Adjusting Carbon Cost Analyses to Account for Prior Tax Distortions

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Abstract

This paper discusses how carbon abatement policies interact with the tax system, and how these interactions affect the overall costs of carbon controls. We provide formulas for adjusting cost estimates of auctioned and grandfathered carbon emissions from partial equilibrium energy models into rough estimates of general equilibrium costs that account for fiscal interactions.

In the basic model with a tax on labor income, the general equilibrium costs of (revenue-neutral) auctioned permits are around 25% higher than the partial equilibrium costs; those of grandfathered permits, which do not directly raise revenues for recycling, are typically more than 100% higher. However, when allowance is made for complicating factors, such as the effect of tax subsidies on raising the distortionary costs of the tax system, the efficiency gains from recycling revenues from auctioned permits are larger. Indeed the general equilibrium costs of (revenue-neutral) auctioned permits can be negative for modest abatement levels.

Key Words: carbon permits; tax distortions; revenue recycling; general equilibrium costs.

JEL Classification Numbers: Q28; H21

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Ian W.H. Parry[*]

1. Introduction

Economists often evaluate carbon control policies using partial equilibrium energy models, or at least models that do not take into account interactions with other sectors of the economy that are distorted by the tax system, particularly labor and capital markets.[1] But recent literature has shown that these interactions can be very important: they can change the economic costs of carbon and other environmental policies in a systematic, and often quite dramatic, fashion. Moreover, the net impact of these interactions can be in different directions for different types of policy instruments.

For example, under certain circumstances the costs of revenue-raising policies, such as auctioned carbon permits, can be much lower than predicted by partial equilibrium analyses, and possibly even negative (even without accounting for environmental benefits). By forcing firms to reduce emissions, these policies tend to have a slight contractionary effect on economic activity, and this effect tends to exacerbate the impact of the tax system on depressing levels of employment and investment. However, when revenues raised from auctioned permits are used to cut distortionary taxes elsewhere in the economy, there is a significant efficiency gain. In some important cases the latter effect can dominate the former, implying that on balance the policy reduces the efficiency costs associated with preexisting taxes. On the other hand, if permits are given out for free, the government forgoes the efficiency gains from revenue recycling, and for this policy the overall costs can be considerably larger than would be predicted by a partial equilibrium analysis that neglected preexisting tax distortions.

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[1] For example, analyses by Boyd et al. (1995), Dowlatabadi (1998), Edmonds et al. (1993), and Manne and Richels (1995) do not integrate preexisting tax distortions. Two models that do account for linkages with the tax system include Goulder (1995a) and Jorgenson and Wilcoxen (1992). For a review of different types of models used to estimate the costs of carbon policies, see Weyant (1998), IPCC (1996), and Repetto and Austin (1997).

An understanding of these issues is crucial for evaluating the economic impacts of carbon policies. Unfortunately, the linkages between carbon policies and the tax system can be very complicated and confusing. For example, there is still a lot of confusion about under what circumstances revenue-raising policies, such as auctioned carbon permits, produce a "double dividend" by both improving the environment and reducing the costs of taxes elsewhere in the economy. Moreover, a framework for understanding how preexisting taxes affect the costs of carbon abatement policies is important for reconciling the results of various large-scale computational models of carbon policies, some of which incorporate distortions from the tax system, and others of which do not.

Since publication of an article by Bovenberg and de Mooij (1994), the literature on the interactions between environmental policies and the tax system has developed rapidly.[2] A report on the topic now seems appropriate for several reasons. Much of the literature is very technical and not readily accessible to the nonspecialist. Most of the exposition below relies on diagrams to illustrate how the costs of carbon policies change because of interactions with the tax system, rather than mathematical derivations or detailed numerical computations, and should be accessible to anyone familiar with a "Harberger" triangle. We also build up the analysis step by step, starting with a highly simplified analysis and then discussing how relaxing some of the simplifying assumptions might affect policy cost estimates.

Much of the existing literature also focuses on the effects of environmental tax shifts—that is, the introduction of environmental taxes with the revenues used to reduce other taxes in the economy. Although several carbon and other environmental tax shifts have recently been implemented in some European countries,[3] other forms of regulation are the focus of attention in the United States. This report considers auctioned and freely allocated carbon permits.[4]

We discuss a number of formulas that provide a simple guide for adjusting partial equilibrium cost estimates of a range of carbon abatement policies, to take into account how these policies affect the costs of the tax system. In other words, the formulas provide a very quick and easy way to obtain approximate general equilibrium cost estimates from a partial

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[2] For surveys of the literature, see, for example, Goulder (1995b), Oates (1995), Bovenberg (1999), Parry and Oates (2000), and Bovenberg and Goulder (2001).

[3] See, for example, Hoerner and Bosquet (2001) for more discussion.

[4] The report is meant *not* as a comprehensive survey of the literature but rather as a summary of the key points needed to (approximately) adjust partial equilibrium cost analyses to account for prior tax distortions.

equilibrium study, without having to use a detailed computational model of the whole economy. Of course, these estimates are only very crude—the point of some of the complex computational models is that they can provide a sophisticated treatment of the energy sector and the tax system.[5]

One caveat is in order. Our focus is purely on the implications of the broader fiscal system for the economic costs of different carbon abatement policies. Obviously, other factors are relevant to the choice among policy instruments, such as uncertainty over control costs, incentives for technological innovation, the political feasibility of policies, effects on the personal distribution of income, ease of monitoring and implementing policies, the extent to which carbon permits might be traded overseas, and so on. However, these other issues have been discussed extensively elsewhere (e.g., Pizer and Kopp 2000) and they are beyond the scope of this report. In addition, our focus is on carbon emissions from fossil fuels; we do not consider the impacts of land use (e.g., forestry policies) on carbon emissions.[6]

The report is organized as follows. Section 2 begins with a simple model showing how partial equilibrium cost estimates of auctioned carbon permits can be adjusted to account for interactions with preexisting taxes in the labor market. We identify two key and opposing efficiency effects, both of which can be sizable relative to the partial equilibrium cost of the carbon policy. First is the *revenue-recycling effect*, which is the efficiency gain from using revenues from permit sales to reduce the distortionary tax in the labor market. Second is the *tax-interaction effect*, which is an efficiency loss from the adverse effect on employment, due to the effect of the carbon policy on increasing firm production costs and product prices. Under fairly neutral assumptions the latter effect dominates the former and the general equilibrium costs of the carbon policy are around 25% larger than the partial equilibrium costs, regardless of the extent of carbon abatement. In this highly simplified model the "double dividend" hypothesis is not valid.

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[5] See in particular the model developed by Lawrence Goulder that incorporates the adjustment of capital in different industries over time in response to tax and carbon policies (e.g., Goulder 1995a; Bovenberg and Goulder 1996, 1997). As discussed below, even the large-scale numerical models may be restricted in certain respects; for example, they may omit important tax deductions or restrict household preferences in various ways.

[6] Another point is that the discussion assumes competitive, well-functioning product and factor markets (aside from distortions created by taxes). This may be unrealistic for certain European countries, where labor unions play a major role in wage determination, and in developing or transitional economies, where markets may not be well established. Nonetheless, the assumption of competitive markets seems a reasonable approximation for fossil fuel and labor markets in the United States.

