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Methods

Incentivizing sustainable waste management

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ABSTRACT

The purpose of this paper is to contribute to the integration of economic and non-economic concepts of waste management and sustainability to achieve new insights to sustainable waste management. Since landfilling will continue to be a significant waste management method, our theory and practice of sustainable waste management should focus upon incentivizing the development of more sustainable landfills. The model sheds light on the design of efficient and fair landfill siting processes; how production inputs to bioreactor landfilling should be selected; and how management practices during the facility's operation phase can achieve greater economic, ecological and social sustainability.

1. Introduction

The purpose of this paper is to combine concepts of sustainability and solid waste disposal to achieve new insights to sustainable waste management. The synthesis requires careful attention to both economic and non-economic literatures. Most economic literature regarding sustainability is macroeconomic in nature, focusing upon optimal economy-wide resource flows subject to concerns for intergenerational equity and the degree to which natural and engineered capital may be substitutable across entire economies. The economics of sustainability literature also tends to cast sustainability as an absolute concept: either the economy is on a sustainable path or it is not.[1] The economic literature regarding the Environmental/Waste Kuznets Curve (EKC/WKC) and the decoupling of economic activity from environmental/waste impacts is likewise relatively macroeconomic in nature, although it does consider both absolute and relative decoupling.[2] Mazzanti and Zoboli (2009), for instance, analyze waste generation and landfilling data for the European Union and find that while waste generation has not yet experienced absolute decoupling (and is therefore not yet consistent with the WKC hypothesis), there is generally some evidence of relative decoupling. They also find that landfilling in the European Union (EU) is decoupling on an absolute basis (and that therefore the EU is on the negative slope of the WKC). The authors attribute EU success in diverting waste from landfills to the EU's Landfill Directive and related environmental policies and suggest that similar policy focus must be brought to bear more deliberately upstream in order to motivate greater decoupling of waste generation.[3]

While much has been gained from taking relatively macroeconomic perspectives to the conceptualization and empirical measurement of sustainable waste management, the policy-impact results of Mazzanti and Zoboli (2009) and others caution us to remember that individual agents within economies—households and firms—have many unresolved questions at the microeconomic level that aggregate to yield a micro-foundation for the macroeconomics of sustainability.[4] These questions are dealt with in related economic literatures regarding "green design," the design of "upstream and downstream" environmental economic policy, and strategies for consuming in a more "eco-friendly" manner. In each of these three related literatures, microeconomic agents essentially ask, "What can I do today to produce or consume in a

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[1] See, for instance, Pezzey and Toman (2002, p. 17), who state: "Because sustainability is a macroeconomic concept, shifting an economy from unsustainability to sustainability changes all its prices. Sustainability prices and sustainability itself are thus related in circular fashion: without sustainability prices, we cannot know whether the economy is currently sustainable; but without knowing whether the economy is currently sustainable, currently observed prices tell us nothing definite about sustainability."

[2] Absolute decoupling means that an environmental impact variable (e.g., waste disposed in landfills) is positive but falling (or unchanged) over time while economic growth is positive. Relative decoupling means that the rate of growth of an environmental impact variable is positive, but less positive than the rate of economic growth. See OECD (2002, p. 11) for further discussions of these definitions, and p. 9 of the report regarding the use of decoupling concepts as indicators of sustainable development.

[3] See Mazzanti and Zoboli (2009, pp. 220–222) for discussion of these points.

[4] Consider Norton and Toman (1997, p. 553): "Decision makers are more and more often being told to "act sustainably" and to pursue policy paths toward 'sustainable development.' And yet these widely supported admonitions provide little guidance to policymakers and other actors, because the term 'sustainable' embodies deep conceptual ambiguities."

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relatively more sustainable manner?" Since these three microeconomic literatures tend not to cast objectives and constraints in the predominantly macroeconomic "economics of sustainability" language, their insights tend not to reach sustainability discussions and the microeconomic opportunities for progress remain relatively unexplored. Therefore, this paper takes a microeconomic approach to sustainability in an effort to link more ideas/literature than has heretofore occurred.

As motivating examples for the microeconomic approach taken in this paper, consider the evolution of dental X-ray technology and of childhood immunizations during the past century. These are particularly compelling examples because their benefits are far-reaching both within and across generations. No grandparent ushering a grandchild to the modern dental clinic would wish to return to dental technology prior to the advent of X-rays (generated by cobalt-60) or is not grateful for at least the opportunity grandchildren now have to receive immunizations against several diseases. Grandparents and grandchildren alike must surely consider these two examples of medical innovation as being consistent with sustainability. Yet, the past century of research, development and in some cases the ongoing usage/maintenance of these and other medical technologies yielded an increase in municipal, hazardous and radioactive waste that requires considerable disposal resources.[5] The technical know-how and engineering infrastructure are passed to future generations, both with respect to the good (dental X-rays, immunizations and best practices in biomedical waste management) as well as the bad (waste residual that must either be incinerated or land-disposed). Two conceptual questions present themselves: (1) In what sense can this transaction of the good and the bad between generations be considered *sustainable* or be considered *sustainable development* and (2), if this intergenerational transaction *cannot* be considered sustainable, what specific changes in policy could the grandchildren design such that *their* grandchildren could be said to inherit a more sustainable result? Casting these questions in the context of medical advances and medical waste reminds us that as undesirable as it may be to create and utilize landfills, the waste (even after source-reduction, recycling, and waste treatment) is passed forward to future generations *along with* very important, sustainability-enhancing technologies. In terms of the aforementioned decoupling literature, increased medical research, development and deployment of medical goods, services and waste could reduce absolute and relative decoupling indicators at the same time that welfare may be improving.

