DISCUSSION PAPER

December 2003 ■ RFF DP 03-46

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RESOURCES FOR THE FUTURE

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Abstract

This paper provides simple formulas for adjusting the costs of carbon taxes and tradable carbon permits to account for interactions with preexisting tax distortions in the labor market. Both policies reduce labor supply as they increase product prices and reduce real household wages; the resulting efficiency losses in the labor market can be substantial relative to partial equilibrium abatement costs. However, much of this added cost can be offset—and perhaps more than offset when additional distortions from the tax system are considered—if revenues from carbon taxes or auctioned permits are used to reduce distortionary taxes. Consequently, there can be a strong case on efficiency grounds for using carbon taxes or auctioned permits over grandfathered carbon permits.

Key Words: carbon taxes, carbon permits; fiscal interactions; revenue recycling.

JEL Classification Numbers: Q28; H21; H23

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1. Introduction

Economists have long recognized that the welfare effects of environmental and other regulatory policies depend on how they interact with distortions in other markets of the economy (e.g., Lipsey and Lancaster 1956; Harberger 1974). One market that is particularly large (around three quarters of gross domestic product, GDP), and badly distorted at the margin, is the labor market, where income, payroll, and other taxes combine to drive a large wedge between the gross wage paid by firms and the net wage received by households. Yet prior to the 1990s, there had been very little analysis of how interactions with the labor market might change the welfare effect of environmental policies, and regulatory policies more generally.

In the early 1990s, economists grappling with ways to combat the emerging possibility of global warming began to emphasize that large welfare gains could be realized from using the revenues from carbon taxes to reduce taxes that distort factor markets (e.g., Pearce 1991; Repetto et al. 1992; Nordhaus 1993; Oates 1993). It was suggested that carbon taxes could yield a "double dividend" by reducing emissions and the costs of preexisting tax distortions at the same time. The idea that "revenue recycling" might keep the overall economic costs of carbon taxes small, or even negative, was particularly appealing as it suggested that the policy would be worthwhile, despite considerable controversy over the benefits from slowing atmospheric accumulation of greenhouse gases.

However, a second wave of papers pointed out another important linkage between emissions taxes and the broader tax system, working in the opposite direction to the revenue-recycling effect (e.g., Bovenberg and de Mooij 1994; Bovenberg and Goulder 1996; Parry 1995;

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Oates 1995). By increasing energy prices, carbon taxes drive up product prices throughout the economy, since energy is an input in most production sectors; this leads to a slight reduction in real household wages and labor supply. In general, the efficiency loss from this reduction in labor supply, or "tax-interaction effect," exceeds the benefits from the revenue-recycling effect, implying that carbon tax swaps increase rather than decrease the costs of labor taxes. This finding is not surprising because, as explained below, it is entirely consistent with the familiar result in public finance that the efficiency costs of narrow taxes (ignoring externalities) tend to exceed those of broad taxes on labor income.

More striking are the implications for other emissions control instruments (e.g., Goulder et al. 1997, 1999; Parry et al. 1999; Fullerton and Metcalf 2001). When carbon emissions are reduced by a system of tradable permits, and the permits are grandfathered (i.e., given out to existing firms for free), the government forgoes the potential efficiency gains from the revenue-recycling effect. Yet the policy still causes the costly tax-interaction effect because it increases energy prices by the same amount as an equivalent carbon tax. Consequently, there is a potentially strong case on efficiency grounds for preferring emissions taxes (or auctioned emissions permits) to grandfathered permits, so long as they are revenue neutral. This case is even stronger when we allow for additional deadweight losses from the U.S. tax system arising because certain types of spending (e.g., homeowner mortgage interest, employer-provided medical insurance) are tax-exempt or deductible while other spending is not (see below).

These findings raise concerns about the momentum for tradable permit approaches in countries that remain pledged to achieving emissions targets embodied in the 1997 Kyoto Protocol, and in the United States, which pioneered the tradable permit approach.[1] Policymakers should be open-minded about the possibility of abandoning this approach in favor of internationally harmonized carbon taxes. To be sure, there are many other factors, besides fiscal issues, that are relevant to the choice among policy approaches, though as we discuss later, many of them seem to favor a tax-based rather than a quantity-based approach.

One caveat is that we focus mainly on an analysis that is applicable to the United States, which has a competitive labor market. Fiscal interactions are more subtle in countries where the

[1] The Kyoto Protocol does not actually specify how individual countries should allocate their emissions allowances. The European scheme, still being worked out, is likely to combine grandfathering and an auction element.

labor market contains significant institutional distortions that lead to "sticky" real wages and involuntary unemployment (e.g., Bovenberg and van der Ploeg 1994a; Schöb 2003, Section 3). The next section explains how fiscal interactions affect the costs of carbon policies in a transparent, though highly simplified, framework. Section 3 discusses complicating factors, including income tax deductions, preexisting energy taxes, and taxes on capital. Section 4 comments on broader issues that are relevant to the choice between taxes and permits. Section 5 concludes and discusses caveats to the analysis.

2. Basic Theoretical Framework

This section presents a heuristic analysis, simplified as follows: labor is the only primary factor; the preexisting tax system distorts only the labor market; and all markets are competitive with constant returns production. We provide formulas for adjusting, approximately, the costs of carbon policies to account for fiscal interactions (for derivations, see Goulder et al. 1999; Parry 1995, 2002; Parry et al. 1999).

2.1 Traditional Analysis

Consider the top panel in Figure 1, which represents the economy-wide market for fossil fuels, denoted X. D^X is the demand curve, and S^X is the supply curve drawn as perfectly elastic because of constant returns. In the absence of policy intervention the competitive output level is X_0, where the marginal value of fossil fuels in production (the height of D^X) equals the per unit cost of producing fossil fuels (the height of S^X).