Section 3 discusses grandfathered carbon permits and compares them with auctioned permits. For a given amount of emissions control, permits have the same impact on fossil fuel prices whether the permits are grandfathered or auctioned, and this means that they induce the same tax-interaction effect. However, if the permits are given out for free rather than auctioned, the policy rents go to firms rather than to the government, implying that the efficiency gain from revenue recycling is forgone.[7] The cost of the tax-interaction effect can be large relative to the partial equilibrium costs of the carbon policy, particularly for modest amounts of emissions control. In turn, this means that the costs of grandfathered emissions permits can substantially exceed the costs of auctioned permits although, as shown in our formulas, the relative cost difference is inversely proportional to the extent of emissions reduction. A final point here is that the cost difference between the two policies arises not from revenue raising per se, but rather from the use of revenues to replace other distortionary taxes. If the revenues from auctioned permits were not used to increase economic efficiency—for example, the revenues simply finance more transfer spending for the private sector—the cost difference between the permit policies would disappear.

Section 4 discusses two generalizations to the basic model. The first is the implications of tax deductions and exemptions (e.g., for homeownership and health insurance), which have recently received attention from economists studying the excess burden of the fiscal system. The basic point is that income taxes are more costly because they distort the pattern of spending between tax-favored items and ordinary spending, in addition to distorting the labor market. In turn, this means that the efficiency gains from recycling revenues from permit sales is larger, implying the overall efficiency costs of (revenue-neutral) auctioned permits are lower, if not negative. Second, we discuss how carbon permits might impinge upon the capital market. This is a particularly difficult issue, not least because the sensitivity of capital to tax rates is so uncertain. Nonetheless, we can still draw some useful qualitative results; for example, if the net impact of the carbon policy is to shift some of the burden of the tax system off capital and onto labor, there will be an additional source of efficiency gain. This might require using the revenues from permit sales exclusively to cut taxes on capital (rather than labor) income.

Section 5 summarizes the main policy implications.

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[7] This is not entirely correct because the government obtains some of the permit rents indirectly through the taxation of profit income.

2. A Simple Model with Auctioned Carbon Permits and Labor Taxes

In this section we develop a simple model to illustrate the linkages between a cap-and-trade policy to limit carbon emissions and preexisting income taxes, where the government auctions the emissions permits. The section begins with the textbook partial equilibrium analysis of an emissions permit program. We then discuss how income taxes reduce efficiency by distorting the labor market. Auctioned emissions permits interact with the labor market in two ways. They can improve efficiency if the revenues are used to reduce labor taxes, but at the same time they reduce efficiency indirectly by raising product prices, reducing household wages, and reducing labor supply. We discuss the net impact of these two effects, what they imply for the "double dividend" hypothesis, and the overall cost of carbon permits.

Partial Equilibrium Analysis of Carbon Permits

Consider Figure 2.1(a), which shows the market for intermediate goods—fossil fuels—whose use produces carbon emissions. D is the demand curve for users of fossil fuels (electric utilities, metal-processing industries, motorists, and so on), and the height of D at a particular output level is the marginal benefit to fossil fuel users. A higher price of fossil fuels will reduce demand: people drive less, use more fuel-efficient vehicles, and conserve on home heating and air conditioning; power generation facilities rely more on gas in place of coal; and so on. S is the supply curve for fossil fuels shown as perfectly elastic.[8] The height of the supply curve is the marginal cost of producing fossil fuels. In the absence of policy intervention, equilibrium output and price are X_0 and p_0, where demand and supply intersect.

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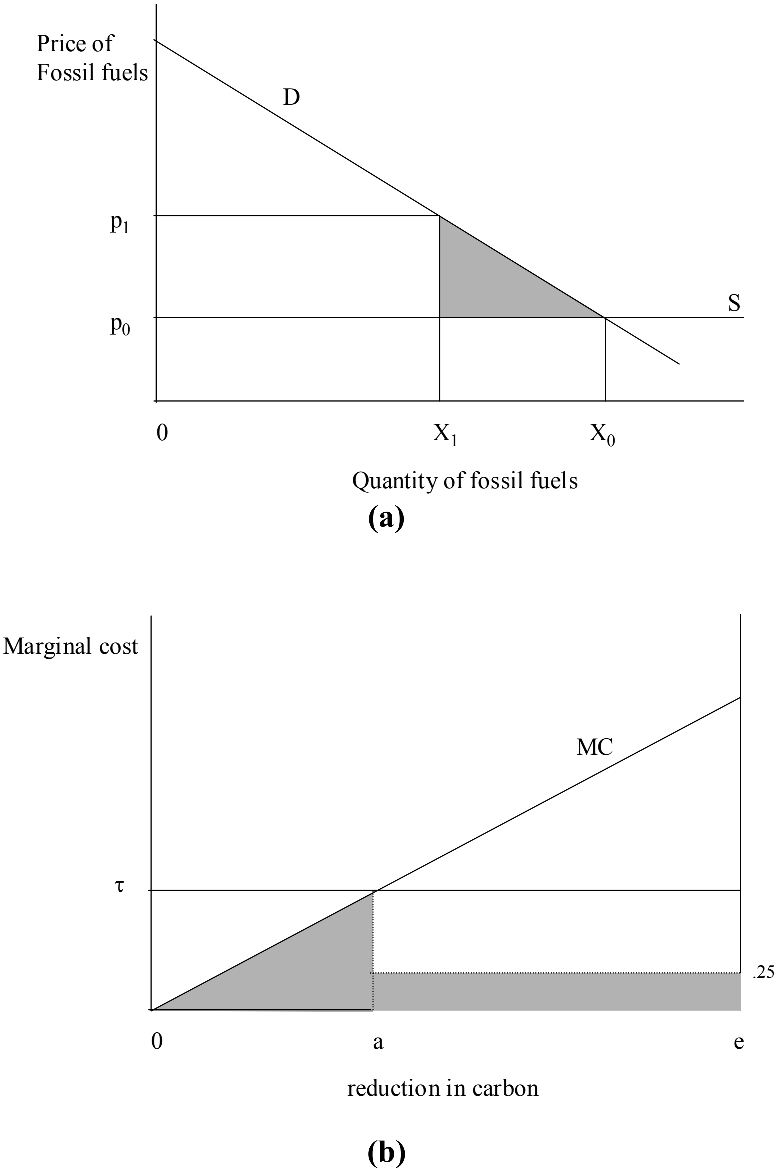
[8] Roughly speaking, this may be a reasonable long-run approximation; for example, fossil fuel–producing industries are competitive in the United States, and at least for coal, reserves are plentiful.

Figure 2.1



Burning fossil fuels produces carbon emissions. Suppose that the government now limits emissions by introducing a system of carbon permits.[9] For expositional purposes we assume that

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[9] Implicitly, we assume that permits are tradable among firms, in keeping with current policy proposals. If permits were not tradable, the marginal cost of reducing emissions may differ across firms, leading to an additional efficiency cost.

emissions are proportional to aggregate fossil fuel use—in practice, reducing carbon emissions will involve substitution away from coal and toward natural gas, but this makes no difference to the main thrust of the analysis. Suppose the carbon policy causes fossil fuel consumption to fall to X_1. Then the resulting efficiency cost is the shaded triangle in Figure 2.1(a).[10] The focus here is purely on the cost of carbon policies; we do not model the benefits arising from avoided future climate change.

