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Combining Rebates with Carbon Taxes

Optimal Strategies for Coping with Emissions Leakage and Tax Interactions

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Carolyn Fischer and Alan K. Fox

1616 P St. NW
Washington, DC 20036
202-328-5000 www.rff.org

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Combining Rebates with Carbon Taxes: Optimal Strategies for Coping with Emissions Leakage and Tax Interactions

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Abstract

Emissions regulations like carbon pricing raise the price of covered sector goods and thus can interact with and exacerbate other preexisting distortions in the economy. One such distortion is labor taxes. Another is emissions “leakage” due to the lack of comparable emissions pricing abroad or among other emitting sectors at home. A potential response is to combine the emissions tax with a rebate to production to mitigate the price increases. We use an optimal tax framework to solve for the optimal emissions tax and output rebate, given these distortions. We then employ a multisector computable general equilibrium model based on the GTAP framework to simulate the effects of a $50 per-ton carbon tax on the major emissions-intensive sectors in the U.S. economy and estimate optimal rebates by sector.

Key Words: carbon tax, tax interaction, carbon leakage

JEL Classification Numbers: Q2, Q43, H2, D58, D61

Contents

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Introduction

Climate change is a global problem, but most of the current efforts to rein in greenhouse gas (GHG) emissions through carbon pricing are unilateral, national, and even subnational in origin. The European Union has led with the implementation of its Emissions Trading System (ETS). In the United States and Canada, in the absence of federal programs, the Northeast's Regional Greenhouse Gas Initiative (RGGI), California's Global Warming Solutions Act (AB32), British Columbia's carbon tax, and the Western Climate Initiative have emerged. However, a serious concern with these individual initiatives is that increases in domestic prices for energy, electricity, and thereby products may lead to a shift in production (and even generation) to unregulated regions. Not only is lost competitiveness a concern for policymakers, but so is the resulting "carbon leakage," which threatens to partially undo the efforts to reduce emissions. These concerns extend to the federal level in the United States and for other developed countries that are positioning themselves to take on significant carbon pricing policies. The Kyoto Protocol, the international agreement to reduce emissions of the greenhouse gases that cause global climate change, also recognizes a principle of "common but differentiated responsibilities," implying that comparable carbon constraints will not be expected from developing countries for some time.

Leakage to unregulated entities is not strictly an extraterritorial phenomenon. If the environmental policy is narrowly applied to a subset of emitting sectors, production and emissions (and thereby leakage) can shift to uncovered sectors within that same region. The reasons for incomplete coverage of a carbon pricing policy may be technical or administrative or arise from other concerns; however, the strategy is common. For example, the EU ETS applies

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[*] Carolyn Fischer (fischer@rff.org) is a Senior Fellow at Resources for the Future, Washington, DC. Alan Fox (Alan.Fox@usitc.gov) is with the Office of Economics of the United States International Trade Commission (ITC), Washington, DC. The opinions and ideas expressed herein are solely those of the authors and do not represent the views of RFF or the U.S. ITC or any of its individual commissioners. This line of research has benefitted from the financial support of EPA-STAR and of the Mistra Foundation ENTWINED program, which are gratefully acknowledged, as is the hospitality and support of the Centre for Advanced Study (CAS) at the Norwegian Academy of Science and Letters in Oslo.

only to a certain set of energy-intensive sectors representing 46 percent of European emissions,[1] and RGGI applies only to electricity generation.

Bernard et al. (2007) show that such inefficient reallocations can be prevented by taxing the unregulated sectors according to the emissions embodied in their output. However, when unregulated sectors reside abroad, such a tax may be prohibited by World Trade Organization rules and, in any case, would only apply to imports, not to all the unregulated production. Among unregulated domestic sectors, a tax on embodied emissions would be as difficult to implement as a full downstream emissions trading program. Barring such a tax, Bernard et al. show that the next best policy is to subsidize the output of the regulated sectors. The optimal subsidy then reflects the value of the emissions crowded out by additional output in that regulated sector.

In practice, such a subsidy could be implemented in several ways. For example, all or part of the emissions tax revenues could be rebated to participants according to their production, as in the case of the Swedish NO_x tax (see Isaksson and Sterner 2006). Within an emissions cap-and-trade program, the subsidy can be implemented by updating the allocation of permits to firms within the affected sectors based on their output (which we will refer to as output-based allocation, or OBA). The value of additional permits represents an incentive to produce more, offsetting part of the price increase induced by the emissions regulation itself. In both the tax and the cap cases, when applied in a multisector setting, the rebate or allocation can be based on a performance metric (such as the emissions intensity corresponding to an average or best available technology) multiplied by an indicator of output. A similar way to combine emissions pricing with a rebate is with tradable performance standards; in this case, each sector must meet an average emissions requirement. The effect is in theory identical: each firm must surrender permits according to its emissions and receives an allocation according to its output. However, in practice it is difficult to set performance standards such that marginal cost equalization is met, unless the permits are also tradable across sectors, and it is more difficult to ensure that a particular emissions target is met.

