



Original Articles

Kuznets curve in municipal solid waste production: An empirical analysis based on municipal-level panel data from the Lombardy region (Italy)

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ABSTRACT

By using a novel database that observes 1,497 municipalities from the Lombardy region in Italy between 2005 and 2011, this paper provides an empirical test of the Waste Kuznets Curve (WKC) hypothesis.

Fixed effects regression analyses, generalized method of moments models and a number of robustness checks strongly indicate that among the municipalities under scrutiny there is an inverted U-shaped relationship between economic development and waste generation. Nevertheless, only a few of the municipalities under scrutiny reach the turning point of the estimated curve. These findings contribute to the expanding empirical literature that tests WKC by using municipal data, considered the most appropriate for this kind of analysis.

1. Introduction

Over the last decade (2001–2010), the European Union has observed a consistent increase in municipal waste (MW) per capita in 18 out of its 28 members (European Environment Agency, 2013). Even if MW only accounts for approximately 10% of total waste generated in the EU, it has a relevant socio-environmental impact (Eurostat, 2016a,b). In this perspective, studies that investigate the determinants of MW generation are particularly valuable since they might inform policies aimed at incentivizing MW reduction, that are very important in the waste management strategy (Beigl et al., 2008).

This paper aims to contribute to the literature by empirically addressing a highly debated issue, namely the existence of a link between economic wealth and waste production as modeled by the Waste Kuznets Curve (WKC), which predicts an inverted U-shaped dependence of waste production on economic development (Stern, 2004).

The empirical evidence concerning the WKC hypothesis is controversial. While cross-national studies (Cole et al., 1997; Karousakis, 2009; Mazzanti and Zoboli, 2009) mostly reject it, single country cross-regional (provincial) studies provide mixed results (Managi and Kaneko, 2009; Mazzanti et al., 2009, 2008). Municipal-level analyses, meanwhile, are much rarer, although those recently published seem to support the WKC hypothesis (Ichinose et al., 2015).

Our paper aims to add to this latter group of contributions by proposing an econometric analysis based on a large and newly constructed municipal-level dataset that considers municipalities from the Lombardy region of Northern Italy ($n = 1497$), which were longitudinally observed between 2005 and 2011.

There are a number of reasons why the use of single country municipal-level data is appropriate for testing the WKC hypothesis. On the one hand, it makes it possible to inspect the consistent within-country heterogeneity in MW generation that exists among municipalities. On the other hand, it is worth noting that MW management strategies are developed by local governments (even if this is done within the framework provided by the EU and national directives; Reggiani and Silvestri, 2017) and this makes the inspection of municipal-level determinants of MW particularly valuable.

The focus on municipalities from Lombardy, one of the richest and most highly populated NUTS2 regions in Europe (Eurostat, 2014) and the one that reports the highest total production of urban waste in Italy (ISPRA, 2013), is appropriate for our empirical investigation since this region has been suggested to be an appealing case study for inspecting waste production and waste management (Gaeta et al., 2017).

The paper is articulated as follows: section two provides a review of the empirical literature concerning the WKC. Section 3 presents the data used in the analysis, and Section 4 discusses the methodological

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issues of the analysis. The results and their discussion are reported in Section 4. Finally, Section 5 draws the conclusions arising from this study.

2. The environmental Kuznets curve and the waste Kuznets curve hypotheses

In the scholarly debate about how economic growth affects environmental quality, the WKC hypothesis has gained substantial attention over recent years. This hypothesis draws on seminal works by Grossman and Krueger (1991), Holtz-Eakin and Selden (1992), and the World Bank (1992) on the EKC, and suggests an inverted-U shaped relation between deterioration of environmental measures and economic development.

According to scholars, the EKC's non-linear trend might be explained by a number of driver mechanisms that do not exclude each other. Firstly, a scale effect explains the ascending part of the curve. Indeed, the greater the output produced by an economy, the higher the inputs used in the production should be. This, in turn, is presumed to exert a positive impact on environmental degradation (Tsurumi and Managi, 2010). Secondly, non-linearity might arise because of the link existing between economic development and an economy's structure (composition effect). Indeed, compared with countries based on subsistence agriculture, those that are specialized in advanced manufacturing are richer, and yet at the same time more resource-intensive and polluting. This implies a positive and monotonic link between development and environmental degradation. Nevertheless, once they reach a certain stage of development, economies tend to shift from manufacturing towards services, and this translates into a reduction of environmental degradation. This would explain the descending part of the EKC (Tsurumi and Managi, 2010). Thirdly, the positive effect of the expansion of economic activities on environmental deterioration that characterizes the first part of the EKC might be inverted thanks to the evolution of technological progress fostered by economic growth (Grossman and Krueger, 1991; Hettige et al., 2000; Selden et al., 1999). Fourthly, the explanation of the EKC shape might depend upon the fact that public opinion interest for "environmental goods" only emerges once their scarcity is perceived (Unruh and Moomaw, 1998; Torras and Boyce, 1998).