For expositional purposes, we assume that carbon emissions are proportional to aggregate fossil fuel use; initial emissions are $E_0 = eX_0$ where e is an exogenous emissions factor.[2] Suppose a tax of τ per unit of emissions is introduced, equivalent to τe per unit of fossil fuels. Output falls to X_1 in Figure 1 as firms and households adopt energy-saving technologies,

[2] Emissions factors differ across individual fuels, so the substitution of gas for coal in, for example, power generation reduces emissions. Models that allow for emissions reduction through fuel substitution and also end-of-pipe abatement technologies (which are currently not applicable to carbon) produce analogous formulas to those below.

motorists drive less and demand more fuel-efficient vehicles, and so forth. The resulting efficiency cost, which we call the *primary cost*, is shown by the shaded triangle, equal to forgone benefits from fossil fuel production net of reduced production costs. The primary cost is also represented by the shaded triangle in the lower panel of Figure 1; here MAC denotes the marginal abatement cost curve for reducing emissions, where the height of MAC equals the difference between D^X and S^X in the top panel, divided by e. Assuming D^X is linear over the relevant range, the primary cost (PC) is

$$(1)\, PC = \frac{\tau}{2}(E_0 - E_1)$$

Suppose, for example, that reducing annual U.S. carbon emissions by 10% below current levels, which are roughly 1,500 million tons, requires a carbon tax of $20 per ton (see Weyant and Hill 1999 and Council of Economic Advisors 1998 for a discussion of estimates); in this case, from (1) the primary cost would be $1.5 billion.

Prior to the 1990s, economists focused only on primary costs when assessing the costs of emissions control policies. However, in the early 1990s they began to emphasize the large revenue potential from carbon taxes; in our example, revenues would be τE_1 = $27 billion (= 20 × .9 × 1500 million). What happens if these revenues are used to cut labor income taxes?

2.2 Labor Market

Figure 2 shows the labor market for the whole economy, which constitutes around three-quarters of GDP. D^L is the aggregate demand for labor by firms where the height of this curve is the value marginal product of labor; the curve is perfectly elastic because of constant returns (this may be a reasonable long run approximation—see Hamermesh 1986, 467).

S^L is the aggregate supply of labor from households; it is upward sloping because higher wages encourage secondary workers to join the labor force, older workers to postpone retirement, existing workers to take a second job or increase overtime, and so forth. The height of S^L is the marginal opportunity cost of forgone nonmarket time: someone well to the left of L_0 in Figure 2 has a low opportunity cost to working (e.g., a single person who would be bored at home) whereas someone to the right of L^* has a high opportunity cost (e.g., the partner of a working spouse who would rather stay home with the children).

The socially optimal level of employment is L^*, where the marginal social benefit and marginal social cost of labor would be equated. However, various taxes, including federal and state income taxes and payroll taxes, combine to create a tax wedge of around 35–40% for the average U.S. worker[3]; denoting this tax by t, equilibrium employment is at L_0, with a wedge of t between the gross wage (normalized to one) and net wage. There is a deadweight loss indicated by the shaded triangle, because employment $L^* - L_0$ is forgone, for which the marginal social benefit would have exceeded the marginal social cost. The difference between L_0 and L^* may not be large in practice—indeed, empirical evidence suggests that labor supply is only moderately sensitive to taxes—but small changes in labor supply can still lead to significant welfare effects, given the large size of the labor market and the large wedge between the gross and net wage.

A number of studies have estimated the *marginal excess burden* of labor taxation (e.g., Ballard et al. 1985; Browning 1987; Snow and Warren 1996; Stuart 1984); this is the efficiency cost from the increase in labor tax required to raise an extra dollar of revenue. Leaving some complications aside (e.g., tax deductions, heterogeneous agents, nonproportional tax increases), a simple formula for the marginal excess burden of labor taxation (denoted M) when the dollar is recycled in transfers to households is (e.g., Snow and Warren 1996; Mayshar 1991)

$$(2)\, M = \frac{\frac{t}{1-t}\varepsilon^c}{1 - \frac{t}{1-t}\varepsilon^u}$$

where ε^u and ε^c denote the uncompensated and compensated labor supply elasticities, respectively.[4] For illustration, we assume $\varepsilon^u = 0.2$ and $\varepsilon^c = 0.35$ based on an average across U.S. studies and professional opinion (see Blundell and MaCurdy 1991, Tables 1 and 2; and Fuchs et al. 1998); using $t = 0.38$ implies M is approximately 0.25. However, there is considerable uncertainty over labor supply elasticities—a plausible range for M might be around 0.1 to 0.5 (Browning 1987)—though the implications of different assumptions can easily be seen in the formulas below.[5]

[3] Most of the labor supply elasticity for the United States is driven by participation decisions, particularly of married females, rather than changes in hours of existing workers. Therefore, the relevant tax wedge reflects a combination of average and marginal rates (e.g., Kleven and Kreiner 2003).

[4] The formula depends on both compensated and uncompensated elasticities because households are only partially compensated for the tax increase; the reduction in their wages is Ldt, but the government receives $Ldt + tdL/dt < Ldt$ in transfers.

[5] Marginal excess burden estimates for other countries tend to be larger because of higher labor tax rates (e.g., Kleven and Kreiner 2003).

2.3 Revenue-Recycling Effect

This is the efficiency gain from recycling carbon tax revenues in other tax reductions (relative to returning them lump-sum). It equals the revenue recycled multiplied by the marginal excess burden:

(3) $RR = M\tau E_1$

The revenue-recycling effect (*RR*) is shown by the shaded rectangle in the lower panel of Figure 1. In our numerical example it equals \$6.75 billion (= 0.25 × \$27 billion), or 4.5 times the primary cost. More generally, using (1) and (3), the revenue-recycling effect relative to the primary cost is $2M(1-z)/z$ where $z=(E_0-E_1)/E_0$ is the proportionate emissions reduction. Thus, the relative importance of the revenue-recycling effect diminishes with the level of abatement: it is 117% and 33% of primary costs at emissions reductions of 30% and 60%, respectively. This is easily seen from the lower panel in Figure 1 by comparing the shaded triangle and rectangle at small and large amounts of abatement.

Based on the reasoning so far, a number of people suggested there might be a "double dividend" from carbon and other environmental taxes, due to the reduction in emissions and in the costs of preexisting taxes; indeed, it was argued that the overall costs of environmental taxes could be negative (e.g., Terkla 1984; Lee and Misiolek 1986; Pearce 1991; Repetto et al. 1992; Nordhaus 1993; Oates 1993).