These mechanisms have been of interest to researchers concerned about preexisting tax distortions. Labor taxes distort the consumption-leisure tradeoff, and environmental regulation that further raises consumer prices exacerbates those costs (a collection of the literature is available in Goulder 2002). Since the output subsidy embodied in performance standards limits

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[1] http://www.carbontrust.co.uk/climatechange/policy/eu_ets.htm (accessed 03/09/09).

those price increases, these mechanisms can outperform a system of grandfathered emissions permits (Goulder et al. 1999; Parry and Williams 1999; Fullerton and Metcalf 2001).

In an international context, trade distortions can be as important as tax distortions: although all domestic sectors are covered by the emissions trading program, trade partners are not covered, which allows carbon to "leak" as production shifts to unregulated producers. Fischer and Fox (2007) consider the effects of different allocation mechanisms, including output-based allocation, on the efficiency and distributional effects of a comprehensive carbon emissions trading program in the United States, when both tax and trade distortions are taken into account. They find that the rebates implicit in OBA mitigate tax interactions, which can lead to higher welfare than grandfathering. However, the rule for determining the sector allotments, which determines the effective rebate, matters. OBA with sectoral distributions based on value added generates implicit rebates similar to a broad-based tax reduction, performing nearly like auctioning with revenue recycling, which generates the highest welfare. OBA based on historical emissions supports the output of more polluting industries, which more effectively counteracts carbon leakage, but is more costly in welfare terms. However, from a welfare perspective, when the domestic coverage of the cap-and-trade program is complete, OBA does not dominate full auctioning with revenue recycling.

We extend this research by focusing simultaneously on the three major policy and market imperfections that can justify support for output rebates in combination with an emissions pricing program: (1) lack of comparable policies abroad, (2) incomplete regulatory coverage at home, and (3) tax interaction. We first extend the theory of Bernard et al. (2007) to incorporate tax interactions, revealing that with Pigouvian taxation of the emissions externality, the optimal rebate to regulated goods reflects not only the marginal benefit of avoided leakage but also a component to adjust for labor tax interactions. Subsequently, we extend the numerical analysis of Fischer and Fox (2007) to consider the case of more limited domestic coverage in a carbon pricing scheme for the United States, along the lines of recent proposals for a domestic cap-and-trade program for CO_2 and of trends in sectoral coverage that have emerged in the EU ETS. In keeping with the theoretical section, we model a carbon tax policy and solve for "optimal" rebates for each of the covered sectors.[2] The analysis is carried out in a modified GTAP framework augmented with a labor-leisure choice to acknowledge the tradeoff between using

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[2] Fischer and Fox (2009) explore a broader range of allocation options in the context of a cap-and-trade program.

carbon tax revenues to offset labor taxes versus granting rebates. The results help identify likely sectors and mechanisms for minimizing the costs of broader emissions reductions when considering the interaction of one country's emissions policies with unregulated emissions and labor market distortions in other countries. However, they also illustrate the potential importance of other economic distortions that are present in international trade but not considered in theoretical models.

Theoretical Background

To understand the optimal tax problem, we expand upon the analysis of Bernard et al. (2007) to add a labor tax and revenue constraint. We will not distinguish between global and domestic leakage in this section. Consider a simple economy with two sectors (one with emissions regulation and one without), two goods, and two factors of production (labor and emissions). Labor is considered the third good and, without loss of generality, will be taken as the numéraire ($w = 1$). The following list summarizes our notation:

Quantities
Q_1 = Production in the regulated sector
Q_2 = Production in the unregulated sector
L_1 = Labor demand in the regulated sector
L_2 = Labor demand in the unregulated sector
L = Labor supply
l = Leisure = $1–L$
C_1 = Demand for good produced in the regulated sector
C_2 = Demand for good produced in the unregulated sector
E_1 = Emissions of pollutant in the regulated sector
E_2 = Emissions of pollutant in the unregulated sector
Prices
p_1 = Consumer prices in the regulated sector
p_2 = Consumer prices in the unregulated sector
q_1 = Producer prices in the regulated sector
q_2 = Producer prices in the unregulated sector
w = Labor wage (numéraire)
τ_1 = Tax on emissions in the regulated sector
t_1 = Tax on regulated commodity
t_L = Tax on labor

Specifications

The household sector consists of a representative consumer, allowing us to avoid consideration of international equity in the analysis. Utility is a function of consumption of both goods and leisure:

$$U = U(C_1, C_2, 1 - L).$$

Households also suffer disutility as a function of total emissions:

$$D = D(E_1 + E_2).$$

The welfare function, then, is the difference between consumption utility and emissions disutility, which we have assumed to be separable:

$$W = U - D = U(C_1, C_2, 1 - L) - D(E_1 + E_2).$$

Production in each sector (*i* = 1, 2) is a function of labor and emissions: $Q_i = f_i(L_i, E_i)$. Equivalently, labor in each sector can be specified as a function of output and emissions:

$$L_i = L_i(Q_i, E_i).$$

Finally, a government revenue constraint requires that

$$t_L L + t_1 Q_1 + \tau_1 E_1 + \tau_2 E_2 = G$$

We assume that the good produced by the unregulated sector is the untaxed commodity.

