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Determining the socially optimal recycling rate

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ABSTRACT

What municipal recycling rate is socially optimal? One credible answer would consider the recycling rate that minimizes the overall social costs of managing municipal waste. Such social costs are comprised of all budgetary costs and revenues associated with operating municipal waste and recycling programs, all costs to recycling households associated with preparing and storing recyclable materials for collection, all external disposal costs associated with waste disposed at landfills or incinerators, and all external benefits associated with the provision of recycled materials that foster environmentally efficient production processes. This paper discusses how to estimate these four components of social cost to then estimate the optimal recycling rate.

1. Introduction

Growing populations, rising incomes, and changes in consumption habits over the past half-century have increased the quantity of municipal solid waste produced in many developed and developing countries. In some cases, regional sanitary landfills and modern incinerators have been developed to manage the waste, while in other regions of the world open dumping remains a popular but unfortunate management option. But because of the perceived environmental threats associated with not only open dumping, but sanitary landfilling and incineration as well, many countries have considered recycling as a method to reduce the volume of waste designated for disposal. Recycling may not only reduce external costs at dumps, landfills, and incinerators, but the recycled materials may also serve as an environmentally efficient substitute for non-renewable virgin materials whose mining processes often involve costs to the environment.

To encourage the recycling of municipal solid waste, the governments of many developed countries have set targets for the percentage of all waste that should be recycled. In Europe, the Packaging Directive as last amended in 2005 has set of recycling target of between 55% and 80% for all European Union member countries to have been achieved by the beginning of 2009. Japan passed in 1997 The Law for the Promotion of Sorted Collection and Recycling of Containers and Packaging that established a recycling target at 24%. Recycling targets in the United States are set at the state level and vary across states. For example, California set a recycling target of 75% to be achieved by 2020 while Texas set a recycling target of 40%.

But are these recycling rates socially optimal? In other words, are these targets consistent with the recycling rate that minimizes the social costs of managing municipal solid waste? The lack of research on the social costs and benefits of waste disposal and recycling suggests the answer is largely unknown. To help fill this void, this paper (1) first defines the social costs and benefits associated with managing municipal waste by disposal or recycling, (2) provides estimates of these costs and benefits from the published literature, (3) discusses the data necessary to determine the optimal recycling rate within any given country, and (4) summarizes the results of one recent cost/benefit study that finds the optimal recycling rate is 36%.

2. The social costs of disposing municipal solid waste

The optimal recycling rate minimizes all social costs associated with managing waste. Assume the social costs of waste management are comprised of (1) all costs to municipalities to collect, process, and transport all waste and recyclable materials, (2) all costs to recycling households to separate and store all waste and recyclable materials, (3) all external costs associated with waste disposal arising at both landfills and incinerators, and (4) all external benefits associated with recycling attributable to environmentally efficient production processes. The objective of the social planner is to select a recycling rate that minimizes the sum of these four sources of costs. This section separately introduces these four sources of social costs. The next section describes how data on each component can be obtained.

Economic costs can be differentiated between costs that are private or internalized and those that are external or externalized.

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Throughout this paper private costs will be defined as those costs associated with waste management that are internalized by municipal governments. External costs are those costs that remain – waste management costs that are born by society at large and not internalized by municipal governments.

2.1. Municipal collection and disposal costs

Disposing municipal solid waste in an open dump, a sanitary landfill, or an incinerator involves both private and external costs. The private costs include the value of economic resources employed to collect the waste from households and small businesses, to transport the waste to a disposal site, to finally dispose the waste, and to administer the collection and disposal program. Carroll (1995), Callan and Thomas (2001), Bohm et al. (2010), and Cruz et al. (2012) estimate private municipal costs as functions of waste and recycling quantities. These private costs can be expected to vary across collection and disposal methods. Waste collection can be made convenient to households by increasing the frequency of collection, moving the location of collection closer to the door of the dwelling, and providing carts for waste collection. Transportation costs vary with the distance to the disposal facility, and can include the costs of truck transportation, transfer stations, and possible rail or barge transportation to the final disposal site. The majority of these collection and transportation costs are paid by municipal governments or by private collectors that have signed a franchise agreement with the municipal government. The municipal government or private firm may then charge households for waste collection services. These charges can be fixed in nature, such as monthly fees, or may vary with the quantity of waste collected by using special bags, tags, or stickers.