An alternative way of viewing the costs of carbon emissions permits is shown in Figure 2.1(b). Along the horizontal axis in this panel we have the amount of emissions abatement from 0 to e, where e denotes benchmark emissions associated with fossil fuel consumption X_0. The MC curve in this figure shows the marginal cost of reducing emissions. It begins at the origin, reflecting the equalization of the demand and supply curves in panel (a) at X_0. The MC curve is upward sloping, reflecting the downward sloping demand curve for fossil fuels: it is increasingly costly to fossil fuel users to reduce consumption by successive units through fuel switching, energy conservation, and so on.

Suppose that the emissions reduction associated with limiting fossil fuel use to X_1 is a. Then the efficiency loss is also represented by the shaded triangle under the MC curve in panel (b). (We explain the shaded rectangle later.) Assuming the MC curve is linear, this triangle has area

(2.1) $0.5\tau a$ (*partial equilibrium cost of emissions permits*)

τ denotes the permit price and in equilibrium it equals the marginal cost at abatement level a.[11]

In this partial equilibrium framework the efficiency cost of the permit policy is independent of whether the permits are sold by the government or given out free to firms. In the former case the government obtains $\tau(e - a)$ in revenues (assuming permits are auctioned at the

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[10] The efficiency cost equals the reduction in benefits to fossil fuel users (the area under the demand curve between X_1 and X_0) less the reduction in the costs of producing fossil fuels (the area under the supply curve between X_1 and X_0).

[11] If the price were less than τ, firms would have excess demand for permits because the price of buying a permit is less than the cost of reducing emissions by one more unit. Thus, the permit price would be bid up until it equaled marginal abatement cost at a. Conversely, if the price were initially above τ, firms would want to sell permits because the revenue would exceed the costs of extra abatement, and equilibrium would be restored by a fall in the permit price. Our discussion ignores imperfections in the permit trading market due to possible transaction costs associated with matching buyers and sellers of permits (see Stavins 1995 for some discussion).

market price), and in the latter case $\tau(e - a)$ is a rent earned by firms. However, when we move to a general equilibrium framework that captures interactions with the tax system, the efficiency properties of these two policies can be radically different. The rest of this section focuses on the case of auctioned permits (Section 3 discusses freely allocated permits).

The Labor Market

We now consider how preexisting income taxes create distortions in factor markets in the rest of the economy, and then we discuss how carbon abatement policies impinge upon these distortions. In this section the focus is only on the labor market, which accounts for about 70% of total factor income; section 4 discusses distortions in the capital market.

Consider Figure 2.2, which shows the labor market for the whole economy. On the horizontal axis we have the level of employment, or total hours worked by the labor force, and on the vertical axis we have the wage rate. D_L is the demand for labor curve. The height of this curve reflects the increase in the value of firm output from hiring one more unit of labor. We simplify by assuming this curve is flat, which seems a reasonable long-run approximation for our purposes.[12] Assuming firms are competitive, they will pay a gross wage equal to the value marginal product of labor. Thus the gross wage equals the height of DL, and we normalize the gross wage to unity.

S_L is the supply of labor curve. This curve is upward sloping because higher wages tend to attract more secondary workers (particularly married females) to participate in the labor force. Higher wages may also encourage older workers to postpone retirement, younger workers to take a second job, or existing workers to put in more hours. The height of S_L is the marginal opportunity cost of work time. For example, a worker well to the left of L_0 in Figure 2.2 has a relatively low opportunity cost of time: this may represent a young, single worker who would be bored staying at home all week. Someone to the right of L^* has a relatively high opportunity cost to being in the labor force; for example, this may be an older worker with plenty of savings who

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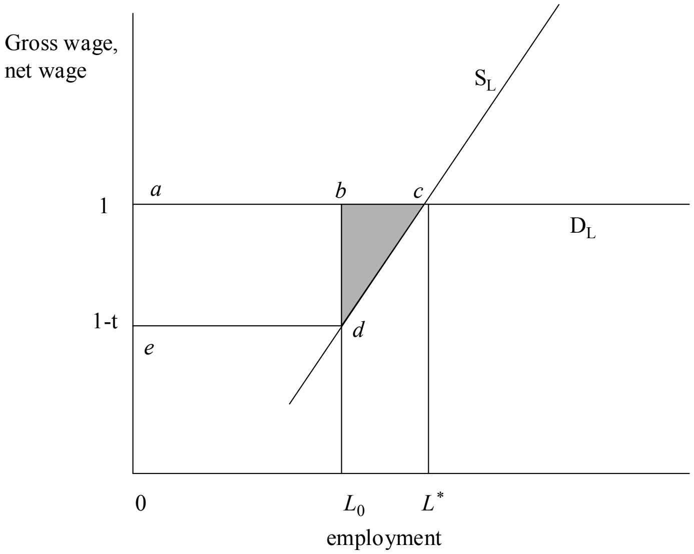
[12] For the one-input analysis above, this is analogous to the assumption of constant returns to scale, which seems reasonable based on empirical evidence (e.g., Hamermesh 1986, 467).

would rather be retired, or the partner of a working spouse who would rather stay home with the children.[13]

Figure 2.2



The optimal level of employment in Figure 2.2 is L^* where S_L and D_L intersect, or where the value product of an extra worker equals the opportunity cost of an extra worker in terms of forgone nonmarket activities. If workers received a wage of unity, assuming the labor market is competitive, then equilibrium employment would be L^*. However, in practice a substantial portion of labor income goes to the government in tax revenue rather than directly to households. For example, firms and workers have to pay social security taxes on labor earnings, and households have to pay federal, state, and local income taxes on labor earnings. In addition sales and excise taxes, which are paid when labor earnings are spent, are effectively a tax on labor. We denote the net of tax household wage by $1-t$, where t is the total taxes paid per unit of labor. Households will supply labor up to the point where the net wage equals the marginal opportunity cost of nonmarket time (in other words, the wage received by the marginal worker just

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[13] In theory the (uncompensated) labor supply curve could be backward bending. That is, if the household wage is increased, people may decide to settle for the same standard of living and work fewer hours. More recent empirical studies tend to reject the backward-bending supply curve for males, and the uncompensated elasticity for female workers appears to be strongly positive (e.g., Blundell and MaCurdy 1999, Tables 1 and 2). This is because most of the labor supply elasticity is driven by changes in the participation rate (for which the uncompensated elasticity is necessarily positive) rather than by changes in the hours of existing workers. Moreover, the compensated labor supply elasticity, which is positive, according to economic theory, is more relevant for our analysis (see below).

compensates him or her for the opportunity cost of being in the labor force). Equilibrium employment is L_0 in Figure 2.2 and government tax revenues are given by tL_0, rectangle *abde*.