Decentralized Markets

It is well understood that if the social planner could choose quantities of output and emissions directly, the marginal damage of all emissions would be equalized with the cost of reducing them and the marginal value of a good's consumption would equal its social marginal cost, inclusive of the externality. In the decentralized problem, the planner uses taxes to influence market prices and achieve this outcome. The maximization problems of the consumer and producers form the constraints for the planner, along with any regulatory constraint.

Consumer Problem

Taking pollution externalities as given, the representative household maximizes utility with respect to consumption and leisure,

$$U(C_1, C_2, 1 - L)$$

subject to a budget constraint:

$$(\lambda) \quad p_1 C_1 + p_2 C_2 - (1 - t_L) L = 0.$$

From the consumer problem, we obtain

$$(C_1) \ \frac{\partial U}{\partial C_1} = p_1 \lambda; \qquad (C_2) \ \frac{\partial U}{\partial C_2} = p_2 \lambda; \qquad (L) \ \frac{\partial U}{\partial l} = \lambda (1 - t_L).$$

Producer Problems

The representative firm in each sector *i* chooses output and emissions to maximize profits:

$$\pi_i = q_i Q_i - L_i(Q_i, E_i) - \tau_i E_i ,$$

from which we obtain

$$(Q_i) \ q_i = \frac{\partial L_i}{\partial Q_i}; \qquad (E_i) \ -\frac{\partial L_i}{\partial E_i} = \tau_i .$$

The first expression implies that the output price equals the marginal cost (or, with some rearranging, that the value of the marginal product of labor equals the wage rate). The second means that the labor cost savings from using more emissions just equal the tax.

Government Revenue

The government revenue constraint implies that any shortfall from the consumption and emissions taxes must be made up by a tax on labor:

$$G = t_1 C_1 + \tau_1 E_1 + t_L L$$

Market Equilibrium

In equilibrium, we have

$$C_1 = Q_1; \quad C_2 = Q_2; \quad L_1(Q_1, E_1) + L_2(Q_2, E_2) + G = L$$

and $q_i = p_i - t_i$, and the revenue constraint is met.

With well-behaved utility and production functions, consumption of each good is decreasing in its own costs, which include output and emissions taxes, so $dC_i / dt_i < 0$ (and $dC_i / d\tau_i < 0$). Let us define the goods as substitutes if $dC_i / dt_j > 0$ and complements if $dC_i / dt_j < 0$. These cross-price effects depend not only on the signs of the cross-partials in the utility function but also on the general equilibrium. Overall labor supply is increasing in the marginal utility of consumption.

Planner Problem

The question at hand is what happens when the policymaker can neither regulate pollution in Sector 2 nor tax the output of that sector. However, the regulated sector can be taxed or subsidized as well as regulated.

The social planner maximizes welfare, *W*, with respect to $t_1, \tau_1,$ subject to the aforementioned constraints. The essence of the optimal tax problem can be seen by totally differentiating welfare:

$$dW = \frac{\partial U}{\partial C_1} dC_1 + \frac{\partial U}{\partial C_2} dC_2 - \frac{\partial U}{\partial l} dL - \frac{\partial D}{\partial E}\left(dE_1 + dE_2\right)$$

Using the first-order conditions from the consumer problem, this equation simplifies to

$$\frac{dW}{\lambda} = p_1 dC_1 + p_2 dC_2 - (1-t_L)dL - \frac{D'}{\lambda}\left(dE_1 + dE_2\right)$$

Furthermore, $dL = dL_1 + dL_2$ and totally differentiating the production function, we get. Using the producer first-order conditions and market equilibrium conditions, this implies $dL_i = q_i dC_i - \tau_i dE_i$. Substituting, we get the marginal welfare impacts of the different policy levers (relative to the marginal utility of consumption):

$$\frac{dW}{\lambda} = t_1 dC_1 - \left(\frac{D'}{\lambda} - \tau_1\right) dE_1 - \left(\frac{D'}{\lambda}\right) dE_2 + t_L dL$$

