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Household heterogeneity, aggregation, and the distributional impacts of environmental taxes

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ABSTRACT

This paper examines how the general equilibrium incidence of an environmental tax depends on the effect of different incomes and preferences of heterogeneous households on aggregate outcomes. We develop a Harberger-type model with general forms of preferences and substitution between capital, labor, and pollution in production that captures the impact of household heterogeneity and interactions with production characteristics on the general equilibrium. We theoretically show that failing to incorporate household heterogeneity can qualitatively affect incidence. We quantitatively illustrate that this aggregation bias can be important for assessing the incidence of a carbon tax, mainly by affecting the returns to factors of production. Our findings are robust to a number of extensions including alternative revenue recycling schemes, pre-existing taxes, non-separable utility in pollution, labor–leisure choice, and multiple commodities.

1. Introduction

The public acceptance for environmental taxes depends crucially on their distributional consequences. A plethora of applied research in public and environmental economics has investigated the incidence of environmental taxes in various policy settings. Not seldom, however, the empirical evidence whether a specific tax is regressive or not is mixed—even if the incidence of a given tax instrument is analyzed in a similar or identical policy context. Differences arise because the incidence analysis does not consider all relevant channels through which an environmental tax affects market outcomes (see, e.g., Atkinson and Stiglitz, 1980 and Fullerton and Metcalf, 2002 for a discussion of incidence impacts in the public finance literature).[1] One important channel which is typically omitted by general equilibrium analyses that employ a single, representative household model is the impact of household heterogeneity on the market equilibrium. Despite the high policy relevance and academic interest for understanding the distributional consequences of price-based pollution controls, an analysis of the effect of household aggregation on tax incidence is lacking.

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[1] Environmental taxes often appear to be regressive on the "uses side of income" as they affect more heavily the welfare of the poorest households than of the richest ones, since poorer households spend a larger fraction of their income on polluting goods (e.g., energy or electricity). "Sources side of income" impacts can dampen or even offset the regressive incidence on the uses side to the extent that environmental tax policies affect the returns to factors of production that are disproportionately owned by richer households and used intensively in the production of dirty relative to clean industries (e.g., capital). The regressivity of many environmental taxes on the uses side, including carbon pricing in the context of climate policy, constitutes a serious concern for policymakers and has been investigated extensively in the literature (Fullerton et al., 2012, Metcalf, 1999, Poterba, 1991). Gasoline taxes are generally found to be progressive on the uses side (Sterner, 2012). More recently, work by Fullerton and Heutel (2007), Araar et al. (2011), and Rausch et al. (2011) has also scrutinized the sources side impacts of carbon taxation.

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This paper develops a theoretical Harberger (1962)-type general equilibrium model of the incidence of an environmental tax featuring heterogeneous households, general forms of preferences, differential spending and income patterns, differential factor intensities in production, and general forms of substitution among inputs of capital, labor, and pollution. Its purpose is two-fold. First, we theoretically investigate the implication of the household aggregation problem for the incidence of environmental taxes, i.e., to what extent incidence results derived from a general equilibrium analysis which ignores household heterogeneity are biased. In the absence of identical homothetic preferences for each individual or homothetic preferences and collinear initial endowment vectors (i.e., identical income shares), aggregated preferences depend on the distribution of income (Polemarchakis, 1983).[2] Thus acknowledging heterogeneity in tastes undercuts the representative consumer framework that is used to calculate the general equilibrium effects on output and factor prices (Kortum, 2010). Second, we apply the heterogeneous household model to quantitatively assess how the aggregation bias affects equilibrium outcomes and the incidence of a tax on carbon dioxide (CO_2) emissions for the case of the United States. We assess the incidence on the sources and uses side of income, and explore how sensitive results are with respect to key characteristics governing households' and firms' behavior.

Our main finding is that the household aggregation problem can have important implications for assessing the incidence of environmental taxes: basing the analysis on a single, representative household model as opposed to an analysis that integrates household heterogeneity can yield both qualitatively and quantitatively different conclusions. Assuming homothetic preferences, we show that the impact of household heterogeneity on the equilibrium can be characterized by two statistical quantities which capture the degree of household heterogeneity in terms of household preferences and income shares. These metrics provide an intuitive way to express the discrepancy in results obtained under a case with heterogeneous households and a case with identical households. We provide examples of conditions for households' and firms' characteristics under which the aggregation bias does or does not matter. For example, with limited substitutability between inputs of capital, labor, and pollution in production, factor and output price changes can be reversed, in turn yielding qualitatively different incidence results among poor and rich households. Moreover, we find that there exist for any benchmark economy, described by data on production and distributions of consumption and income among households, values of production elasticities such that household aggregation leads to reversed factor price changes. We find that for non-homothetic preferences the burden of an environmental tax on factors of production can be qualitatively different as compared to a case with homothetic preferences.