The labor tax creates a deadweight loss equal to the shaded triangle *bcd* in Figure 2.2. This is equal to the gap between the marginal benefit of labor and the marginal social cost, integrated between L_0 and L^*. This deadweight loss depends on both the height of the shaded triangle (the tax wedge) and the base, L^*-L_0. Empirical evidence suggests that the supply of labor curve is fairly inelastic (see Appendix A), implying that the difference between L^* and L_0 may not be that large. However, the deadweight loss triangle can still be sizable because the tax wedge is very substantial, amounting to around 40% of the gross wage (Appendix A).[14]

The Marginal Excess Burden of Taxation

It is helpful to define a concept known as the *marginal excess burden* (M) of labor taxation, which usefully summarizes the degree of distortion in the labor market. M is the deadweight loss from the increase in taxation necessary to raise an extra dollar of tax revenue. Consider an incremental increase in the labor tax of dt. In Figure 2.3 the net household wage falls from $1-t$ to $1-t-dt$, and employment falls from L_0 to L_1.

The change in government tax revenue has two components. The first is rectangle X in Figure 2.3, equal to the amount of labor times the increases in taxes paid per unit of labor, or L_0dt. The second is the reduction in revenue due to the fall in labor supply, shown by rectangle Y, which has area $t(-dL/dt)dt = t(dL/d(1-t))dt$.

The reduction in employment from L_0 to L_1 pushes the equilibrium even further away from the optimal employment level L^* in Figure 2.3, and it increases the amount of deadweight loss by rectangle Y. The marginal excess burden is therefore Y/(X-Y)—that is, the increase in deadweight loss per extra dollar of revenue. Using the above formulas and canceling dt, we have:

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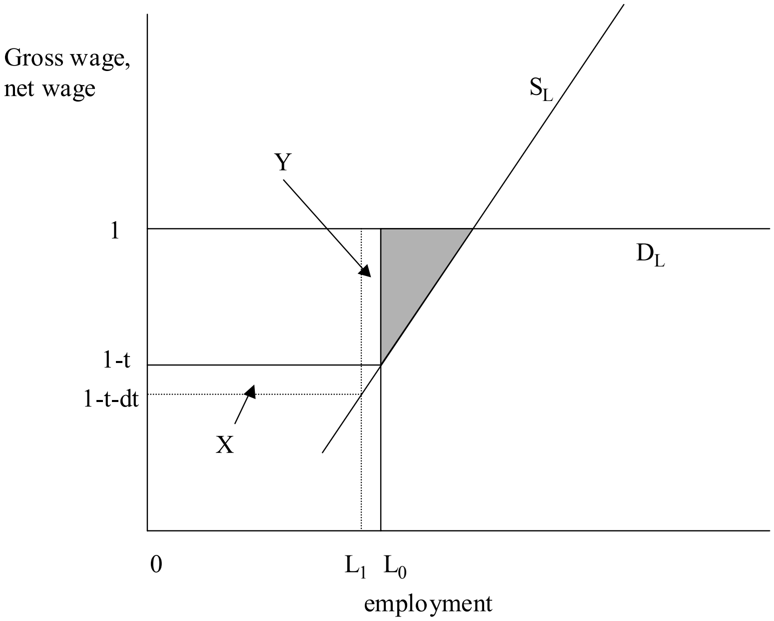
[14] Note that L^*-L_0 has little to do with the official rate of unemployment. If, for example, higher labor taxes cause some secondary workers to quit the labor force, some older workers to retire earlier, or some younger workers to quit their second jobs, employment will fall in each case, but there will be no effect on the measured unemployment rate. Even if the economy is at the "full employment" stage of the business cycle, this does not mean that there is no deadweight loss in the labor market from tax distortions.

$$(2.2)\qquad M=\frac{t\dfrac{dL}{d(1-t)}}{L_0-t\dfrac{dL}{d(1-t)}}=\frac{\dfrac{t}{1-t}\varepsilon}{1-\dfrac{t}{1-t}\varepsilon}\qquad \textit{(marginal excess burden of taxation)}$$

where $\varepsilon=\{dL/d(1-t)\}(1-t)/L_0$. ε is the labor supply elasticity—that is, the percentage increase in labor supply that would result from a 1% increase in the net-of-tax household wage. From (2.2) we see that M is greater the greater the labor supply elasticity and the greater the labor tax rate.

Figure 2.3



There is controversy over the magnitude of the marginal excess burden due, for example, to uncertainty about the labor supply elasticity, the size of the labor tax wedge, and whether the compensated or uncompensated labor supply elasticities should be used. For illustration we use a value of 0.25 based on a compensated elasticity of 0.3 and a labor tax of 0.4, and we consider a range of 0.15 to 0.4 (see Appendix A).[15]

Revenue-Recycling Effect

If increasing labor tax revenue by a dollar causes a welfare loss of M, then reducing labor tax revenue by a dollar must produce a welfare *gain* equivalent to M. Suppose that all of the revenue obtained from auctioning permits, $\tau(e-a)$ in Figure 2.1(b), is used to reduce the labor tax. The resulting welfare gain is:

$$M\tau(e-a) \qquad \textit{(revenue-recycling effect)} \tag{2.3}$$

This welfare gain has become known as the *revenue-recycling effect* (e.g., Goulder 1995b). It is shown by the shaded rectangle in Figure 2.1(b).

An important issue is the magnitude of the revenue-recycling effect, and how large it is relative to the partial equilibrium cost of carbon permits. Dividing the revenue-recycling effect in (2.3) by the partial equilibrium cost in (2.1) gives:

$$\frac{2M(1-a/e)}{a/e} \qquad \textit{(revenue-recycling effect relative to partial equilibrium cost)} \tag{2.4}$$

where a/e is the proportionate reduction in emissions.

Figure 2.4 graphs the expression in equation (2.4) for values of a/e up to 50%. The solid curve corresponds to $M = 0.25$, and the dashed curves correspond to values of 0.15 and 0.4. The relative size of the revenue-recycling effect is sensitive to the extent of abatement. When abatement is 5% and $M = 0.25$, the revenue-recycling effect is 9.5 times the size of the partial equilibrium cost; when abatement is 20%, it is twice the partial equilibrium cost; and it is 60% of the partial equilibrium cost at an abatement level of 50%.[16]

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[15] These numbers are roughly comparable with other studies (e.g., Browning 1987; Snow and Warren 1996; Jorgenson and Yun 1991).

[16] Under the Kyoto Protocol, the United States would have been obliged to reduce emissions to 7% below 1990 levels (1,251 million tons) by 2010, which would have implied a reduction in emissions below benchmark levels of around 30% (536 million tons, EIA 1999, 89). The predicted permit price in 2010 under this amount of abatement is around \$50 to \$150/ton (e.g., IWG 1997; CEA 1998; Weyant and Hill 1999). Using (2.1), (2.3), and $M = 0.25$, under the \$50 permit price, the partial equilibrium costs would be \$13 billion, and the efficiency gains from revenue recycling, \$13 billion; under the high permit price the partial equilibrium costs would be \$40 billion, and the revenue-recycling effect, \$39 billion. For a broader discussion of the efficiency gains from recycling carbon policy revenues, see, for example, Shackleton et al. (1996), Goulder (1995), and Parry et al. (1999).