We can further simplify by noting that output taxes change emissions by crowding out (or in) output. Thus, $dE_i / dt_j = m_i dC_i / dt_j$ for all {*i,j*}, where *m* is the marginal emissions rate. Similarly, the impact on emissions in one sector of a change in the emissions tax in the other sector depends on crowding out: $dE_i / d\tau_j = m_i dC_i / d\tau_j$, for $i \neq j$. Note that since the emissions tax also affects the emissions intensity, $dE_1 / d\tau_1 = m_1 dC_1 / d\tau_1 + C_1 dm_1 / d\tau_1$. Thus,

$$\frac{1}{\lambda}\frac{dW}{dt_1} = t_1 \frac{dC_1}{dt_1} - \left(\frac{D'}{\lambda} - \tau_1\right) m_1 \frac{dC_1}{dt_1} - \left(\frac{D'}{\lambda}\right) m_2 \frac{dC_2}{dt_1} + t_L \frac{dL}{dt_1}$$

$$\frac{1}{\lambda}\frac{dW}{d\tau_1} = t_1 \frac{dC_1}{d\tau_1} - \left(\frac{D'}{\lambda} - \tau_1\right) \frac{dE_1}{d\tau_1} - \left(\frac{D'}{\lambda}\right) m_2 \frac{dC_2}{d\tau_1} + t_L \frac{dL}{d\tau_1}$$

Solving for the optimal tax by setting the welfare change equal to zero, and using the Chain Rule, we get

$$t_1 = \underbrace{\left(\frac{D'}{\lambda}\right) m_2 \frac{dC_2}{dC_1}}_{\substack{\text{leakage impact}\\(-)}} + \underbrace{\left(\frac{D'}{\lambda} - \tau_1\right) m_1}_{\substack{\text{uninternalized}\\\text{per-unit damages}}} - \underbrace{t_L \frac{dL}{dC_1}}_{\text{tax interaction}} \tag{1}$$

$$\tau_1 = \underbrace{\frac{D'}{\lambda}}_{\substack{\text{marginal}\\\text{damage}}} + \underbrace{\left(\left(\frac{D'}{\lambda}\right) m_2 \frac{dC_2}{dC_1} - t_1\right)\frac{dC_1}{dE_1}}_{\text{uninternalized leakage }(-)} - \underbrace{t_L \frac{dL}{dE_1}}_{\text{tax interaction}} \tag{2}$$

Solving for the optimal tax combination, we get

$$\tau_1 = \frac{D'}{\lambda}$$

and

$$t_1 = \left(\frac{D'}{\lambda}\right) m_2 \frac{dC_2}{dC_1} - t_L \frac{dL}{dC_1}$$

The first equation states that the optimal emissions tax equals the marginal damages. The second states that the optimal rebate has two components. First, it internalized the marginal damages of the emissions generated by the substitution of consumption away from the regulated good toward the unregulated good. Second, the rebate is needed to counteract the tax interaction problem. Thus, a subsidy to Sector 1 to prevent emissions leakage and tax interaction can be preferred to full recycling of the environmental tax revenues.

Let us put these results in the context of Bovenberg and de Mooij (1994), Fullerton (1997), Williams (2000), and others who assume that emissions have a linear relationship with output. In their case, $E_1 = C_1$ (or $m_1 = 1$), so the emissions tax would be a commodity tax. Suppose that Sector 2 is a clean good, so $dE_2 = 0$ and $m_2 = 0$. Then for the dirty good we have

$$\tau_1 = \frac{D'}{\lambda}; \quad t_1 = -t_L \frac{dL}{dC_1}$$

This combination is equivalent to their result of an optimal second-best emissions (commodity) tax being lower than the Pigouvian level by the tax interaction effect. Similarly, in this case, in which technical abatement opportunities are available, if a rebate is not a policy option, we would have $\tau_1 = \frac{D'}{\lambda} - t_L \frac{dL}{dE_1}$. When a rebate is an option, though, it is a more effective means of addressing the tax interaction effects than distorting the marginal abatement incentives. Since the labor supply disincentive derives from the product price increase, a price rebate addresses the tax interaction problem directly.

Another issue for output-based rebating is the accuracy of 100 percent rebating, which is the case of distributing all the permits gratis according to output. The optimal rebate rate is one if the subsidy expenditures equal the emissions tax revenues:

$$C_1\left(\left(\frac{D'}{\lambda}\right)m_2\frac{-dC_2}{dC_1} + t_L\frac{dL}{dC_1}\right) = \left(\frac{D'}{\lambda}\right)E_1$$

that is, if

$$\underbrace{m_2\frac{-dC_2}{dC_1}\frac{D'}{\lambda}}_{\text{leakage costs}} = \left(\underbrace{m_1\frac{D'}{\lambda}}_{\substack{\text{emissions}\\ \text{damages}}} - t_L\underbrace{\frac{dL}{dC_1}}_{\substack{\text{labor tax}\\ \text{distortion}}}\right)$$

In the absence of a labor tax, this holds if the emissions tradeoff (leakage factor) is one-to-one, such as for two perfect substitutes with identical emissions rates. With preexisting labor taxes, this leakage factor must be higher than one to justify 100 percent rebating because of the opportunity cost of public revenues. How much higher than one depends on the relative size of the labor tax distortion to the marginal emissions damages.

