Resources, Conservation and Recycling 94 (2015) 43–55

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Waste management alternatives: (Dis)economies of scale in recovery and decoupling

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ARTICLE INFO

Article history:
Received 1 November 2013
Received in revised form
11 September 2014
Accepted 12 November 2014
Available online 4 December 2014

JEL classification:
Q01
Q53
Q56

Keywords:
Waste disposal
Recycling
Landfill
Decoupling
Environmental Kuznets Curve
Economies of scale

ABSTRACT

This paper formulates a theoretical model which allows different waste management strategies in equilibrium, depending on the technology of waste recovery and the utility functional specification. In the model there are two waste treatment alternatives: 'not-recovered waste', composed of landfill and incineration without recovery and 'recovered waste', which is the aggregate of recycling, composting and incineration with recovery. We show that if recovery activities present constant or economies of scale then it is optimal to have zero not-recovered waste. The presence of diseconomies of scale in recovery of waste can either result in an equilibrium with zero or positive not-recovered waste, but recovery of waste is necessarily positive. We test for the presence of an EKC, and find that it is only compatible in our model when we assume decreasing marginal utility of consumption, and diseconomies of scale are limited. However, in the presence of (constant) economies of scale in recovery, we observe complete decoupling.

1. Introduction

Worldwide, recycling rates are increasing. On average, recycling rates for OECD countries more than doubled in between 1995 and 2008, from 9.9% to 23.5% However, there are significant cross-country differences.[1] In 2008, Mexico's recycling rate, for example, was less than 4% of total waste treated, whereas South Korea reached the remarkable score of nearly 60%.[2] Similarly, while landfill is the predominant waste management option in most developing nations, some developed countries have been able to completely eliminate this option from their waste management alternatives. The waste management strategy is not, however, only determined by a country's development level. Countries such as Luxembourg and Portugal have similar landfill rates (close to 50%) while Luxembourg has more than 4 times the GDP per capita than Portugal.[3] In this paper we formulate a theoretical model which allows different waste management strategies in equilibrium, depending on the technology of waste recovery and the utility functional specification. In our model there are two waste treatment alternatives: 'not-recovered waste', composed of landfill and incineration without recovery and 'recovered waste', which is the aggregate of recycling, composting and incineration with recovery. Our main purpose is to provide the microeconomic foundations of different waste treatment strategies based on assumptions which are more representative of the waste management state. For this purpose, we differentiate from the more general seminal paper by Andreoni and Levinson (2001), by allowing (i) non-recovered waste to be costly; (ii) (dis)economies of scale in recovered waste, and (iii) a non-linear utility function.

In the literature on waste, a recurrent theme is that of the Environmental Kuznets Curve (hereafter abbreviated as EKC). The

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[1] In 2010, at one extreme we have for instance Bulgaria and Romania where the percentage of total waste treatment deposited onto or into land was 100% and 98.6% respectively and at the other extreme Austria, Germany, the Netherlands and Switzerland, where it was less than 1% (EUROSTAT, 2012b).

[2] Based on OECD online statistics on waste. We compute recycling rates as the share of recycled waste in total waste.

[3] Based on 2010 data. Data for landfilling rate is EUROSTAT (2012b), where landfilling rates considers total waste treated. The data for GDP per capita (constant US$) comes from the World Bank, WDI.

http://dx.doi.org/10.1016/j.resconrec.2014.11.005
0921-3449/

inverted U-shape of the EKC is a well-known hypothesized and empirically corroborated relationship between income and various indicators of environmental quality.[4] Related to the EKC, the IPAT model states that environmental impact (I) is the product of three elements: Population (P), per capita Affluence (A) and Technology (T) (I = P*A*T). Mazzanti et al. (2007), e.g., describe the relationship between the EKC approach and the accounting identity proposed by the IPAT model. The component T can be associated to the decoupling hypothesis. In our paper, a technological parameter β is similarly crucial to understanding the possibility of relative and absolute decoupling.

The literature analyzing the relationship between income and indicators of environmental quality considered different measures for the environmental good (or bad), such as carbon dioxide emissions and other greenhouse gases, waste generation, water pollutants, among others. Essentially, there are two strong mechanisms at work to produce such an outcome. When we become richer, the marginal value of increased consumption declines and the marginal disutility of pollution increases (if only in relative terms), so there comes a point at which the sacrifice (welfare loss) of reduced consumption because of abatement costs of recovery is less than the marginal disutility of more waste. A nonlinear relationship between a dirty and a clean good is no surprise when the marginal utility of consumption of the clean good is decreasing, and the marginal (dis)utility of consumption of the dirty good is constant (a standard representation in the literature). However, due to the practically unlimited possibility of landfill disposal and therefore a low and constant marginal disutility of waste, the point at which this mechanism starts to work can be at very high, maybe yet unobserved levels of GDP per capita. Therefore, reliance on this mechanism is risky, especially when pollutants are involved in which environmental damages are irreversible. According to the second mechanism more (gross) waste is produced when we become richer, which opens up the possibility to benefit from economies of scale in waste recovery. Both mechanisms are incorporated in our model, the first by means of assuming a declining marginal utility of consumption and constant disutility of waste, the second by means of the possibility of increasing returns to scale in recovery.