2.4 The Tax-Interaction Effect

A second wave of papers revealed another linkage with the labor market that undermines the double-dividend argument (e.g., Bovenberg and de Mooij 1994; Bovenberg and van der Ploeg 1994b; Bovenberg and Goulder 2002; Parry 1995, 1997). A carbon tax increases the price of electricity, gasoline, and other energy goods; in turn, this drives up the prices of products in general, since they require energy inputs in production. The general increase in the price level reduces real household wages, which should slightly reduce employment given econometric evidence that lower real household wages lead to lower labor force participation and work effort. This leads to an efficiency loss of $t\Delta L$, where ΔL is the (small) reduction in labor supply (this is the addition to the deadweight loss triangle in Figure 2 from a slight shift in of the labor supply curve). And labor tax revenues fall by $t\Delta L$; to maintain revenues, labor taxes must be increased slightly, resulting in an efficiency cost of $Mt\Delta L$. The combined loss from these two effects, $(1+M)t\Delta L$, is referred to as the *tax-interaction effect*.

Assuming linearity and (for the moment) that final output produced with fossil fuels is an average substitute for leisure, the tax-interaction effect (*TI*) can be expressed (e.g., Parry 2002) as follows:

$$(4)\, TI = M\tau\left\{E_0 - \frac{(E_0 - E_1)}{2}\right\}$$

Comparing (3) and (4), the tax-interaction effect exceeds the revenue-recycling effect for all levels of emissions reduction; that is, the net effect of the carbon tax is to increase rather than decrease the efficiency costs of preexisting labor taxes, and there is no double dividend.[6] Suppose this was not the case. Then, at least for small amounts of abatement, the overall costs of the carbon tax swap would be negative, implying that even with no environmental benefits, it is always optimal to raise at least some revenues from carbon taxes.[7] But this contradicts an extensive literature on optimal tax theory (e.g., Diamond and Mirrlees 1971; Atkinson and Stiglitz 1980; Sandmo 1975; Ng 1980), which implies that, leaving aside certain special cases, narrow taxes on sector-specific inputs or outputs involve higher efficiency costs per dollar of revenue than economy-wide labor taxes. The above analysis could be consistent with this literature only if the tax-interaction effect exceeds the revenue-recycling effect.

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[6] Several versions of the double-dividend hypothesis have appeared in the literature (e.g., Goulder 1995). The weak form of the hypothesis asserts that using revenues to cut distortionary taxes rather than returning them in lump-sum transfers increases efficiency; an intermediate form asserts that the tax-interaction effect exceeds the revenue-recycling effect; a strong form asserts that the revenue-recycling effect offsets both the primary cost and the tax-interaction effect, so the cost of the environmental tax is negative. The above results reject the latter two definitions but not the weak double dividend, which is clearly valid so long as the reduced tax has a positive marginal excess burden.

The intuition for the failure of the strong double dividend is straightforward. In the absence of nonlabor income, a shift from a labor tax to a uniform tax on all consumption goods has no effect on the household's real wage and labor supply (assuming no money illusion). A further tax shift onto energy goods leaves this basic result unchanged but adds an additional intercommodity distortion. For further discussion of the double dividend, see, for example, Goulder (1995), Bovenberg and Goulder (2002), Schöb (2003), and Smith (1998).

[7] This is because the primary cost is a second-order effect (a triangle) and converges to zero for an arbitrarily small amount of abatement; the welfare change in the labor market is first-order (a rectangle).

More generally it can be shown that the tax-interaction effect is smaller (larger) if consumption goods produced by polluting industries are relatively weak (strong) substitutes for leisure (e.g., Bovenberg and Goulder 2002; Parry 1995). There is a lack of solid empirical evidence on this issue. However, given that energy is used pervasively in production sectors throughout the economy, a logical starting assumption is that aggregate output affected by a carbon tax is an average substitute for leisure.

From (1), (3), and (4), the ratio of the total cost of the emissions tax with fiscal interactions to the primary cost is

$$(5)\ \frac{PC - RR + TI}{PC} = 1 + M$$

With $M = 0.25$, fiscal interactions raise the costs of carbon taxes by 25% relative to primary costs.[8]

2.5 Tradable Permits

Now suppose that fuel producers must have a permit for each ton of carbon content in their fuels, and that the government restricts the availability of permits so that emissions are reduced by $E_0 - E_1$ in Figure 1. Assuming competition, perfect certainty, and tradability of permits across firms, the equilibrium permit price will be τ. The primary abatement costs are the same as under the equivalent emissions tax. The tax-interaction effect is also the same because the policy has the same impact on driving up energy and final goods prices, and reducing the real household wage. This can be seen from the top panel in Figure 1, where the price of fossil fuels at X_1 is the same regardless of whether fuels are reduced by a tax or the equivalent binding quota.

The crucial difference is that if permits are given out free to firms, as they were in the case of the U.S. sulfur-trading program, firms receive the policy rents rather than the government; that is, they receive a valuable asset (permits with a market price). A portion of the

[8] Some, though not all, studies show a negligible effect of environmental regulations on employment at the industry level (e.g., Berman and Bui 2001), and this has sometimes been interpreted to mean that we do not need to worry about the employment effects of carbon and other environmental policies. However, these findings do not tell us anything about the tax-interaction and revenue-recycling effects, which apply so long as *economy-wide labor supply* is responsive to changes in real net wages. And changes in economy-wide employment need not be large to generate welfare effects that can be substantial relative to primary costs, given the huge size of the labor market and that it is badly distorted at the margin.

rents may indirectly go to the government—rents are reflected in higher firm profits that are taxed at the corporate level and again at the personal level when they are paid out in dividends or lead to capital gains. Denoting the rate of profits/rent taxation by θ, and assuming that government revenues are used to cut labor taxes, freely allocated permits will produce an indirect revenue-recycling effect of

$$(6)\ RR^p = \theta M \tau E_1$$

Following other studies (e.g., Goulder et al. 1997) we adopt a value for θ of 0.4 for grandfathered permits; for auctioned permits, $\theta = 1$.