More generally, with two dirty goods, it is interesting to see how additional policy constraints affect the second-best (or *n*th-best) taxes. One constraint could be on the earmarking of the allocation. If the resulting rebate is too low (high), then Equation (2) reveals that the optimal emissions price will be lower (higher) than if the leakage and tax distortions were exactly internalized.

Meanwhile, if the emissions price is too low and is restricted from fully internalizing the marginal damages, Equation (1) shows that the optimal rebate is lower, reflecting the need for taxing the emissions embodied in additional output that did not get taxed directly.

To understand the relative magnitude of these kinds of policy constraints on welfare and other measures of the burdens of regulation, we next turn to a simulation model.

Numerical Model

Model Description

We employ a modified version of the model used in Fischer and Fox (2007), in which greater descriptive detail can be found. This computable general equilibrium (CGE) model from the Global Trade Analysis Project (GTAP) offers a richness in calculating trade impacts and allows us to evaluate the distributional and efficiency effects of emissions permit allocation mechanisms, spanning a more diverse and disaggregated set of energy-using sectors than in most climate models. Although it does not allow for dynamic responses or for technological change, it does allow for capital reallocation.[3] Our results should therefore be considered illustrative of short- to medium-term effects (say, three to five years, a relatively short perspective for climate policy).

The model and simulations in this paper are based on Version 5.4 of the GTAPinGAMS package developed by Thomas Rutherford and documented for Version 4 of the dataset and model in Rutherford and Paltsev (2000). The GTAP-EG dataset used is a GAMS dataset merging the GTAP economic data with information on energy flows. We adapt the framework to employ the Version 6.0 Release Candidate, which updates the analysis to 2001, the base year of the more recent GTAP database.[4]

The model is a multisector, multiregion general equilibrium model of the world economy as of 2001. Energy requirements and their corresponding carbon emissions are incorporated into this framework. The production function incorporates most intermediate inputs in fixed proportion, although energy inputs are built into a separate energy nest. For the chemicals sector, which includes petrochemicals, we divided its energy use into feedstock requirements, which are treated as intermediate inputs, and the remainder, which is treated as energy, using the feedstock use ratios for oil and gas in Lee (2002). Energy production is a constant elasticity of substitution (CES) function nested to three levels. At the lowest level, oil and gas are relatively substitutable for one another (elasticity = 2) within the "liquid" nest, but liquid energy is less substitutable against coal in the "nonelectric" nest. Lastly, "nonelectric" has low substitutability (0.1) against

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[3] In the default, capital reallocation occurs within, not across, regions. Paltsev (2001) conducts sensitivity analysis with respect to this assumption and finds that the carbon leakage rate does not change significantly with greater international capital mobility.

[4] A more complete discussion of the energy data used can be found in Complainville and van der Mensbrugghe (1998).

electricity in the “energy” nest. “Energy” itself has low substitutability (0.5) for the labor-capital composite from the “value-added” nest. Within the “value-added” nest, labor, private capital and public capital have unitary elasticity. Foreign and domestic varieties are substitutable for one another through a standard Armington structure, with the elasticity of substitution between the domestic variety and foreign composite set to half the elasticity of substitution among foreign varieties. The latter elasticities are largely derived from econometrically based estimates, as in Hertel et al. (2004).

Consumption is a composite of goods, services, and in our modification, leisure. The energy goods oil, gas, and coal enter into final demand in fixed proportions in the energy nest, and are unitary elastic with electricity. This composite is then substitutable at 0.5 with other final demand goods and services. Goods and services (including energy) are then substitutable against leisure; the derivation is given in Fischer and Fox (2007) and Fox (2002).

Government demand is represented by a similar demand structure and private consumption, with the exception of the labor-leisure component. Government demand is held fixed through all the experiments, although the funding mechanism (adjustment of a lump-sum tax or the tax on labor) varies as noted below.

Three features added to the GTAP-EG structure allow us to model the impact of the policy scenarios. First, we add a carbon price that is applied to the covered sectors. Second, the appropriate structure for simulating a production rebate must be incorporated into the model. Third, the household is given a labor-leisure choice so that labor taxes are distorting, allowing us to conduct simulations recycling revenue from pollution permits to offset the distorting tax instrument. Since we have no data on labor taxes within the GTAP-EG database, we assume a labor tax rate of 40 percent within Annex B (developing) countries and a 20 percent tax rate within all other countries and the Rest of World.