We quantitatively illustrate that the aggregation bias for empirically motivated cases can be important for assessing the incidence of a carbon tax. As the aggregation bias on welfare is largely caused by the aggregation bias on the returns to factors of production, it mainly affects the sources of income. Additionally, we find that most of the variation in welfare impacts when altering production and household characteristics is driven by sources side impacts, and may even lead to a reversal of the incidence pattern across households. Our analysis thus points to the importance of including sources of income impacts for tax incidence analysis. We also find that household heterogeneity in the elasticities of substitution in utility magnifies the aggregation bias due to heterogeneity in expenditure and income patterns. In our static model, heterogeneity in income elasticities has a smaller effect compared to heterogeneity in substitution elasticities.

Our findings are robust to a number of extensions including alternative revenue recycling schemes, pre-existing taxes, non-separable utility in pollution, labor–leisure choice, and multiple commodities. Any extension of the model obviously produces quantitatively different results, but the point of the paper that household heterogeneity affects equilibrium and hence the incidence of environmental taxes remains. In fact, we argue that the case for the aggregation bias is strengthened rather than weakened.

Our paper builds on a small but growing literature that uses analytical general equilibrium models to study the incidence of environmental taxes. Our model builds on a series of influential papers by Fullerton and others (Fullerton and Heutel, 2007, 2010, Fullerton et al., 2012, Fullerton and Monti, 2013) that extend the Harberger (1962) model and previous theoretical work by Rapanos (1992, 1995) to develop a model which represents pollution as an input along with capital and labor and that allows for general forms of substitution between inputs. We extend the single-consumer model presented in Fullerton and Heutel (2007) to include heterogeneous households. We additionally incorporate non-homothetic preferences. By fully integrating household heterogeneity, our paper also differs from the contributions in Fullerton and Heutel (2010) and Fullerton et al. (2012) that use price impacts derived from the single-consumer model in Fullerton and Heutel (2007) to determine the burdens of a carbon tax using household survey data. Fullerton and Monti (2013) integrate two types of households into an analytical general equilibrium model and investigate the distributional impacts of a pollution tax swap (recycling revenues through a wage tax of low-income workers). They do not, however, study the impact of household heterogeneity on equilibrium outcomes.

Our analysis is also related to the literature that uses computational methods to assess the distributional impacts of environmental taxes. A widespread approach is to employ input–output analysis to derive price changes for different consumers goods and then calculate tax burdens for households based on micro-household survey data.[3] Common to these studies is that they adopt a partial equilibrium perspective that does not consider behavioral changes and focuses on the uses sides of the incidence only. A few papers use numerical general equilibrium models with a single, representative consumer to derive price impacts on commodity and factor prices. Metcalf et al. (2008) carry out an analysis of carbon tax proposals and find that a carbon tax is highly regressive but that the regressivity is reduced due to sources side effects to the extent that resource and equity owners bear some fraction of the tax burden. Similarly, Araar et al. (2011) and Dissou and Siddiqui (2014) use price effects to assess the distributional impacts of a carbon tax. None of these studies, however, captures the impact of household heterogeneity on equilibrium outcomes.

Lastly, a few papers integrate heterogeneous households into a numerical general equilibrium framework. For example, Rausch et al. (2010a,b) investigate the incidence of a U.S. carbon tax in a

[2] On a more fundamental conceptual level, and not related to the incidence of (environmental) taxation, the aggregation problem for heterogeneous consumers in general equilibrium models has been studied by Ackermann (2002) based on prior work by Rizvi (1994) and Martel (1996).

[3] Examples include Robinson (1985) who studies the distributional burden of industrial abatement in the U.S. economy and Poterba (1991) who focuses on the incidence of U.S. gasoline taxes. Bull et al. (1994) and Hassett and Metcalf (2009) compare a tax based on energy content and a tax based on carbon, and Metcalf (1999,2009) analyzes a revenue-neutral package of environmental taxes, including a carbon tax, an increase in motor fuel taxes, and taxes on various stationary source emissions. Dinan and Rogers (2002) assess the efficiency and distributional impacts of a U.S. cap-and-trade program for CO_2 emissions, and Mathur and Morris (2014) investigate the distributional effects of a carbon tax in broader U.S. fiscal reform. Other works study the incidence impacts of greenhouse gas emissions pricing policies across household income groups for different countries (e.g., Labandeira and Labeaga (1999) for Spain, Callan et al. (2009) for Ireland, and Jiang and Shao (2014) for China).