The intuition for why the relative size of the revenue-recycling effect declines with abatement is straightforward. When abatement is small in Figure 2.1, the partial equilibrium cost triangle is relatively small. However, the welfare gain from revenue recycling is relatively large because emissions are close to the level without the carbon policy; therefore the shaded rectangle in Figure 2.1(b) has a large base. Conversely, if abatement is larger, the base of the partial equilibrium cost triangle in Figure 2.1(b) is larger but the base of the revenue-recycling rectangle is smaller.[17]

Finally, note from equation (2.4) that the size of the revenue-recycling effect *relative* to the partial equilibrium cost depends only on the marginal excess burden and the proportionate reduction in emissions. Thus, the *relative* size of the revenue-recycling effect is independent of the share of fossil fuels in gross domestic product (GDP) and the permit price τ, which reflects the slope of the marginal abatement cost curve in Figure 2.1(b).[18]

Of course, the revenue-recycling effect hinges on the assumption that revenues from permit sales are used to reduce other taxes. In particular, the revenue might be earmarked for spending on carbon-related projects (e.g., subsidies for energy-efficient technology adoption, carbon sequestration in forestry), or it might go into the general budget and be used to finance a general increase in public spending. We explore how different options for revenue recycling change the welfare effect of auctioned permits in Section 3.

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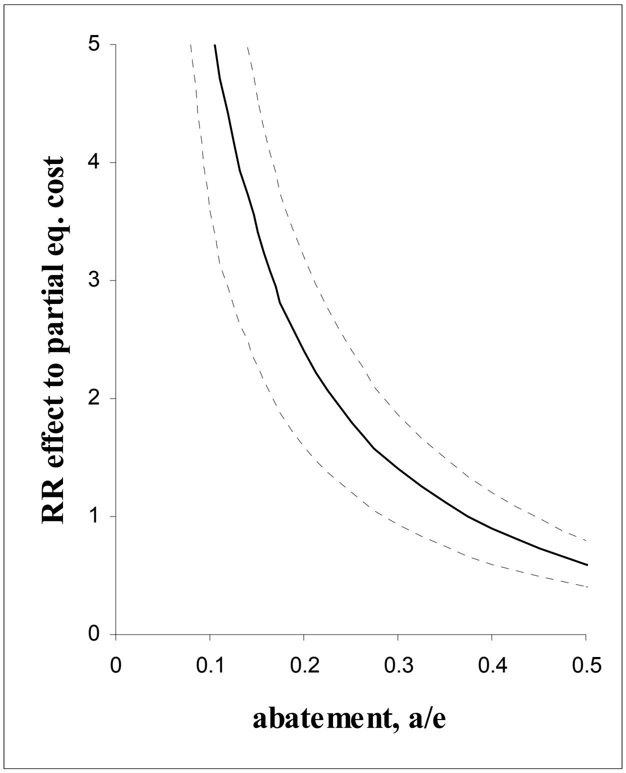
[17] The revenue-recycling effect is zero in the extreme cases when there is no abatement (the permit price is zero), and when abatement is 100% (a=e).

[18] For a given level of abatement, suppose the marginal abatement cost, and hence the permit price, were doubled. This would double the partial equilibrium cost triangle, but it would also double the revenue-recycling rectangle. This proportionality would not hold exactly if the marginal abatement cost curve were convex rather than linear.

Figure 2.4



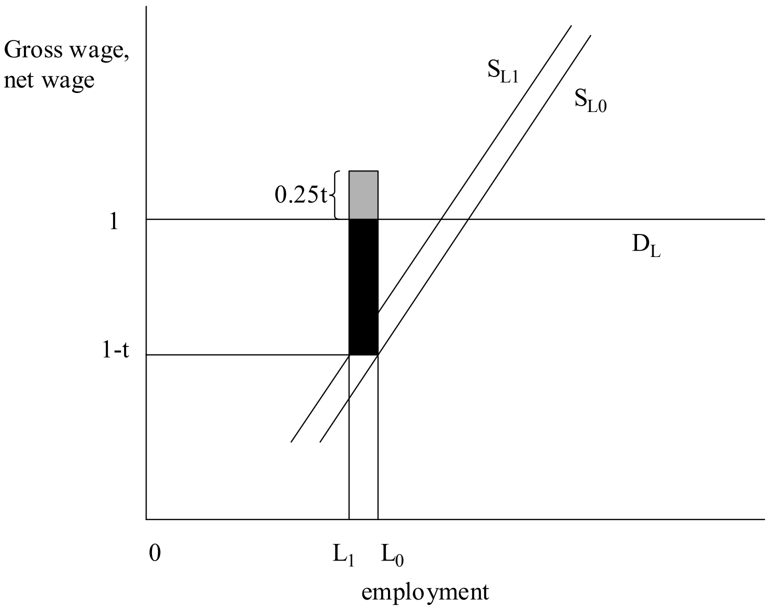
The Tax-Interaction Effect

An additional linkage between the carbon policy and the labor market must be taken into account. To see this, we need to recognize that the position of the labor supply curve in Figure 2.2 depends on the consumer price level. Suppose the prices of goods purchased by households increase. This would shift up the labor supply curve because the amount of goods that can be purchased with a given wage falls, and therefore the return to being in the labor force falls. In other words, higher product prices act like an implicit tax on labor earnings and discourage labor supply in the same way as an explicit tax on labor earnings.

A carbon policy gives rise to higher product prices in the economy. For example, it increases the price of gasoline, electricity, and other goods that are produced by fossil fuels. Suppose that the rise in the consumer price level causes the labor supply curve to shift up to S_{L1}

in Figure 2.5. As a result, employment will fall from L_0 to L_1.[19] This leads to a welfare loss equal to the larger, darker-shaded rectangle in Figure 2.5. This rectangle is equal to the tax wedge between the marginal benefit and the marginal social cost of labor, multiplied by the reduction in labor. But this rectangle also represents a loss of labor tax revenues—that is, to maintain the same level of spending, the government must now slightly increase the rate of labor tax. The efficiency cost of this tax increase equals the marginal excess burden (0.25) times the revenue that has to be made up. Thus, the overall welfare loss is 1.25 times the darker-shaded rectangle, or the sum of the light and dark rectangles in Figure 2.5. This combined welfare loss is referred to as the *tax-interaction effect* in the environmental economics literature (Goulder 1995a); it is the welfare loss from the impact of the emissions control policy on exacerbating the efficiency cost of preexisting (labor) taxes.

Figure 2.5



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[19] At first glance it may seem a stretch to say that some people will leave the labor force when the government imposes a carbon policy—indeed most people may not even realize that the policy has been implemented. However, our theory implies that when people at the margin are deciding whether to participate in the labor force, they behave as though they weigh the benefits of working—that is, the goods they can buy—against the costs of the nonmarket time they give up. As we discuss later, if people do not behave like this, they suffer from money illusion, and some extremely peculiar tax systems would then be efficient, undermining the whole of accepted tax theory.