To incorporate the carbon emissions payment requirement, we introduce a carbon permit as a Leontief technology in an additional composite fossil fuel nest to production in the covered sectors. The composite of permit and energy input is then included in the production block for the output good. In this manner, one permit is demanded for each unit of carbon that enters into production, and we can track pollution permits through the model. Finally, we incorporate a rebate in the form of a (negative) endogenous tax into the sector’s production function.

Policy Scenarios

We consider a scenario in which the United States adopts a carbon tax at $50 per ton C (roughly $14 per ton CO_2, which is well in the range of many proposed prices). In principle, an emissions price can be implemented by either a tax or a cap-and-trade program; however, in the latter program, different levels of coverage or amounts of rebates will affect the equilibrium allowance price. Many of those price changes can be mitigated by several of the proposed cost containment mechanisms, like a safety valve (price ceiling), international linking, or banking and borrowing. For our purposes, fixing the price allows us to value all emissions consistently across scenarios as we search for the optimal rebate. (In related work, Fischer and Fox 2009 look at the effects on efficiency and leakage of different allowance allocation options, depending on different degrees of program coverage.)

We observe that sector coverage ranges widely across programs and proposals. Among the major climate-change bills put forth in the 110th Congress, coverage of proposed emissions trading systems has ranged from the electricity sector alone (Feinstein-Carper[5]) to major sources or sectors (Lieberman-McCain[6] and Kerry-Snowe[7]) to sectors chosen at the discretion of the Environmental Protection Agency (Sanders-Boxer[8]) to a comprehensive upstream program (Bingaman-Specter[9]). Among the carbon tax bills, however, coverage has been fully upstream.[10] The European ETS covers only major sources and sectors.

We consider a central scenario in which the carbon tax is applied downstream to the six major energy-intensive sectors: electricity, petroleum and coal products (refined), iron and steel, chemicals, nonmetallic minerals (which include cement, glass, and ceramics), and paper, pulp, and print. This scenario follows the middle-of-the-range proposals that target major point-source emitters. Given our model, we must assume that the covered sectors are covered in their entirety, which tends to overstate somewhat the magnitude of covered pollution. These sectors represent 55 percent of U.S. CO_2 emissions, according to our data. In a second scenario, we include transportation fuels, which increases coverage to 75 percent.

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[5] S. 317: Electric Utility Cap and Trade Act of 2007 and S. 1177: Clean Air Planning Act of 2007.

[6] S. 280: Climate Stewardship and Innovation Act of 2007.

[7] S. 485: Global Warming Reduction Act of 2007.

[8] S. 309: Global Warming Pollution Reduction Act

[9] S.1766: Low Carbon Economy Act of 2007.

[10] H.R. 2069: Save Our Climate Act of 2007, and H.R. 3416: America's Energy Security Trust Fund Act of 2007.

Results

Solving for Optimal Rebates

Following the theoretical model, our goal is to solve for the optimal rebates to accompany the carbon tax; that is, for the covered sectors, we want to find the set of rebates that maximize global welfare, including the value of emissions reductions. In this complex CGE model, however, there are many preexisting distortions besides just the emissions externality, incomplete coverage, and labor taxes. In fact, in the global context of tariffs, terms of trade effects, wealth redistribution incentives, and so on, the optimal policy seems to involve imposing additional taxes on U.S. production. We therefore first solve for these global welfare-maximizing taxes on U.S. energy-intensive sectors in the absence of any climate policy, and then see how they change when the carbon tax is imposed. These changes are our measure of the optimal rebates associated with the carbon tax, and they reflect the interaction between the carbon tax and the leakage and tax distortions.

Table 1 reports the magnitude of these optimal rebates as a percentage of the value of the emissions in each sector after the carbon tax. It reveals that full rebating for electricity and refined petroleum products is not desired. Optimal rebates for electricity are roughly one-third of emissions payments—somewhat less when transportation is excluded and somewhat more when it is included. The coverage of transportation has an important influence of the desirability of rebating for refining: when transportation is excluded, one wants to tax refined petroleum products in addition to levying the carbon tax on the refining process, to encourage conservation among those uncovered sectors. When transportation is included, however, a small (28 percent) rebate is optimal, and the transportation sector also gets a 60 percent rebate. For energy-intensive manufacturing, on the other hand, regardless of the carbon tax coverage of transportation, optimal rebates are well over 100 percent; in fact they all exceed 200 percent, and for the iron and steel sector, 500 percent.

Table 1. Optimal Rebate as a Percentage of Emissions Payments

Sector	*Without transportation*	*With transportation*
Electricity	31	36
Refined petroleum	–67	28
Chemicals	221	210
Nonmetallic minerals	249	261
Pup, paper, and print	217	239
Iron and steel	519	556
Transportation	—	60

Those high rates reflect in part the fact that in the model, foreign producers are on average more carbon intensive than U.S. producers in these sector aggregates, emitting more than twice as much for nonmetallic minerals and almost three times as much for iron and steel. However, these rebates represent the (second-best) internalization of not only carbon leakage to unregulated sectors—both foreign and domestic—but also interactions between the carbon tax and all the other preexisting distortions throughout the system.