Using (1), (4), and (5), the total cost of grandfathered permits (with fiscal interactions) relative to the primary cost can be expressed as follows:

$$(7)\ \frac{PC - RR^p + TI}{PC} = 1 + \frac{M\{(1-.5z) - \theta(1-z)\}}{.5z}$$

Figure 3 plots the expressions in equations (5) and (7) for emissions reductions up to 40%. The main point here is that fiscal interactions raise the cost of grandfathered permits by a much greater amount than they raise the cost of revenue-neutral carbon taxes (or auctioned permits), since the net loss from the tax-interaction and (indirect) revenue-recycling effect is much greater under grandfathered permits. In our example, the total costs of grandfathered permits are $6 billion at an emissions reduction of 10%, or four times the primary costs.[9]

2.6 Welfare Effects

There is much dispute about attaching a dollar figure to the benefits from slowing atmospheric greenhouse gas accumulation. Controversies rage over appropriate discount rates, how to value nonmarket effects such as species extinction, the likelihood and extent of instabilities within the climate system, and how to account for the greater vulnerability of poor countries to climate change. The majority of studies put the benefits from reducing carbon at

[9] The costs ratios in (5) and (7) do not depend on the share of fossil fuels in GDP, or the slope of the marginal abatement cost function, since these factors affect the primary cost and revenue-recycling and tax-interaction effects all in the same proportion. This proportionality does not apply when linearity assumptions are relaxed; however, relatively simple numerical models that incorporate more general functional forms yield very similar relative costs to those in Figure 3 (e.g., Goulder et al. 1997, 1999; Parry et al. 1999).

around $25 per ton or less, though some estimates that incorporate low discount rates and distributional weights are more than $200 per ton.[10]

Take a "mainstream" estimate of $20 per ton, such that a $20 carbon tax, or permit-equivalent, would be optimal in the absence of fiscal interactions. Total benefits from reducing emissions by 150 million tons are therefore $3 billion. If we ignored fiscal interactions, we would compute a welfare gain (environmental benefits less primary costs) of $1.5 billion per annum (using (1)); with fiscal interactions the carbon tax still produces a welfare gain, $1.13 billion, but grandfathered permits produce a welfare loss of $6 billion. Grandfathered permits can easily be welfare improving under higher benefit scenarios (when benefits per ton exceed $40); but the point here is that accounting for fiscal interactions may substantially affect the magnitude, and possibly even the sign, of the welfare effect of grandfathered permits (Parry et al. 1999).

Fiscal interactions do not always have such striking implications for the costs and social welfare effects of environmental policies. As shown in Figure 3, the cost of grandfathered permits with fiscal interactions relative to primary cost declines with the extent of abatement; the tax-interaction effect (net of the indirect revenue-recycling effect) increases in rough proportion with the extent of abatement, while the primary cost increases in rough proportion to the square of the abatement level. The United States is currently debating the Bush administration's Clear Skies initiative, along with competing bills, that would reduce power plant emissions of sulfur dioxide, nitrogen oxide, and mercury by around 70% or more below no-abatement levels; the welfare gain from auctioning permits (relative to primary costs) would be less dramatic in these cases.

2.7 Alternative Assumptions for Revenue Recycling

Although a number of revenue-neutral environmental tax packages have recently been implemented in European countries (see Hoerner and Bosquest 2001, 3) there is no guarantee

[10] Most damage estimates are fairly moderate because the bulk of world GDP (manufacturing and services) is not especially sensitive to predicted changes in climate over the next century, and discounting greatly reduces the present value of long-range costs (e.g., Nordhaus 1994; Fankhauser 1995). However, the marginal damage from emissions is likely to rise in the future as economic growth increases the real value of GDP at potential risk. For example, optimal carbon taxes in the RICE model rise from around $10 per ton to $70 per ton over the next century (Nordhaus and Boyer 2000, Ch. 7). For reviews of the literature, see Tol et al. (2000) and Pearce (2003).

that new revenue sources would be used to lower other distortionary taxes, particularly if an environmental agency rather than the U.S. Treasury were responsible for the policy. If revenues were used for government deficit reduction, this would reduce future debt interest and repayment of principal, allowing future taxes to be reduced: there is still an efficiency gain, though it occurs in the future.

If revenues were used to expand public spending, the revenue-recycling effect is larger or smaller depending on whether the social benefits from increased spending exceed the social benefits forgone by not using the revenues to cut distortionary taxes. This would have to be assessed on a case-by-case basis; for example, it is often argued that environmental tax revenues should be used to subsidize the development of renewable energy sources. Nonetheless, probably the biggest worry about carbon taxes is that the revenues may not be used productively.[11]

2.8 Other Policies for Reducing Carbon

Despite ongoing pressure to implement a system of tradable carbon permits, the Bush administration has so far favored a more piecemeal approach that includes tax credits for energy-saving and alternative-fuel technologies (e.g., Lyon 2003). It is sometimes suggested that such subsidy policies might be quite costly because their financing implies higher taxes elsewhere in the economy. But again, the argument neglects the tax-interaction effect: if subsidies lower (marginal) production costs and product prices, they will have a stimulating effect on labor supply at the margin, though most likely the beneficial tax-interaction effect will not fully offset the efficiency costs of additional financing requirements (Parry 1998).[12]

Pollution regulation in the United States traditionally took the form of command-and-control (CAC) approaches, such as technology mandates and uniform standards for emissions per unit of output across firms. These policies raise product prices and induce a costly tax-

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[11] Moreover, even though revenues from energy taxes implemented in the United Kingdom and Germany in the late 1990s were initially tied to reductions in labor taxes, labor taxes were subsequently raised in both countries. And much of the recent, substantial expansion of public spending in the United Kingdom seems to have leaked into public sector pay rather than increased output, which may not be a good omen.

[12] Alternatively, firms might receive subsidies for reducing emissions. This policy is equivalent to a lump-sum subsidy to firms, plus a tax on emissions; in this case both the tax-interaction and revenue-financing effects cause efficiency losses (Parry 1998).

interaction effect while raising no revenues for recycling. However, the tax-interaction effect can be weaker under CAC policies than under emissions taxes and tradable permits (Goulder et al. 1999; Fullerton and Metcalf 2001). Under the market-based policies, prices rise because of (a) primary abatement costs and (b) the tax paid on remaining emissions, or the scarcity rents created by permits. The latter effect is absent under CAC policies but the former effect is larger, since CAC policies generally do not exploit the least-cost combination of options for emissions reductions within or across firms. Nonetheless, the increase in cost due to fiscal interactions can actually be greater under grandfathered permits than under CAC policies, particularly at modest levels of emissions abatement.

3. Complicating Factors

3.1 Tax Deductions

Motivated by recent studies in public finance, Parry and Bento (2000) extended the model outlined above to account for inter-commodity tax distortions. These distortions are important in the United States, where a significant sector of the economy is effectively subsidized through the tax system; for example, owner-occupied housing and employer-provided medical insurance receive large tax deductions or exemptions. In Parry and Bento (2000) the marginal excess burden of taxation—and hence the revenue-recycling effect—increases by around 60% when tax deductions are included; this is because the deadweight losses from income taxes are greater when they distort the choice between tax-favored and ordinary consumption, in addition to the labor market.

