM (AR1)	REM	REM (AR1)	FEM	REM(AR1)
$adjR^2$				0.938				
F test and Chi-sq prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	515	515	515	515	515	515	515	515

Coefficients are shown in cells: *10% significance, **5%, ***1%.

Table 3. Regional level: base estimations and additional specifications

specification	1	2	3	4	5	6	7	8
Const							***	
GDP	0.037***	0.054***						
GDP^2		-0.00000087						
logGDP			1.154***	0.881***	0.871***			
$(logGDP)^2$								
logC						0.133***	0.352***	0.106**
$(logC)^2$								
DENS		-0.61			-0.0011	-0.0096***		-2.38***
COLLEC		1.85***		0.0038***	0.032**	0.0089***		0.0096***
Turning point		31034€ (outside the observed range)						
FEM/REM	FEM	FEM (AR1)	FEM	FEM	FEM(AR1)	FEM	REM	FEM
$adjR^2$	0.9088	0.832	0.906	0.919	0.91	0.91	0.845	0.927
F test and Chi-sq prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	180	180	180	180	180	160	160	160

Coefficients are shown in cells: *10% significance, **5%, ***1%.

Table 4. The effect of waste policy instruments

	1	2	3
Cons	Not sign	Not sign	Not sign
VA	0.0472***	0.0464***	
VA^2	-0.00000104***	-0.00000102***	
logVA			9.045**
$(logVA)^2$			-0.4478**
DENS	0.025	0.026	0.000048
TARIFF	0.321**		0.00053*
COST-REC		0.275	0.00016
Turning point	22692€	22549€	24427€.
FEM/REM	REM(AR1)	REM(AR1)	REM(AR1)
F test and Chi-sq prob.	0.000	0.000	0.000
N	515	515	515

Coefficients are shown in cells: *10% significance, **5%, ***1%.