We find similar results when the objective function is restricted to U.S. welfare (equivalent variation plus the value of global emissions changes). The U.S. focus includes interactions with the terms of trade, which were counterbalanced by foreign changes when maximizing global welfare was the objective. Because of these effects, the optimal taxes in the absence of a carbon tax are much lower and are negative for most energy-intensive manufacturing, as one might expect; however, they respond similarly to the imposition of a carbon tax. When transportation is not covered, optimal rebates for energy-intensive manufacturing are all roughly 200 percent, except for steel, which is a bit over 300 percent. The rebates for electricity and refined oil products are 36 percent and –47 percent, respectively.

Applying Optimal Rebates

Although the numerical results validate the theory, some caution should be taken in applying them in practice—that is, in a world with other preexisting distortions. As we noted, in the model, global welfare improves when additional production taxes are imposed on covered U.S. sectors, whether or not a carbon tax is in place. Therefore, when starting from a baseline without these taxes, offering rebates reduces global welfare. However, it does increase U.S. welfare. Furthermore, it is interesting to observe the general equilibrium effects of the rebate policy on the pattern of compliance and leakage.

Table 2 compares the macroeconomic results from the carbon tax alone (with revenue recycling) with the carbon tax plus the above rebates, in the scenario excluding transportation. The rebates nearly eliminate the welfare cost for the United States, with very slight declines in production, employment, and the real wage but gains in leisure. Although the rebates do mitigate carbon leakage somewhat, domestic emissions also expand; if one values those global emissions changes at the $50 per-ton C tax rate, the U.S. welfare gain is fully offset by these losses.

Table 2. Percentage Change in Summary Indicators

Indicator for United States	*Carbon tax alone*	*With rebates*
Welfare (equivalent variation)	–0.760	–0.025
Production	–0.23	–0.22
Employment	0.07	0.04
Real wage	0.26	0.14
Total domestic emissions	–10.0	–9.7

Table 3 compares the effects of the two scenarios on different measures of leakage. It reveals that by conventional measures of leakage—that is, the change in foreign emissions as a share of domestic reductions—the rebates have little effect, either overall or for the covered sectors as a whole. The reason is that while foreign emissions expand less with the rebates—2 percent less overall and 39 percent among covered sectors—domestic sectors also reduce less. However, the rebates do change the distribution of leakage among the covered sectors. The energy-intensive manufacturing sectors exhibit the highest rates of leakage, in large part because 78 percent of the lost production in the United States due to the carbon tax is made up by production increases abroad. With the rebates, that shift in production drops dramatically, leakage rates drop by more than a third, and the expansion of foreign emissions drop by half, relative to the carbon tax alone.

Table 3. Emissions Leakage Measures

Indicator for United States	*Carbon tax alone*	*With rebates*
Foreign leakage relative to total domestic reductions	14.2%	14.2%
Foreign covered sector leakage	12.8%	13.0%
Foreign energy-intensive manufacturing leakage	27.4%	17.1%
Foreign and domestic leakage relative to covered sector	9.4%	4.9%

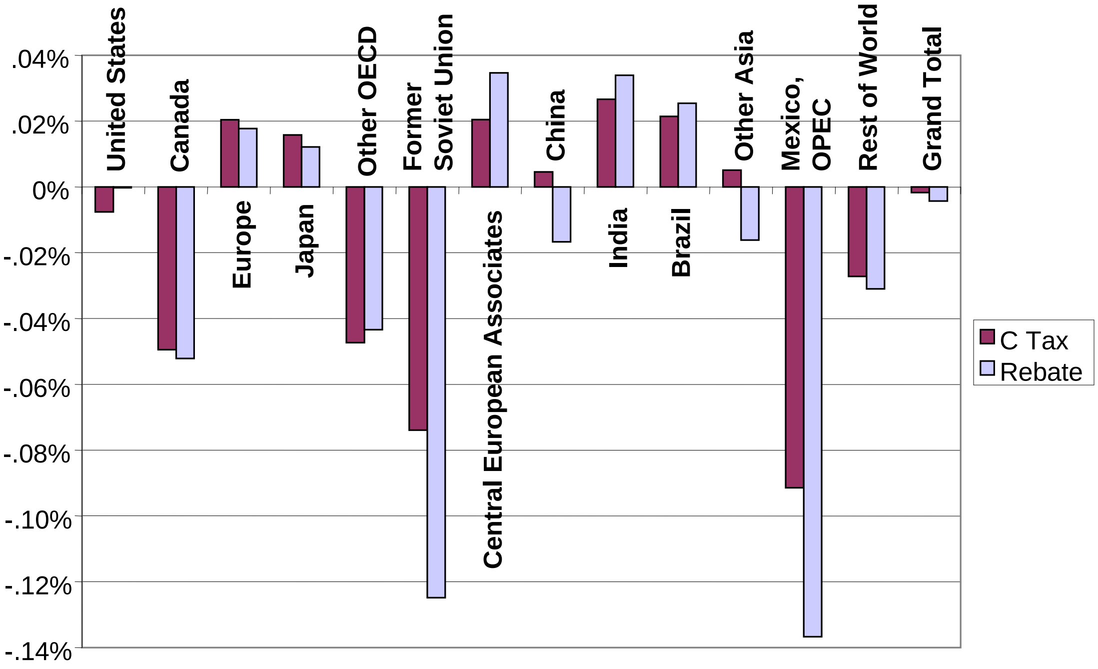
Meanwhile, domestic leakage of emissions to uncovered sectors is substantially reduced. To be more precise, *domestic leakage* may be somewhat misleading; domestic uncovered sectors actually reduce their emissions along with the covered sectors under the carbon tax, but by far less than if they were themselves covered, and the rebates help capture some of those additional reductions.

