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Can a unilateral carbon tax reduce emissions elsewhere?

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ABSTRACT

One country or sector that tries to reduce greenhouse gas emissions may fear that other countries or sectors will get a competitive advantage and increase emissions. Computable general equilibrium (CGE) models such as Elliott et al. (2010a, 2010b) indicate that 15–25% of abatement might be offset by this "leakage." Yet the Fullerton et al. (2012) simple two-sector analytical general equilibrium model shows an offsetting term with negative leakage. In this paper, we use a full CGE model with many countries and many goods to measure effects in a way that allows for this negative leakage term. We vary elasticities of substitution and confirm the analytical model's prediction that whether this negative leakage term offsets the positive leakage terms depends on the ability of consumers to substitute into the untaxed good relative to the ability of firms to substitute from carbon emissions into labor or capital.

Carbon dioxide and other greenhouse gases contribute to climate change, a global problem that would seem to require a global solution. Yet a global agreement seems further away than ever. Any nation trying to reduce its own emissions might raise its own cost of production and provide benefits that accrue mostly to the rest of the world. Even worse, a unilateral effort may provide competitive advantage to other nations who can then increase production and emissions. This "leakage" of emissions reduces the effectiveness of any one sector's effort to cut emissions.

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This problem involves many nations in competition for trade in goods produced using different combinations of inputs and emissions of greenhouse gases (GHG), so it has been studied using global models of computable general equilibrium (CGE). Several existing models have interesting similarities and important differences.[1] Such a model may involve more than a dozen regions, and many commodities are produced using inputs of labor, capital, energy, and materials. The production of electricity itself may use labor, capital, coal, oil, natural gas, and other inputs. Tracking the carbon content of each such fuel and using various input demand elasticities, such a model can calculate behavioral responses to a carbon tax in one region, each sector's shift away from carbon-intensive sources of energy, consequent effects on production costs and equilibrium prices, and the overall cost-effectiveness of carbon policy.

In these CGE models, leakage has two major components. The first is a "terms of trade effect" (TTE), where unilateral carbon policy provides a competitive trade advantage to other nations and shifts production in a way that depends on the elasticities of demand for those products. If another nation's product is a close substitute, then this TTE is large and leakage might be large. The second is a "fuel price effect" (FPE), where the unilateral policy reduces domestic demand for oil and thus reduces the worldwide price of oil – encouraging other nations to consume more of it.

Other research reviewed below has used analytical or theoretical approaches. In particular, Fullerton et al. (2012) use a simple two-sector analytical general equilibrium model to solve for closed-form expressions that show how the amount of leakage depends on elasticity and share parameters that appear in several terms. In their model, the two sectors might produce two different goods in a closed economy, or they might represent two countries that each produces a unique good. Thus, a "unilateral carbon tax" in this paper can refer to a carbon tax in only one country, or in only one sector of a closed economy. In fact, our major example of a "unilateral" carbon policy below is a carbon tax only in the electricity sector of a closed economy.

Fullerton et al. (2012) derive a positive term for the TTE and another for the FPE, but they also find several negative terms. One is an "input–output effect" (IOE): if a carbon tax applies in the production of one good that is used as an intermediate input in the production of the other good, then the other good also becomes more expensive, may reduce production, and may therefore cut emissions. They also introduce a new negative term they call the "abatement resource effect" (ARE).

They show that the ARE requires three conditions. First, the two goods cannot be perfect substitutes (for otherwise a carbon tax in one sector would just shift all demand to the other output and cause only positive leakage). Second, the taxed sector must have some ability to substitute from carbon-intensive inputs to other inputs (such as use of capital for solar panels or wind turbines). Third, labor and/or capital must be mobile between the two sectors. Then, when a carbon tax is imposed in one sector, consumers may shift some demand to the other output; but to satisfy remaining demand, producers can substitute out of fossil fuels and into more use of labor or capital, drawing those resources away from the other sector – which can reduce production and emissions in the other sector.

In the analytical model, these negative terms may offset some or all of the positive leakage terms. When a CGE paper reports 10% or 20% positive leakage, we may have no way to know the extent to which larger positive leakage effects are offset by the ARE or other negative leakage effects. Hence, the purpose of this paper is to find the numerical importance of a negative leakage effect within the standard results of a CGE model. This question is important for understanding the drivers of leakage in such models, since policymakers can then use our results to identify circumstances where leakage is likely to be larger or smaller, and perhaps where overall leakage might be negative. If so, then a well-designed carbon policy might be able to reduce world-wide emissions by more than in the one sector subject to that policy.

[1] CGE models and results reviewed below include those of Fischer and Fox (2010) and Böhringer et al. (2011), as well as MIT's "Emissions Prediction and Policy Analysis" (EPPA) model used by Paltsev (2001), Babiker (2005), and Winchester et al. (2011). In this paper, we use the "Community Integrated Model of Economic and Resource Trajectories for Humankind" (CIM-EARTH), a relatively new model of Elliott et al. (2010a, 2010b).