Our approach is similar to that of Andreoni and Levinson (2001) (hereafter AL) in providing a micro-economic model of the linkages between consumption and different forms of waste treatment. AL (*ibid*.: 271) show that "... an EKC can be derived directly from the technological link between consumption of a desired good and abatement of its undesirable good". Their Theorem 1 states that for some sufficiently large income and under the conditions that pollution clean-up is a normal good and abatement technology exhibits increasing returns to scale, optimal pollution will ultimately become zero, that is the downward sloping part of the EKC will cut the horizontal axis at some point. More specifically, due to their Cobb-Douglas specification of abatement, the optimal consumption and abatement efforts are constant shares of resources per capita. When abatement technology is characterized by economies of scale, it follows that there is a range where pollution decreases as resources increase. The policy significance of the downward sloping part of the EKC is that, provided the turning point is not located at a too high level of per capita resources, continued economic growth and a clean(er) environment are compatible in the end. AL show that an inverse-U curve between pollution and income does not depend on changes in preferences as income rises, but solely on increasing returns of abatement. Their model as ours focusses attention on pollution as a by-product of consumption. However, in our model, set-up based on 'not-recovered waste' as the pollution variable, both pollution (such as landfill disposal) and abatement (such as recycling) are costly. This is a crucial difference to the model set-up by AL, in which not-recovered waste is assumed to be costless. Moreover, in our model the costs of recovery only depends on the amount of waste to be recovered and a technology parameter representing in- or decreasing returns to scale in recovery, whereas AL assume that recovery costs not only vary by the amount of waste to be recovered, but also by the level of consumption (see also footnote 8 below). It will turn out that these differences in assumptions have implications for the occurrence of (absolute or relative) decoupling between income and waste.

Using our more general specification model, we show that under constant or increasing returns to scale in recovery, there will always be complete decoupling, resulting in a state of full recovery and zero waste. Only under decreasing returns to scale, combined with a declining marginal utility of consumption, may an EKC with absolute and relative decoupling be observed. The latter is also illustrated empirically for a set of EU countries. These main results contrast with the ones found by AL, who show that an EKC result from increasing returns of abatement, regardless of preferences.

Recently, some papers attempted to investigate empirically the relationship between income and waste using cross-country data. Johnstone and Labonne (2004) use a database of municipal solid waste generation in OECD countries, for the period 1980–2000. They find that household municipal waste is less than unit elastic with respect to household final consumption expenditures.[5] Thus, even though on average waste increases with income in OECD countries, the effect is less than proportional (relative decoupling). Mazzanti and Zoboli (2008, 2009) test for a Waste Kuznets Curve (WKC) using a sample of (25) member countries of the European Union for the period 1995–2005. The authors analyze the effect of income on municipal solid waste generation, incineration, recycling and landfill and do not find evidence for an overall WKC. As Johnstone and Labonne (2004), Mazzanti and Zoboli (2008, 2009) also find evidence of relative decoupling (specifically, a positive coefficient for the effect of consumption on waste, but a less than unity elasticity). Recycling, on the other hand, is positively related to income, with an elasticity higher than one.[6] When looking at landfill waste alone, Mazzanti and Zoboli (2008, 2009) find evidence of a WKC and absolute decoupling. Finally, with respect to incineration their findings indicate a positive relationship with income. Mazzanti et al. (2012) take an economic-geographical perspective based on panel data on Italian data and find that absolute decoupling is present for landfilled waste, although not for waste generation. A recent paper by Kinnaman et al. (2014) analyze the socially optimal recycling rate, based on Japanese data, and found that given the social cost of waste management, the desirable recycling rate can be lower than the ones observed in developed countries.

In Section 2 we build a model in which pollution in the form of not-recovered waste can entirely be eliminated. Alternatively, waste recovery (as an abatement technology) could remove dirty activities completely. In this case, a quadratic relationship between the dirty and the clean good depends on a decreasing marginal utility of consumption. Moreover, opposite to AL model it is the decreasing returns to scale in abatement technology (and not increasing returns to scale) which generate the inverse-U curve. If increasing returns are present, then pollution would

[4] There is no consensus, however, about the extent to which the EKC is ubiquitous. Stern (2004) provides a survey on the EKC showing that in many cases it is based on outcomes of statistical analyses which are not robust.

[5] The authors proxy disposal income by household final consumption expenditures.

[6] Mazzanti and Zoboli (2008) explain this finding by the presence of economies of scale in recycling activities.