Private costs of disposal vary widely with the mode of disposal. Incineration is likely the most costly disposal option, followed by sanitary landfilling and then open dumping. Incinerators require land, vast quantities of physical capital to burn the waste and then treat the airborne pollutants, engineers and technicians to operate the facility and resolve technical difficulties as they arise, and fossil fuels to inject to keep the burning temperatures sufficiently high. Incineration can also produce private benefits. The resulting heat can be used to generate electricity or power district heating systems thereby reducing demand for fossil fuels.

The private costs of sanitary landfills, although often less than those associated with incineration, can still be substantial. Sanitary landfills require a large expanse of suitable land. Impermeable bases must be created using clay or several layers of plastic. As the waste is disposed, plumbing systems are installed to catch leachate and methane (both byproduct of decomposing solid waste in an oxygen starved environment). The leachate must be treated using reverse osmosis or other methods before the liquid can be released into the environment. In many developed countries the waste must be covered daily to mitigate odor and the attraction of unwelcome birds and rodents. Groundwater monitoring takes place along the boundaries of the landfill. Breaches, if detected, must be repaired. A potential private benefit associated with sanitary landfilling arises when the captured methane can be burned to generate electricity thereby offsetting the use of fossil fuels.

If tipping fees paid for disposal are competitively set, then future user costs associated with converting land to disposal facilities may be internalized by waste-generating municipalities. Competitive landfills can be expected to levy a tipping fee that reflects not only all current marginal costs of operation, but reductions in land value attributable to converting land to a disposal site. Municipally-owned landfill may charge low tipping fees that do not reflect the value of the land to either the present or to future generations.

Open dumping also requires a large expanse of land. But private costs are relatively small compared to the other two disposal options discussed above – modest ground preparation and the construction of a basic access road may suffice. If property rights for land are poorly defined and enforced, then the private disposal costs to municipalities may essentially be zero.

Recycling systems also require economic resources to operate and can generate private benefits to the economy. Private costs internalized by many municipalities include the value of the additional economic resources necessary to collect separate streams of recyclable materials from households such as paper, metals, plastic, and a host of other possible materials. These materials may also require staging and processing before being transported to separate markets. These costs are internalized into many municipal budgets.

If the separated recyclable materials have value to the economy, then recycling produces private benefits. Recycled materials can serve as inputs to production to numerous goods in the economy. These benefits are internalized by municipal governments if markets for recycled materials are sufficiently competitive, as the competitive sales price received by the municipality generates revenue to the municipal budget.

2.2. Household recycling costs

The second component of social waste management costs is all household resources employed to separate, prepare, and store recycled materials for separate collection. Households may also be required to transport their recyclable materials to neighborhood drop-off recycling centers. These costs may not be internalized by municipal governments unless household preferences over recycling efforts influence the municipal political process.

2.3. External disposal costs

External costs are associated with landfilling, incineration, and open dumping. Sanitary landfills can threaten area groundwater supplies, can produce odor, may be unsightly, and may depress neighboring property values. Incinerators can generate air pollution that is dangerous to human health and to ecosystems. The ash remaining from the incineration can include heavy metals and may be hazardous to the environment when landfilled. The external costs of open dumping include all of the above plus threats to human health, water supplies, and the natural environment all originating from the open decomposition of waste.

2.4. External recycling benefits

Recycling generates external benefits if they replace virgin materials in manufacturing. Life cycle assessment models suggest the use of recyclable materials over virgin materials reduces air and water pollutants, energy use, and the release of toxic substances harmful to human health and the natural environment. These benefits of recycling are not likely internalized by municipal governments or the manufacturers using the recycled materials.

The optimal recycling rate is defined as that rate that minimizes the total of all of these private and external costs associated with managing municipal waste and recycled materials. Increasing the recycling rate reduces private and external costs of collecting and disposing waste, increases costs to collect, process, store, and transport recyclable materials to markets, increases recycling costs to households, and reduces external costs associated with manufacturing some goods and services. If the reductions to social costs exceed the increases, then increasing the recycling rate is socially efficient. Given the differences in collection and disposal technologies and practices and differences in household consumption habits, tastes, and preferences, the optimal recycling rate is likely to vary across countries and even across municipalities within each