On the other hand, if emissions per unit of final output are the same for both the tax-favored and the non-tax-favored sectors (which seems a reasonable rough approximation), a carbon tax will not affect their relative prices and will have no effect on the tax-subsidy distortion. Consequently the tax-interaction effect from the change in labor supply is similar to before (although the loss of labor tax revenues involves a higher efficiency cost).

Figure 4, which is based on Parry and Bento, illustrates the total costs of carbon taxes and grandfathered permits relative to primary costs when the efficiency gain per dollar of recycled carbon tax revenue is 0.4 rather than 0.25. The larger revenue-recycling effect substantially lowers the cost of carbon taxes for modest levels of abatement; overall costs are negative for emissions reductions below 16% (i.e., the revenue-recycling effect exceeds primary costs plus the tax-interaction effect). And the cost differential between grandfathered permits and carbon taxes at modest abatement levels, which was already large, is even more striking; at a 10% emissions reduction, the carbon tax has a negative cost of $1.3 billion (or –88% of primary costs); grandfathered permits have costs of $5.2 billion (344% of primary costs).[13]

The possibility of a double dividend in this case is illustrative of a general theme: a double dividend is possible when (a) the preexisting tax system is inefficient along some nonenvironmental dimension and (b) the environmental tax shift serves to reduce this nonenvironmental inefficiency. Of course, directly reforming the tax system would be a far better response to preexisting inefficiencies than indirectly mitigating them through carbon or other environmental tax swaps. Nonetheless, there is considerable political opposition to direct tax reforms (i.e., removing tax subsidies for housing and medical insurance) in the United States.

3.2 Preexisting energy taxes

Gasoline taxes are another source of preexisting tax distortions, though there are offsetting externalities associated with automobile use. We provide a quick illustration of how induced changes in gasoline consumption might affect the social costs of a carbon tax.

In the United States, annual gasoline consumption is about 130 billion gallons. A carbon tax of $20 per ton would increase the retail price of gasoline by about 5 cents per gallon, or about 3%.[14] Assuming a gasoline demand elasticity of –0.6 (e.g., Dahl and Sterner 1991, Table 2), gasoline consumption would fall by about 2.5 billion gallons in response to the carbon tax. The welfare change from this fuel reduction (excluding carbon benefits) is

$$(8)\ (D - t_G)(-\Delta G) - Mt_G(-\Delta G)$$

D denotes the marginal external damage per gallon from gasoline consumption, and t_G is the gasoline tax per gallon. The first component in (8) is the reduction in gasoline $(-\Delta G)$ times

[13] These results should be viewed with caution. There is much dispute over the marginal excess burden in the presence of tax deductions (one estimate by Feldstein 1999 exceeds unity); housing and health care markets contain a variety of nontax distortions (regulations, externalities, and information asymmetries) that have been excluded from marginal excess burden estimates; and tax deductions may have less relevance for other countries, such as the United Kingdom, where tax relief for private medical insurance and homeownership have been phased out.

[14] One gallon of gasoline contains 0.0024 ton of carbon (National Research Council 2002, 85); gasoline prices have recently averaged about $1.50 per gallon (from www.eia.doe.gov).

the gap between the marginal external cost net of the gasoline tax. The second component is the welfare loss from the reduction in gasoline tax revenues, equal to the marginal excess burden times the revenue loss $(-t_G \Delta G)$. For the United States, Parry and Small (2002) put the external costs of local pollution, traffic congestion, and accidents at the equivalent of about $0.80 per gallon (though there is much dispute over the magnitude of these costs), and federal and state gasoline taxes amount to about $0.40 per gallon. Using these figures and $M = 0.25$, there is a welfare gain from (8) of $0.75 billion, or half the primary cost. This back-of-the-envelope calculation therefore suggests that preexisting gasoline taxes and externalities are important to consider in the context of carbon policies, though less so than preexisting labor tax distortions.

3.3 Capital Market Interactions

A number of studies in public finance have explored the efficiency costs of taxes on capital (i.e., dividend, capital gains, and capital income taxes) using dynamic models with endogenous capital accumulation (e.g., Chamley 1981; Judd 1987; Lucas 1990). In these models the marginal excess burden for capital taxes usually exceeds those for labor taxes, implying that capital is overtaxed from an efficiency perspective, though by how much is sensitive to different assumptions.

Bovenberg and Goulder (1997) use a dynamic model that incorporates a detailed treatment of the tax system and energy sector to explore how capital market interactions affect the costs of energy tax shifts. They show that the costs of energy taxes can either be higher or lower than those implied by models ignoring the capital market, depending on whether the tax shift expands or reduces inefficiencies associated with the over-taxation of capital. Their empirical analyses suggest that abatement policies tend to shift the burden of taxation from labor onto capital because the energy sector is relatively capital intensive, at least when revenues are used to cut personal income taxes. Thus, an analysis exclusively focused on labor may bias downward the estimates of overall abatement costs.[15]

[15] Other numerical investigations are broadly consistent with these findings (see Goulder 1998, Table 3). One exception is Jorgenson and Wilcoxen (1996), who find that a carbon tax with revenues used to cut capital taxes has a negative cost. In their model the marginal excess burden of capital taxation is substantially higher than in other models, since they assume a relatively high capital-supply elasticity and perfect capital mobility across sectors.

One issue that has received little attention is the possibility that part of the burden of carbon taxes comes at the expense of rents earned by owners of nonrenewable resources, rather than being passed on in higher product prices (e.g., Perroni and Whalley 1998). My guess is that this issue is of minor importance for carbon taxes: coal reserves are very abundant, and the scarcity rent component of oil prices appears small (e.g., Leiby et al. 1997, 18–19).

