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Evaluating policy interventions with general equilibrium externalities ☆

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Abstract

We report on the results of analytical and numerical models that describe the effects of non-separable externalities (or public goods) on public policies with important general equilibrium consequences. In the numerical exercise, we calibrate a general equilibrium model with non-separable air quality benefits in order to measure the excess burden and total net benefits of transportation and energy taxes in the 1995 U.S. economy. The change in the physical level and the economic value in air quality associated with a given policy is a function of the substitution patterns between air quality and market goods that we assume. The size of the deadweight loss due to pre-existing distortions such as a tax on labor income is substantially affected by these substitution patterns.
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1. Introduction

This paper illustrates how non-separable externalities can be important for evaluating the general equilibrium implications of policy interventions. Our analysis uses a consistent description of general equilibrium that simultaneously characterizes a market economy and the polluting activities that give rise to externalities due to reductions in air quality. Market data, measures of ambient air quality and emission rates, along with estimates of the incremental willingness to pay to reduce air pollution are used to calibrate this model for the U.S. economy.

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When air quality and consumption goods are non-separable elements of consumer preferences or production technologies, a change in the level of air quality can affect market demands. These market responses, in the form of changes in the quantities supplied, also affect air quality. Such interactions imply market equilibria are influenced through non-market feedback effects. That is, pollution affects the level and composition of economic activity which, in turn, affects the level of pollution. These two features – non-separability and feedbacks – define what we refer to as general equilibrium externalities. In this context, the costs and benefits of a new policy depend on: the direct efficiency costs incurred in newly regulated sectors, the impact of these regulations on the costs of pre-existing distortions in other sectors, and the character of the interaction between the level of the externality and market demands. We evaluate both the excess burden (or gross cost) and the full welfare effects (net benefits) of policies that alter the level of the externality.

There is a substantial theoretical literature on the effect of non-separable externalities and public goods on excess burden in both the public finance tradition (Boadway and Keen, 1993; Kaplow, 1996) and in the study of second-best environmental taxation (de Mooij, 2000; Schwartz and Repetto, 2000; Williams, 2002; Williams, 2003). These studies uniformly agree that the substitution patterns between the externality (or public good), market goods, and labor may be an important determinants of the excess burden of a new regulation. They also highlight the need to establish some quantitative gauge of the importance of these connections. Recent empirical evidence suggests that the separability assumptions that dominate the study of second-best environmental regulation are unlikely to hold in a number of important policy contexts (West and Williams, 2007).

Recognition of the basic mechanism for feedbacks between economic activity and externalities is present in several previous studies, but authors have tended to focus on the effect of a change in the level of externality on labor supply. As a rule, they have not linked the equilibrium level of the externality back to equilibrium consumption and leisure choices in a way that provides direct insight into how these feedback mechanisms influence the assessment of the benefits of a policy intervention or the deadweight losses of policy changes in the presence of multiple distortions.

In the analytical section of the paper, we use early literature on reciprocal externalities (Diamond and Mirrlees, 1973; Sandmo, 1980; Cornes, 1980) to describe the general equilibrium consequences of feedbacks in terms of compensated demand responses and income effects.[1] Our numerical simulations are organized to parallel this analytical framework — we solve the model with sets of restrictions that map directly back to the partial effects identified in the analytical discussion.

In the numerical exercise, we make use of a well-documented numerical model that was developed to assess the excess burden of a new tax introduced into an economy with a large pre-existing tax distortion (Goulder and Williams, 2003). We add externalities due to air pollution and assume air quality makes non-separable contribution to preferences, calibrating the model using emission rates and estimates of the tradeoffs consumers would make to enhance air quality that are based on established estimates.

We consider two different new taxes that might be expected to impact air quality. This first involves final consumption of transportation services and the second is intermediate energy use. The latter parallels one of the taxes that Goulder and Williams consider. This structuring of the analysis implies our amended model can replicate the Goulder and Williams results when we make air quality separable and, as a result, we can illustrate directly how non-separability would influence their assessment of the importance of multiple distortions for measuring the effects of policy. More broadly, this strategy links our results to a number of studies of second-best environmental taxation by Goulder, Williams and co-authors (Bovenberg and Goulder, 1997; Goulder et al., 1997, 1999).[2]

Using the Goulder and Williams experiment (a new 5% energy tax with a pre-existing 40% income tax) as a benchmark, we find that introducing non-separability produces measures of the general equilibrium excess burden of the tax that differ substantially from the comparable measures presented in Goulder and Williams. The errors range from 13% to 32% when air quality is assumed to be twice as substitutable with leisure as the average good. We find similar results (errors ranging from 4% to 21%) when the goods are assumed to be strong complements. The size of the error depends on the magnitude of the assumed marginal willingness to pay for air quality improvements. The substitution pattern between air quality, leisure, and market goods is also a key determinant of the sign and magnitude

[1] For the most part, this literature has missed this connection to general equilibrium externalities and focused, instead, on describing the conditions under which "anomalous" quantity responses (i.e. upward sloping compensated demand functions) due to reciprocal externalities are possible.

[2] This research is closely related to an extensive set of analytical work on the modeling of tax interaction effects and the double dividend hypothesis. See Fullerton (1997) for a discussion of the importance of normalization rules in describing the effects of taxes and Fullerton and Metcalf (2001) for an overview of the analytical work especially relevant to the evaluation of environmental policy instruments.

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