The Tax-Interaction Effect Exceeds the Revenue-Recycling Effect

For now, we will assume that final output produced with fossil fuels is an average substitute for leisure. Under this assumption (which is relaxed in Section 4), it is fairly straightforward to derive the following formula for the welfare cost of the tax-interaction effect (e.g., Parry 1995, 1997, Goulder et al. 1999):

$$M \cdot \tau(e - a/2) \qquad \textit{(tax-interaction effect)} \tag{2.5}$$

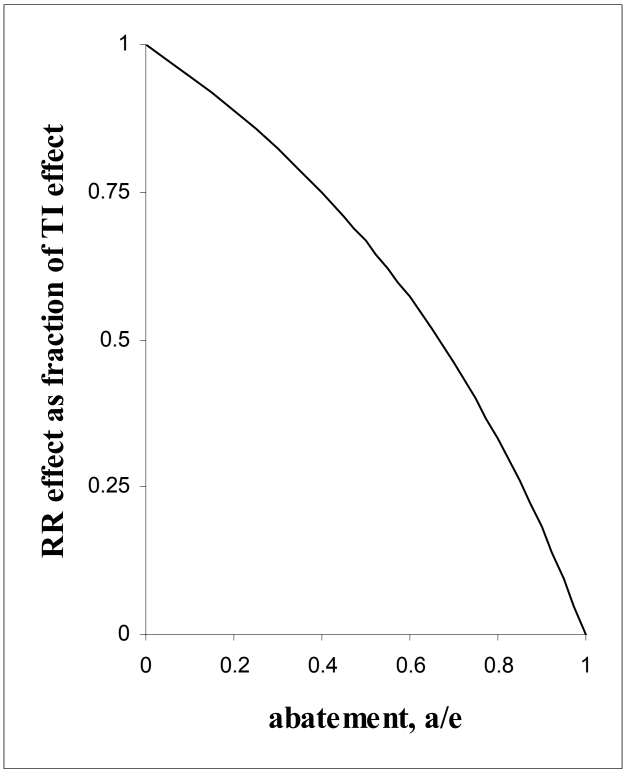
Dividing the revenue-recycling effect in (2.3) by the tax-interaction effect in (2.5) gives:

$$\frac{1 - a/e}{1 - a/2e} \qquad \textit{(revenue-recycling effect to tax-interaction effect)} \tag{2.6}$$

The expression in (2.6) is always less than 1 because a/e lies between 0 and 1. In other words, the tax-interaction effect always exceeds the revenue-recycling effect in the simple model developed so far. That is, the carbon abatement policy causes an overall reduction in labor supply and a net efficiency loss in the labor market, despite the recycling of permit revenues in labor tax reductions. Figure 2.6 graphs the expression in equation (2.6). Here we see that the revenue-recycling effect offsets 89% of the tax-interaction effect when the abatement level is 20%, and it offsets 67% of the tax-interaction effect when the abatement level is 50%. Note that the size of the revenue-recycling effect *relative* to the tax-interaction effect does *not* depend on the marginal excess burden.

Why does the tax-interaction effect exceed the revenue-recycling effect? Suppose it did not and that the auctioned carbon permit policy produced a net efficiency gain in the labor market. For an arbitrarily small amount of abatement, the partial equilibrium cost triangle in Figure 2.1b would be very small—less than the efficiency gain in the labor market (a first-order effect). In other words, if the revenue-recycling effect exceeded the tax-interaction effect, the carbon policy would improve overall welfare (at least for a small amount of abatement) even without taking into account the environmental benefits from abatement. If this were the case, it would always be optimal to raise at least some revenues from auctioned permits (or carbon taxes) and rely less on labor taxation. But this contradicts what we know from an extensive literature on optimal tax theory (e.g., Diamond and Mirrlees 1971; Atkinson and Stiglitz 1980; Sandmo 1976). This literature shows that, leaving aside any externality benefits and the possibility of imperfect competition, when output from a sector is an average leisure substitute, it can never be optimal to finance the government's spending needs by raising revenues from taxing the output of this sector or an intermediate good used in the sector. The reason is that the substitution possibilities for avoiding a sector-specific tax (or permit-equivalent tax) are greater than the possibilities for avoiding a labor tax, for a given amount of revenue raised; hence the sector-specific tax is more distortionary.[20] The above analysis could be consistent with these very well established results only if the tax-interaction effect exceeds the revenue-recycling effect.

Figure 2.6



As we shall see in Section 4, when we introduce some complicating factors of the tax system, it is possible for the revenue-recycling effect to exceed the tax-interaction effect. However, this is not the case in the model so far, and hence the general equilibrium cost of the carbon policy (which includes the welfare loss in the labor market) exceeds the partial equilibrium cost.

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[20] The labor tax distorts only the labor-leisure decision. In contrast, the carbon policy distorts production efficiency by raising the price of fossil fuels relative to other inputs. It also distorts the household consumption bundle by raising the relative price of energy-intensive goods, and it distorts the labor-leisure decision by raising product prices and reducing the amount of goods that can be purchased with labor income.

Adjusting Cost Estimates to Account for Prior Taxes

To explore by how much the general equilibrium cost of the auctioned permit policy differs from the partial equilibrium cost, add the tax-interaction effect (2.6) and subtract the revenue-recycling effect (2.3) from the partial equilibrium cost (2.1), and divide the result by the partial equilibrium cost. This gives (see also Goulder et al. 1999):

(2.7) $1+M$ (*ratio of general to partial equilibrium cost*)

Therefore, using our value of 0.25 for the marginal excess burden, the general equilibrium cost of auctioned carbon permits is 25% larger than the partial equilibrium cost, or between 15% and 40% if we use our range of values for M.

The formula for the proportionate change in the costs of the auctioned permit policy due to interactions with the tax system is extremely simple. It does not depend on the extent of abatement, the share of fossil fuels in GDP, or the slope of the marginal abatement cost function. All these other factors affect the partial equilibrium cost and the general equilibrium cost by the same proportion (given our linearity assumptions), leaving the relative costs unaffected.

The Rise and Fall of the Double Dividend Hypothesis

In recent years there has been a good deal of discussion, and a good deal of confusion, about whether revenue-raising environmental policies, such as auctioned emissions permits and emissions taxes, produce a “double dividend.” This refers to the possibility that these policies might simultaneously both reduce externality distortions *and* reduce the cost of the tax system. The first dividend is potentially correct—internalizing a pollution externality obviously produces a source of social welfare gain. But the second dividend is much more contentious.

Different people have used slightly different definitions of the second dividend (see, e.g., Goulder 1995a for some discussion). For our purposes, the most convenient definition is that the double dividend occurs when a revenue-raising carbon policy reduces the efficiency costs of preexisting taxes. In our model this occurs when labor supply increases, and therefore the general equilibrium costs of auctioned carbon permits are less than the partial equilibrium costs. If the carbon policy does reduce the efficiency costs of preexisting taxes, *and* the resulting efficiency gain is larger than the partial equilibrium cost of the carbon policy, then we will say that there is a “strong” double dividend. In this case, the general equilibrium costs of the environmental tax are negative, even when we ignore any environmental benefits.

We have already shown that no double dividend arises in the above model. Since the tax-interaction effect dominates the revenue-recycling effect, there is a net efficiency loss in the labor market. As we shall see in subsequent sections, when the above model is generalized in various respects, the efficiency loss from exacerbating preexisting tax distortions may fall and perhaps reverse sign, thereby admitting the possibility of a double dividend.