4. Further Considerations in the Choice Between Taxes and Permits

4.1 Distributional Effects

Another drawback of grandfathered permits is their adverse effect on the distribution of household income. The rents or profits created by grandfathered permits ultimately accrue to shareholders, either directly through dividends and capital gains, or indirectly through their holdings in retirement accounts. Stock ownership is highly skewed toward the better-off; the top income quintile in the United States owns approximately 60% of stocks, while the bottom income quintile owns less than 2%. Indeed, this windfall to the wealthy can more than compensate them for higher energy prices: Dinan and Rogers (2002) estimate that using grandfathered permits to reduce U.S. carbon emissions by 15% would reduce annual real income for the lowest income quintile by around \$500 per household but *increase* that for the top income quintile by more than \$1,500 per household.[16] Emissions taxes (and auctioned permits) do not create windfall gains for shareholders. Instead, the government obtains revenues that can be recycled to households in distributionally neutral tax reductions, or reductions that favor the poor.[17]

The choice between carbon taxes and permits also affects the distribution of policy costs among interest groups competing for political influence. The political process should favor grandfathered permits over pollution taxes, if affected firms have political clout (Buchanan and Tullock 1975). Nonetheless, at least for modest carbon taxes, fossil fuel producers may require only limited compensation (through, for example, exempting a small fraction of inframarginal emissions from the tax base) to keep their equity values from falling. This is because the supply curve for fossil fuels is flat relative to the demand curve, and only a small portion of the tax burden comes at the expense of producer surplus (Bovenberg and Goulder 2001). This suggests

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[16] Poor households suffer disproportionately not only because they receive so little rent, but also because they have higher budget shares for energy-intensive goods (e.g., OECD 1996, Ch. 4).

[17] Tax reductions that favor the poor, such as higher personal allowances or expanded earned-income tax credits, may have lower efficiency gains than proportionate reductions in marginal tax rates. In particular, cutting average tax rates stimulates labor supply through the participation decision only, whereas cutting marginal rates also encourages an increase in average hours worked (e.g., Pearson and Smith 1991).

that political feasibility does not have to be a major obstacle to the implementation of carbon taxes, though energy firms may still lobby for fully grandfathered permits over carbon taxes.

4.2 Uncertainty over control costs

There remains substantial uncertainty over the (primary) costs of reducing carbon emissions. A familiar result from one-period models with uncertain abatement costs (e.g., Weitzman 1974) is that emissions taxes yield higher expected welfare gains than permits when the marginal environmental benefit curve is flat relative to the marginal abatement cost curve, and the converse applies when marginal benefits are relatively steep. Taxes allow emissions to vary but place a cap on abatement costs. That is, if abatement costs turn out to be high, firms can avoid abatement and pay more in taxes, but if abatement costs are low, firms can lower tax payments by doing more abatement. In contrast, under permits, emissions must be reduced by a fixed amount; the emissions cap is not automatically relaxed if control costs turn out to be high, or tightened if control costs are low.

Carbon dioxide is a stock pollutant—atmospheric accumulations of carbon dioxide decay at a rate of only about 1% per year. Global carbon emissions in one year add less than 4% to the atmospheric stock; therefore the marginal damage from global emissions in one year is essentially constant, even though climate change damages are nonlinear in the stock. Using a carefully calibrated dynamic model with abatement cost uncertainty, Newell and Pizer (2002) estimate that the expected welfare gains from carbon taxes amount to *several times* those under emissions permits, under a wide range of scenarios.[18]

4.3 Other Issues

At the international level, reaching agreement on baselines for allocating permit allowances across countries can be problematic. The 1997 Kyoto Protocol set targets for allowable emissions in 2008–2012 based on countries' actual emissions in 1990. This penalizes countries like South Korea and the United States, where emissions have expanded rapidly in the intervening years because of above-average economic growth, while "letting off the hook" countries like Germany and Britain, where emissions fell because of the closure of uneconomical

[18] Uncertainty over future government policy may also be an issue, but there has been little analysis of whether emissions permits might be a more credible policy instrument than emissions taxes.

coal mines. It may prove difficult to agree on baseline adjustments in the future to account for diverging economic conditions across countries.

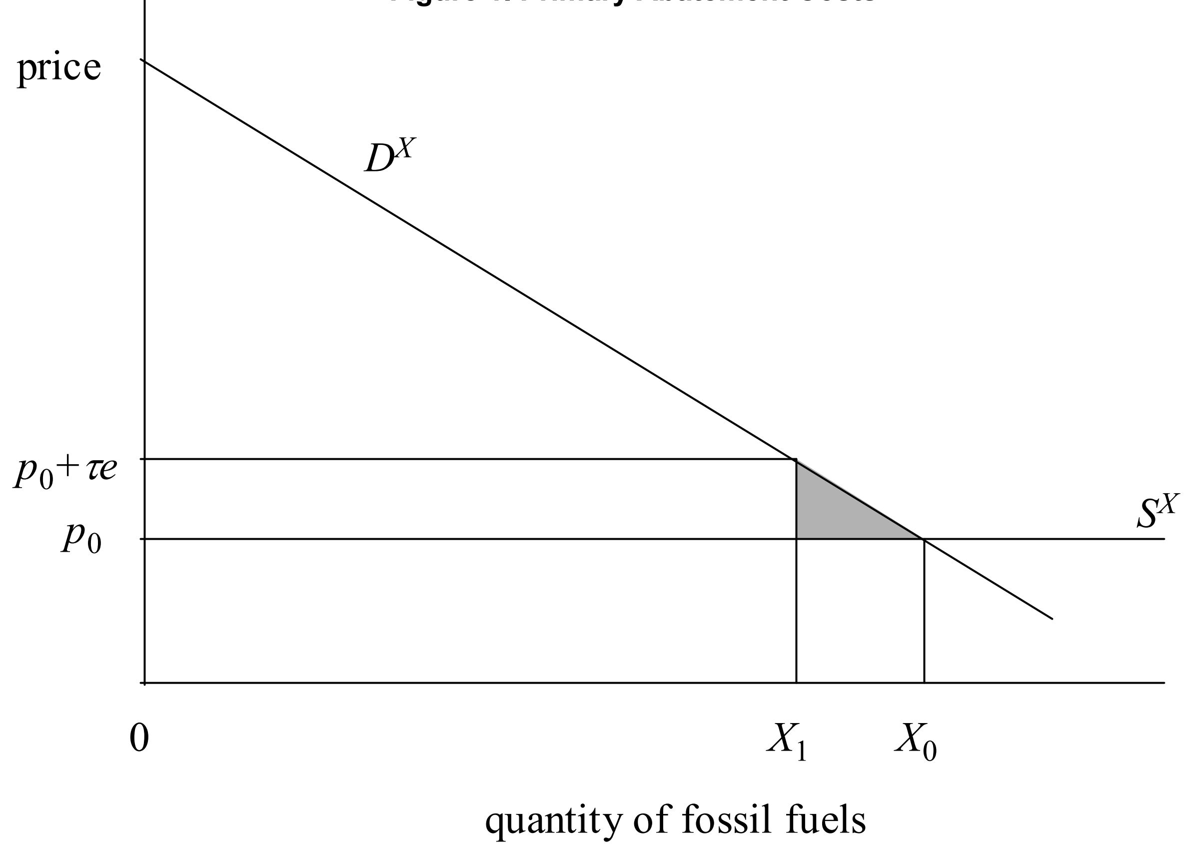
A different issue would arise under a carbon tax, imposed at the same rate across all countries participating in a climate change treaty, regardless of prevailing economic conditions and emissions rates. The problem is that individual countries may undermine its effect by reducing fuel taxes or granting tax breaks and regulatory relief to industries most adversely affected. In principle, countries could agree on a convention for calculating effective carbon taxes and how they change over time with changes in the broader taxation and regulation of the energy sector. However, changes in energy policy might be warranted on other grounds; for example, if the cordon pricing scheme recently introduced to reduce traffic congestion in London spreads to other urban centers in the United Kingdom, some relief for motorists through lower gasoline taxes would seem appropriate. For a more in-depth discussion of these and other practical issues in the choice of carbon taxes and permits, see Nordhaus (2003).