Thus, the rebates have many of the effects one would expect. The (generous) subsidies to energy-intensive manufacturing nearly eliminate the deterioration in net exports and reduce the foreign leakage rates for those sectors. The tax on refined oil products induces additional reductions from the uncovered domestic sectors, although it exacerbates foreign leakage by encouraging more imports of refined products and also by driving down global oil prices, which expands consumption abroad. The partial rebate to electricity helps downstream sectors, particularly electricity-intensive manufacturing, but the increase in emissions more than offsets the decrease in the uncovered sectors. On the other hand, it also helps reduce foreign leakage, in part through downstream demand changes and in part by mitigating the fall in global prices for natural gas and coal.

Overall, the net result is no significant change in global emissions, relative to the carbon tax alone. However, the redistribution of the emissions reductions to uncovered domestic and foreign sectors lowers the cost of the climate policy to the United States. Of course, those other sectors bear the cost of the redistribution, which is not globally efficient in this second-best world; the loss in welfare to other countries is roughly double the welfare gain to the United States.

Figure 1 illustrates the international distribution of the effects of climate policy in the United States. The rebates (and more pointedly the tax on refined oil products) tend to exacerbate the losses by crude oil–producing countries. Asian countries see their gains from the U.S. carbon tax erode to losses with the rebates to energy-intensive manufacturing. However, several trade partners, including India, Brazil, and Eastern Europe, do benefit from the rebates.

Figure 1. Percentage Change in Welfare (Equivalent Variation) by Region



Conclusion

As national and subnational climate policies evolve, concerns naturally arise about the potential for adverse effects on energy-intensive, trade-sensitive industries, and for the erosion of the environmental benefits if an increase in domestic production costs causes more production activities to shift to nations or regions with weaker climate mitigation policies. We find some support for these concerns, but we also note that equal—or even greater—attention should be paid to the activities of domestic sectors left uncovered by the climate policy.

The revenues from emissions pricing policies are valuable, since they can offset the taxation of productive factors like labor and improve the efficiency of the economy as a whole. Therefore, it is important to understand under what circumstances those valuable revenues should be partly used to mitigate some of the effects of carbon regulation on covered sectors. By mitigating price increases of covered sector products, rebates reduce both the interaction with preexisting taxes and the loss of competitiveness that can lead to leakage. Thus, the optimal rebate is higher for goods that are stronger substitutes for higher-emitting unregulated goods and that are stronger complements with employment.

The numerical results illustrate these points. Rebates are higher for the trade-sensitive, energy-intensive manufacturing sectors, such as iron and steel. Refined oil products are highly complementary with emissions of uncovered sectors, so they should be taxed in addition to the carbon tax when the transportation sector is not covered. Electricity generation is the largest emitter and has important countervailing effects. On the one hand, it is complementary with downstream emitting sectors, but that includes already-covered sectors and many sectors that are trade sensitive and subject to foreign leakage. Thus, a modest rebate can help redistribute emissions reductions among these sectors in a more cost-effective way—at least for the implementing country—but at a cost of forgoing significant reductions.

Of course, even if they could calculate “optimal” rebates, countries are not likely to be able to implement rebates that exceed the value of actual emissions liabilities, which can run afoul of trade rules regarding subsidies. Furthermore, from a global perspective, incomplete coverage and labor taxation are not the only market failures. Further research could employ a wider variety of climate models to investigate these issues of policy interactions and better understand the sensitivity of leakage and rebate effectiveness to numerical model structure and parameters. Additional scenarios also merit investigation, including the response of cap-and-trade programs (where the price is endogenous), the role of expanded coverage of carbon pricing among trading partners, and the effects of all these strategies on the least developed countries.

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