The main argument in this paper is that raising the sustainability of landfilling is crucial for enabling progress on these two questions (in the microeconomic context of waste management), and that this shall most likely occur at the confluence of the economic and non-economic literature on sustainability. Finding agreement upon policy-making processes and policy outcomes that are "sustainable" on economic, social and ecological grounds in an absolute sense is very difficult. Therefore, the goal in this paper is to explore how to *raise* sustainability in one or more of the economic, social and ecological dimensions relative to baseline economic profit, ecological/environmental quality, and degree of intragenerational and intergenerational equity that emerge from private decision-making by profit-maximizing landfill operators. Assuming that the current baselines comprise an "unsustainable" state of affairs, the model is extended to consider how the inputs to landfilling would be selected in the planning and operational phases by a social planner who, unlike private waste disposal firms, is accountable for the intra- and intergenerational disamenities associated with landfilling. Raising the sustainability of landfilling is conceptualized in the model by internalizing site-level externalities in a manner that directly compensates landfill host communities.

[5] See, e.g., Townsend and Cheeseman (2005) regarding challenges and opportunities in general medical waste management, and Oke (2008) regarding the challenges of managing immunization waste in particular.

The model therefore poses striving for neoclassical economic efficiency at the landfill as a very significant step toward achieving sustainability, consistent with van den Bergh's (2010) recent argument, as well as with the OECD's (2002, p. 9) view that "…establishing an efficient level of decoupling for a particular environmental resource or sink ideally would involve "getting the prices right," and then allowing the market to determine the appropriate level of use at the established price." However, raising the economic efficiency of the landfill is considered a necessary but not sufficient condition for sustainability, consistent with Howarth's (2007) Fair-Sharing Principle and with Baumgärtner and Quaas's (2010) recent argument. As Howarth (2007, p. 661) describes, taking this view of operationalizing sustainability brings together aspects of concepts previously discussed in the literature as "strong" and "weak" sustainability. The landfilling model presented below is consistent with strong sustainability in that externalities will be reduced to socially efficient rates and compensation must be paid directly to those who experience landfill disamenities. This is in contrast to the standard neoclassical ("weak sustainability") economic approach by which economic efficiency requires only a *potential* Pareto-improvement. Yet, the landfilling model features elements of weak sustainability in that tradeoffs between potential inputs at the landfill are permitted by standard cost–benefit analysis. Indeed, trying to better understand how natural inputs can supplant traditional engineered inputs at landfills is a significant focus of bioreactor landfill engineering.

The first step in the analysis is to propose in Section 2 a microeconomic model of landfilling at the level of strategic input selection. As such, the model is a level deeper than typically considered in the economic literature, wherein site-level externalities—perceived as the chief threat to sustainably managing landfills—are typically assumed to be known with certainty and taken into account in a straightforward manner by a social planner. In contrast, exploring landfill microeconomics at the level of isoquants and isocosts faced by a private firm enables us to see how various types of uncertainties affect optimal landfilling in the siting/development phase; the operational phase; and the post-operation phase. As such, this approach enables in Section 3 careful attention to a concept of sustainable waste management—especially at the level of the landfill—that economists and non-economists should likely agree upon. We find that raising the sustainability of the siting process that precipitates construction of new landfills requires particular attention. In Section 4 we consider practical methods by which greater sustainability in landfilling can be achieved. Conclusions follow in Section 5.

2. The Microeconomics of Solid Waste Management

Historically, landfilling is the dominant method in (municipal, hazardous and radioactive) waste management. Significant technological change has evolved in landfilling (of all waste types) such that the landfill is a more significant method than at any time in its history. Indeed, reliance on landfilling is pervasive in all countries, and environmental engineers and waste management specialists do not expect significant technological change away from landfilling in the foreseeable future.[6] The literature regarding the economics of waste management supports this view from non-economists. Pearce and Turner (1993, pp. 71–72), for instance, argue that it is not always obvious on economic grounds that increasing recycling effort is worthwhile. Indeed, Palmer et al. (1997, p. 147) find that the economics supports only a modest (7.5%) reduction in recyclable municipal solid waste flows in the United States. Kinnaman (2006, p. 220) agrees, noting that recycling costs about twice as much per ton as disposal; he argues that the data favors simplifying solid waste

[6] See, e.g., Zacharof and Butler (2004, p. 241) who open their paper as follows: "The reliance on landfill for the ultimate disposal of treated or untreated waste will inevitably remain for a considerable number of years.