5. Conclusion

A simple cost-benefit analysis suggests that grandfathered carbon permits might be welfare reducing under certain scenarios for environmental benefits, because of their impact on compounding preexisting tax distortions. Nevertheless, there are many reasons why it may still be better to go ahead with a grandfathered permit scheme than to do nothing about carbon emissions. There is much dispute over marginal benefits from carbon emissions mitigation, and marginal benefits grow over time with expansion of the global economy. Establishing a price for carbon emissions could boost the development of energy-efficient technologies, thereby substantially reducing the costs of future emissions abatement. Once the program is introduced, it is conceivable that an increasing portion of the permits might be auctioned over time; and once in place, emissions targets could be quickly altered in response to emerging evidence on the seriousness of climate change.

Nonetheless, on economic grounds there appears to be an almost overwhelming case for an internationally harmonized carbon tax, at least if taxes could be introduced in a revenue-neutral fashion in individual nations. The efficiency costs of moderate carbon taxes can be dramatically lower than those of equivalently scaled grandfathered permits, and for the United States, costs might actually be negative. These economic arguments, in addition to the transparency of the carbon tax compared with the endless bargaining over intercountry permit allocations endemic in the Kyoto Protocol, suggest that a regime of harmonized taxes is more likely to achieve what is ultimately the most important objective—the establishment of a credible international emissions control regime that will stand the test of time.