But it is useful to consider why people expected the double dividend to emerge, even in the simple model used for this section. The reason is that they incorporated the revenue-recycling effect, which is fairly straightforward to understand, but failed to recognize the tax-interaction effect, which is subtler.[21] Moreover, because the revenue-recycling effect can be substantial relative to the partial equilibrium cost, particularly at modest amounts of abatement (see Figure 2.4), some early studies made some quite striking predictions about the double dividend. For example, Nordhaus (1993) estimated that the optimal tax on carbon emissions to internalize future climate change damages increased from $5 per ton to $55 per ton when the revenue-recycling effect was taken into account. Repetto et al. (1992) estimated that using the revenues from a $40 per ton carbon tax to reduce other taxes would produce an efficiency gain of $20 billion to $30 billion per year, in addition to any efficiency gains from reducing the carbon externality. However, according to our analysis so far, all of these additional sources of efficiency gains would be more than offset when full account is taken of the tax-interaction effect.

Further Issues

We finish this section by discussing three issues that have caused confusion about the appropriate balance between revenue-raising carbon policies and other taxes, and about the employment effects of carbon policies. First, it has been argued that we should raise revenue by taxing economic “bads,” such as pollution, rather than by taxing goods, such as employment. At first glance this argument seems self-evident—surely it is better to raise revenue by penalizing polluting activities rather than relying on labor taxes that reduce employment. In other words,

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[21] These effects were implicit in earlier literature (e.g., Sandmo 1976; Ng 1981), and in the optimal tax literature (e.g., Atkinson and Stiglitz 1980) but were not decomposed until more recently (Parry 1995, 1997; Goulder et al. 1997).

this argument calls for a shift in the tax system away from labor income taxes and onto externalities to simultaneously improve the environment and increase employment.

But this is the double dividend argument again. The main problem with the argument is that it neglects the tax-interaction effect: a carbon policy reduces employment just as a direct labor tax does. Therefore, raising revenue from pollution policies instead of labor taxes will not increase employment, at least according to the analysis so far. Indeed, employment falls because the tax-interaction effect more than compensates for the revenue-recycling effect. Some level of emissions control would be appropriate on efficiency grounds if we integrated environmental benefits into the analysis, but the justification for this would be to address environmental externalities, *not* to reduce employment.

Second, some 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 permits and other environmental policies.[22] However, the results do not tell us anything about the tax-interaction and revenue-recycling effects. These effects operate through the impact of changes in real, net-of-tax wages on *labor supply* at the *economy-wide level*. As long as the labor supply elasticity is positive, we would expect labor supply to fall as higher product prices reduce the real wage.[23] A further important point to grasp is that the above analysis does *not* say that the employment losses from carbon policies are large; on the contrary, they are probably modest. However, this does not mean that the welfare losses from the fall in employment are necessarily small relative to the partial equilibrium costs of the carbon policy. The reason is that the welfare losses also depend on the tax wedge in the labor market, which is quite substantial.

Finally, it should be emphasized that even though the double dividend hypothesis is not valid in the above model, the case for auctioned carbon permits has not been eliminated. There

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[22] Other studies find more substantial employment effects, however. See Greenstone (2001).

[23] In fact it is quite possible for aggregate labor supply to fall while employment in the regulated industries actually rises. This could occur in a more general model if the emissions control policy induces firms to substitute labor for capital at the firm level.

Unfortunately, econometric testing of the tax-interaction and revenue-recycling effects is very difficult, if not impossible, to do. This is because at any one time a whole host of other factors—business cycle effects, demographics, tax policy, changes in the terms of trade, and so on—will have a much more important influence on determining the overall level of employment in the economy than a new carbon policy. Instead, we can rely only on indirect evidence that (1) people at the margin perceive an increase in the consumer price level as reducing their real wage (i.e., they do not suffer money illusion) and (2) labor supply is positively related to real wages.

can still be reason to implement this policy on environmental grounds, even if the general equilibrium costs of the policy are somewhat larger than the partial equilibrium costs.[24]

3. Freely Allocated Emissions Permits

This section looks at the cost of carbon emissions permits that are given out free to firms, and compares their cost with that of auctioned permits. Freely allocated permits lead to the same partial equilibrium costs, and the same tax-interaction effect, as auctioned permits (for a given emissions reduction). They also produce an indirect revenue-recycling effect to the extent that permit rents are taxed. However, this is only a minor fraction of the revenue-recycling effect under auctioned permits. Consequently, the overall cost difference between auctioned and freely allocated permits can be striking.

The Costs of Freely Allocated Permits

Returning to Figure 2.1, suppose that the government restricts emissions to $e-a$ by tradable permits, and the permits are given away to existing firms. The partial equilibrium costs will again be given by equation (2.1). In theory, the policy also produces the same tax-interaction effect as in equation (2.5) because it has the same impact on the price of fossil fuels as the auctioned permit policy.

However, because the permits are free to existing firms, all of the permit rents, $\tau(e-a)$, initially accrue to firms.[25] Thus, unlike in the case of auctioned permits, the government does not directly obtain a source of revenue that can be used to cut other taxes. However, a portion of the rents may indirectly go to the government. In particular, the permit rents will be reflected in higher firm profits, dividends, and share values, which may be subject to corporate, personal income, and capital gains taxation, respectively. Donating the combined effect of these taxes on profits or rents by t_P, freely allocated permits produce an indirect revenue-recycling effect (assuming revenues are used to cut labor taxes) of:

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[24] Besides producing welfare gains from mitigating pollution externalities, carbon policies may also induce significant welfare gains from stimulating research and development into cleaner production technologies. See Parry et al. (2002) for more discussion.

[25] These rents are the value of the permits—that is, the revenues a firm could obtain if it sold the permits rather than used them to cover its own emissions. They arise because the policy limits emissions and drives up the price of emissions, in the same way that a monopoly or cartel limits output and drives up price.

(3.1) $t_P M\tau(e-a)$ (*indirect revenue-recycling effect*)

Comparing equations (3.1) and (2.3), the indirect revenue-recycling effect under freely allocated emissions permits equals that under auctioned permits only in the extreme (and unrealistic) case when profits are subject to 100% taxation ($t_P = 1$). At the other extreme, if there is no taxation of profits ($t_P = 0$), there is no indirect revenue-recycling effect. For the United States, income from capital or profits is effectively taxed at around 35%.[26] Therefore, about 65% of the efficiency benefits of revenue recycling is forgone if freely allocated carbon permits are used instead of (revenue-neutral) auctioned permits.

Dividing the indirect revenue-recycling effect (3.1) by the tax-interaction effect (2.5) gives:

(3.2) $$\frac{t_P\{1-a/e\}}{1-.5a/e}$$ (*indirect revenue-recycling effect to tax-interaction effect*)

In the extreme case when $t_P = 0$, this expression is zero, since there is no indirect revenue-recycling effect, and when $t_P = 1$, this expression is the same as in (2.6) because the indirect revenue-recycling effect is identical to that under auctioned permits. Figure 3.1 plots this expression for the case when $t_P = 0.35$. Here we see that the indirect revenue-recycling effect offsets only around 25% to 30% of the tax-interaction effect, whereas under auctioned permits in Figure 2.6 the offset was 67% to 100%.