Subsequent studies have specified the EKC hypothesis by considering different indicators of environmental degradation, e.g. greenhouse gas emissions, water pollution, and change in forest area (Bhattarai and Hammig, 2001; Lee et al., 2016; Mazzanti and Zoboli, 2009; Sinha and Bhattacharya, 2017; Wang et al., 2016; Wong and Lewis, 2013). Nevertheless, until recent years surprisingly little attention has been given to the application of the EKC to waste generation, i.e. to the WKC hypothesis, even if the number of contributions specifically focused on this topic is increasing (Abrate and Ferraris, 2010; Mazzanti et al., 2009).

As in the case of studies focused on the EKC, most tests of the WKC hypothesis are carried out through cross-national empirical investigations. By analyzing cross-national solid waste generation data from 1960 to 1990 provided by the Organisation for Economic Co-operation and Development (OECD) for 39 countries, Shafik (1994) finds a monotonic and direct relationship between waste production and income. According to his interpretation, this is because thanks to landfills "solid waste disposal can be transformed into a localized and potentially harmless problem" (p. 767). The same result, i.e. waste generation monotonically increasing throughout the income range examined, is found by Cole et al. (1997), who focus on cross-national municipal waste data collected in 13 OECD countries over the period 1975–1990. Following a perspective similar to Shafik (1994), these authors suggest that an increase of income determines an increase of waste generation. The idea that waste generation monotonically increases with income is also supported by Johnston and Labonne (2004) and Karousakis (2009), who both analyze cross-national OECD data on municipal solid waste

from 1980 to 2000. Based on 1995–2005 data from 25 European countries, Mazzanti and Zoboli (2009) reach the same conclusion, even if the elasticity of municipal solid waste production to income drivers found by their analysis is lower than that observed by previous contributions. While all the contributions just mentioned suggest a rejection of the WKC hypothesis, this result is not univocal since it is contested, for example, by Raymond (2004). His analysis focuses on data from 142 countries and finds that the waste/consumption stress indicator¹ exhibits an inverted U-shape relation with income.

More generally, it is worth noting that while all the cited WKC studies have their merits, cross-national empirical investigations also have notable limits. Firstly, they estimate "average" international curves (Mazzanti and Zoboli, 2009), which might not hold when the analysis is addressed to sub-national administrative units that might reveal high heterogeneity in waste generation (Ichinose et al., 2015). This is a crucial limitation since, in EU countries, as well as in the USA and Japan, local authorities are mainly responsible for the implementation of waste policies, and therefore the empirical investigation of waste generation determinants can produce policy-relevant findings only when it is carried out with these taken into consideration as units of analysis. Secondly, since cross-country studies are based on cross-national heterogeneity in income and waste generation, they do not allow us to check whether the Kuznets curve hypothesis holds for all the countries under scrutiny (Mazzanti et al., 2009; Lim, 1997).

In order to overcome these issues, scholars have recently started to focus on single-country case studies and to use more refined data, such as those acquired from sub-national jurisdictions. Apart from the issues noted above, compared with cross-national studies, these within-country empirical studies may benefit from the high number of sub-national observations that can usually be collected. The literature that focuses on these sub-national data is expanding, but still not extensive (Mazzanti et al., 2009).

Part of this literature exploits provincial or regional data. This is the case of Managi and Kaneko (2009), who analyse Chinese provincial-level data for 1992–2003 and find that solid waste generation monotonically increases with per capita GDP. Mazzanti et al. (2009) exploit a panel dataset covering the 103 Italian provinces from 2000 to 2004. Their findings strongly support the WKC hypothesis by highlighting the existence of a non-linear U-shaped relationship between municipal solid waste generation and per capita added value (which is used as a proxy of level of economic development). The rather high income at which the Kuznets curve turning point is observed unfortunately suggests that only a few provinces reach the level of wealth where waste generation would be expected to lower.

Another stream of the literature, this consisting of the most recent contributions, is based on the use of municipal-level data, particularly appropriate when the focus is on those institutional contexts where municipalities do play a crucial role in waste management. Studies that belong to this stream seem to confirm the WKC hypothesis. Ichinose et al. (2011) use cross-sectional Japanese municipal-level data on solid waste production that were collected in 2005; their analysis finds evidence of a WKC with a turning point whose value is significantly lower than the maximum income observed in the sample under scrutiny. Trujillo Lora et al. (2013) rely on Colombian data from 707 municipalities observed over the period 2008–2011. According to their analysis, the quantity of landfilled solid waste (which represents more than 90% of total waste generated) reported by each of these municipalities exhibits a WKC relationship with economic development, whose turning point is heterogeneous across the regions of the country. To the best of our knowledge there is only one Italian example of such a

¹ The waste/consumption indicator used in this paper is one of the components of the Environmental Sustainability Index (ESI), developed by the Yale Center for Environmental Law and Policy, the Center for International Earth Science Information Network at Columbia University, and the World Economic Forum in order to rank countries according to their environmental sustainability.

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