Figure 1. Primary Abatement Costs



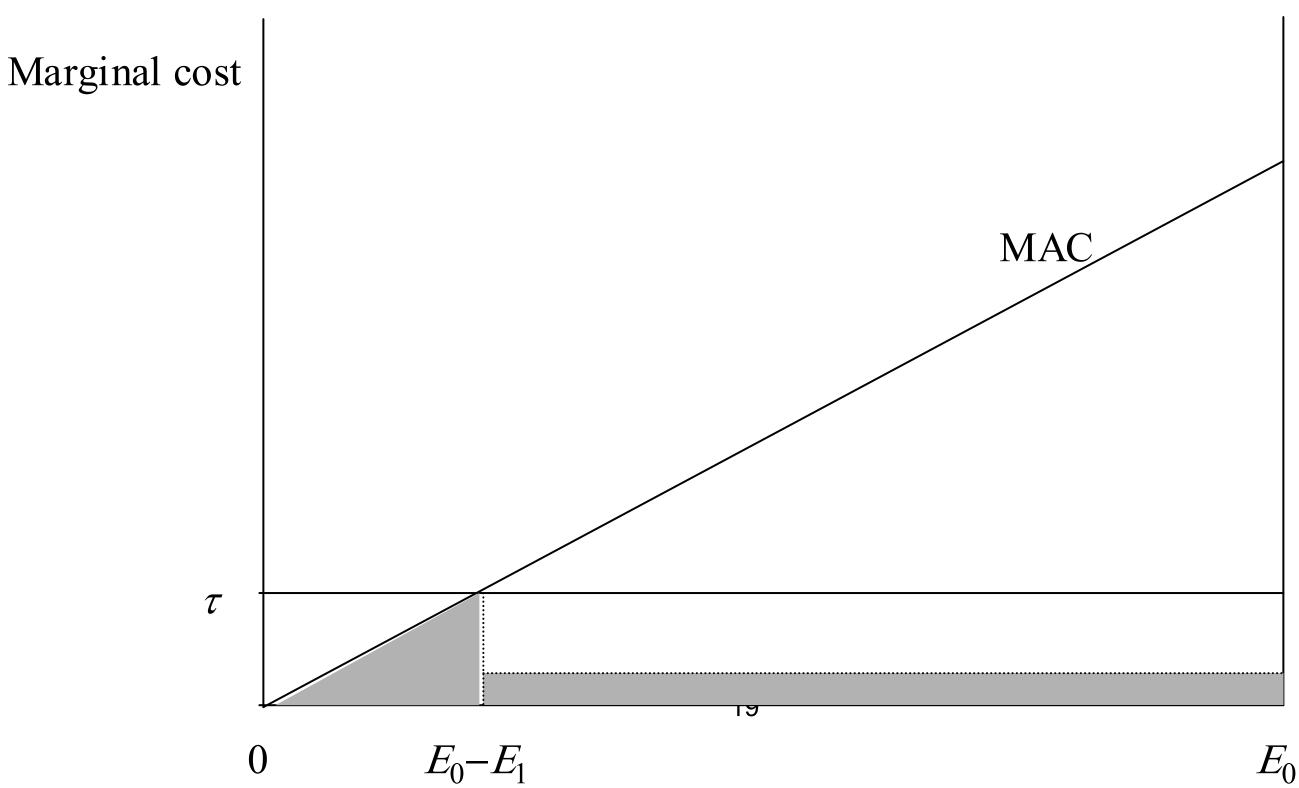


Figure 2. Tax Distortions in the Labor Market

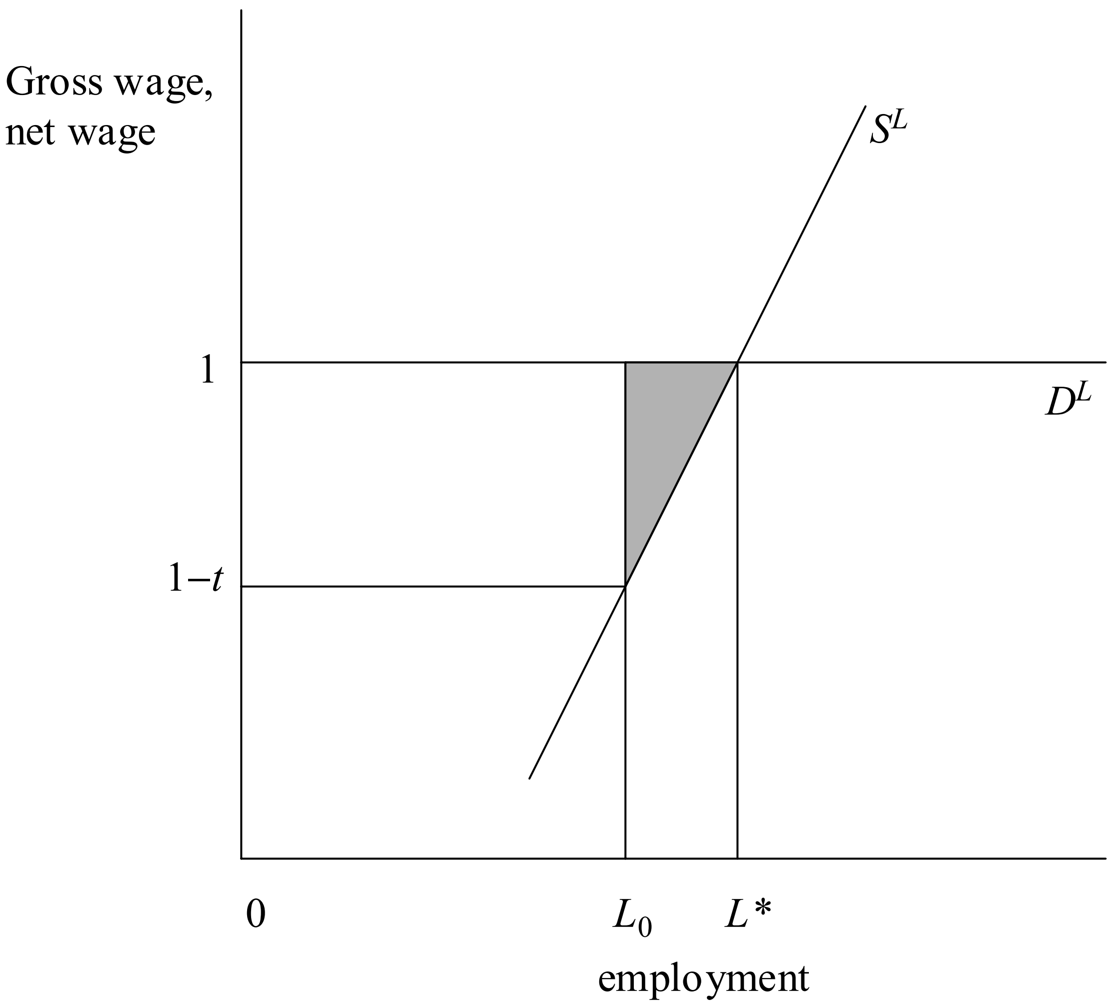


Figure 3. Policy Costs with Fiscal Interactions Relative to Primary Costs

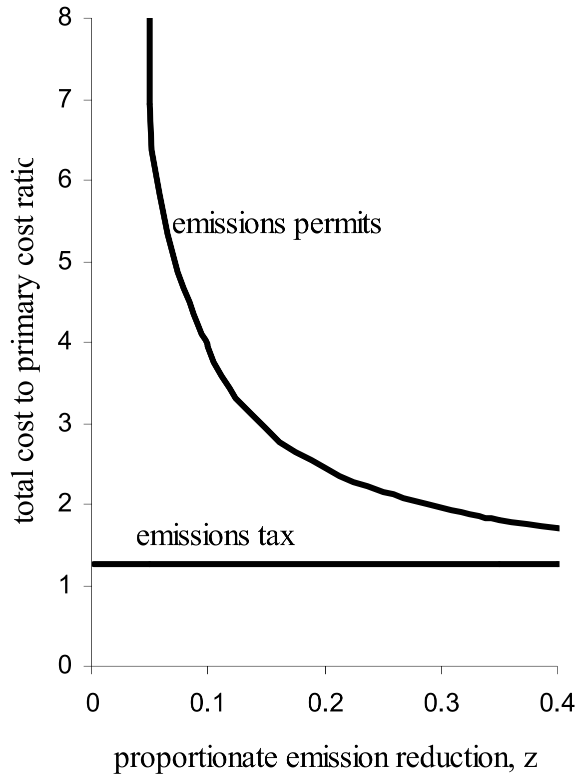
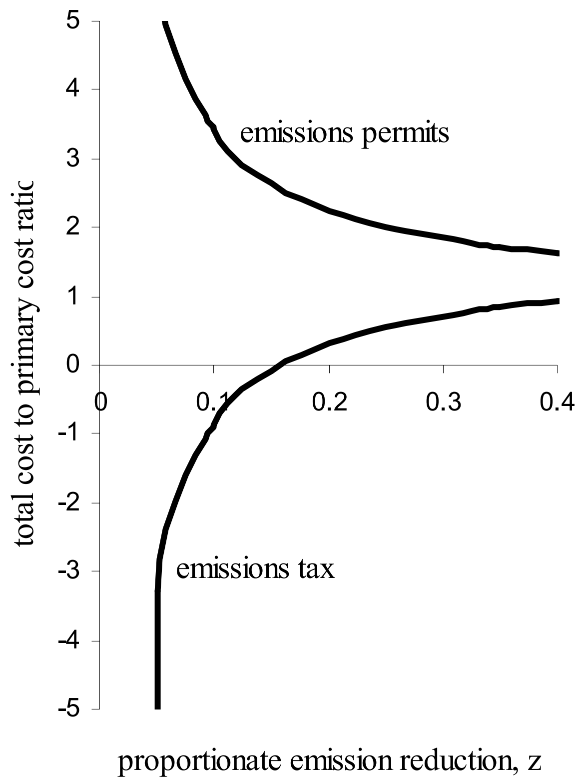


Figure 4. Relative Policy Costs Accounting for Tax Deductions



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