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The general equilibrium incidence of environmental taxes ☆

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Abstract

We study the distributional effects of a pollution tax in general equilibrium, with general forms of substitution where pollution might be a relative complement or substitute for labor or for capital in production. We find closed form solutions for pollution, output prices, and factor prices. Various special cases help clarify the impact of differential factor intensities, substitution effects, and output effects. Intuitively, the pollution tax might place disproportionate burdens on capital if the polluting sector is capital intensive, or if labor is a better substitute for pollution than is capital; however, conditions are found where these intuitive results do not hold. We show exact conditions for the wage to rise relative to the capital return. Plausible values are then assigned to all the parameters, and we find that variations over the possible range of factor intensities have less impact than variations over the possible range of elasticities.

JEL classification: H23; Q52
Keywords: Distributional burdens; Pollution policy; Analytical solutions; Sources side; Uses side

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Policy makers need to know the distributional effects of environmental taxes. Previous studies that find environmental taxes to be regressive have focused on the uses side of income; that is, how low-income consumers use a relatively high fraction of their income to buy gasoline, electricity, and other products that involve burning fossil fuel. Yet these studies ignore the sources side of income. Environmental policies can have important effects on firms' demands for capital and labor inputs, which can impact the returns to owners of capital and labor in a general equilibrium setting.

The literature in public economics contains much work on general equilibrium tax incidence, but the literature on environmental taxation has focused mostly on efficiency effects. As reviewed below, neither literature yet has studied the general equilibrium incidence of a pollution tax in a model with general forms of substitution. Environmental tax incidence has been studied only in partial equilibrium models, in computational general equilibrium (CGE) models, or in analytical general equilibrium models with limited forms of substitution. This paper provides a theoretical general equilibrium model of the incidence of an environmental tax that allows for differential factor intensities and fully general forms of substitution among inputs of labor, capital, and pollution. We show incidence on the sources side as well as the uses side.

Many empirical studies provide partial equilibrium analyses of the incidence of an environmental tax. For example, Robison (1985) examines the distribution of the costs of pollution abatement from 1973 to 1977 and finds regressive burdens equal to 1.09% of the income of the lowest income class and only 0.22% of income for the highest income class. Using CGE models, Mayeres (2000) and Metcalf (1999) look at various ways to return the revenue from an environmental tax, showing that these distributional effects can more than offset the incidence of the environmental tax itself. Morgenstern et al. (2002) discuss four CGE studies that examine various distributional effects of carbon policy, but none derive analytical results and none show effects on factor prices.[1]

Previous theoretical work on environmental tax incidence by Rapanos (1992, 1995) models pollution in one sector as a negative externality that affects production in the other sector. The model is somewhat restrictive in two respects. First, the externality has a specific effect on production in the other sector, which affects incidence. Second, Rapanos assumes that pollution bears a fixed relation to output (or to capital input) of the polluting sector, so a tax on pollution has the same incidence as a tax on output (or on capital input). In contrast, this paper models pollution as a variable input to the dirty sector's production function. In response to any price change, the producer can change the mix of labor, capital, and pollution. In particular, pollution can be a relative complement or substitute for labor or capital, so that a pollution tax can change the relative demands for those other two factors and affect their relative returns.

Bovenberg and Goulder (1997) examine the efficiency costs of a revenue-neutral environmental tax swap and also solve for the change in the wage rate. Their analytical model considers variable pollution, but the production function has a single elasticity of substitution among the three inputs (capital, labor, and pollution). This formulation does not allow for relative complementarity of inputs in production, a possibility that drives significant results below.[2] Chua (2003) presents a model where pollution is a scalar multiple of output, but it can be lowered by paying an abatement

[1] Also, West and Williams (2004) use micro data to model demand equations and empirically estimate the distribution of burdens of environmental policy. Parry (2004) examines the distribution of the scarcity rents created by grandfathered emissions permits. In a model with unemployment, Wagner (2005) shows that an emissions tax can help labor to the extent that it stimulates employment in the abatement sector.

[2] DeMooij and Bovenberg (1998) allow for complementarity of inputs, and they derive the change in the wage rate, but their model is primarily used to examine the efficiency of revenue-neutral tax swaps. To the extent that they examine incidence, their results are somewhat limited by the fact that capital either has an exogenous price or is supplied inelastically in the polluting industry.