The general equilibrium cost of grandfathered permits, expressed relative to the partial equilibrium cost, is (adding (2.1) and (2.5), subtracting (3.1), and dividing by (2.1)):

(3.3) $$1+\frac{M\{(1-.5a/e)-t_P(1-a/e)\}}{.5a/e}$$

This expression is plotted in the upper set of curves in Figure 3.2, where for the solid curve we use $M = 0.25$ and $t_P = 0.35$ (the lower and upper curves indicate cases when $M = 0.15$ and 0.4, respectively). Here we see that the general equilibrium costs are about four times the partial

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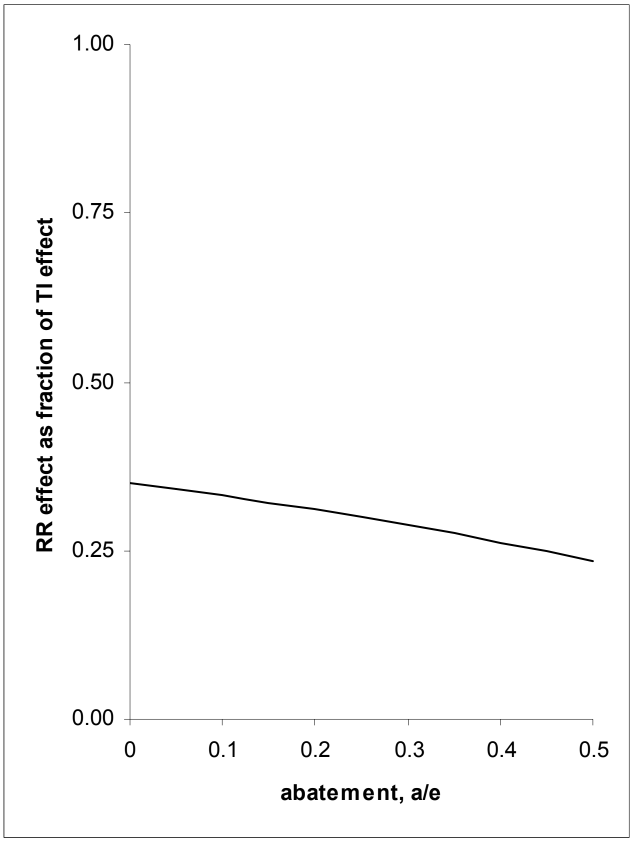
[26] See, for example, Lucas (1990). Both labor and capital income are subject to personal income taxes. Unlike labor income, profits are not subject to social security taxes, but they are subject to corporate income taxes.

equilibrium costs for an emissions reduction of 10% and twice partial equilibrium costs for an emissions reduction of 30% (for M = 0.25).[27]

Figure 3.1



The lower set of curves in Figure 3.2 shows the ratio of general to partial equilibrium costs for auctioned permits using (2.7), and this cost ratio is fixed at 1.15, 1.25, or 1.4 under different assumptions for the marginal excess burden. Thus, by comparing the upper and lower set of curves, we can compare the relative costs of auctioned and grandfathered carbon permits.

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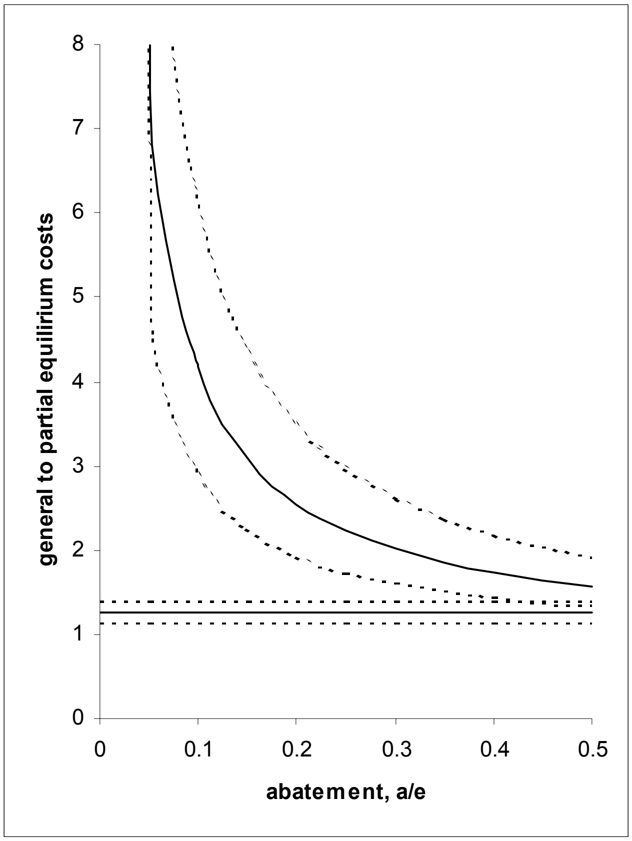
[27] Returning to the example of footnote 16 above, these simple formulas imply that interactions with the tax system would raise the cost of meeting the Kyoto targets under grandfathered permits by either $26 billion ($50 permit price scenario) or $80 billion ($150 permit price scenario).

For example, in our central case grandfathered permits are 3.3 times as costly as auctioned permits for an emissions reduction of 10%, and 1.6 times as costly for an emissions reduction of 30%.[28]

Figure 3.2



Partially Auctioned Permits

Instead of choosing either to grandfather or to auction all the carbon permits, the government may instead choose to grandfather a portion of the permits and auction off the rest. Suppose that the government grandfathers fraction α of the permits and auctions fraction $1-\alpha$ of

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[28] See Parry et al. (1999) and Goulder et al. (1999) for more discussion.

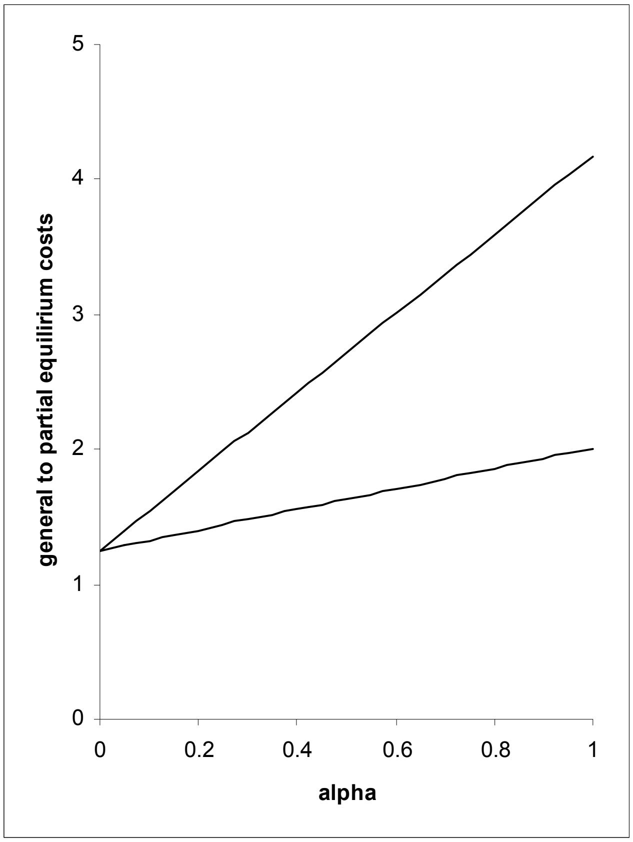
the permits. Taking a weighted average of (2.7) and (3.3), the general equilibrium cost of this policy, expressed relative to the partial equilibrium cost, is given by:

$$(3.4) \quad 1 + M\{1 - \alpha + \alpha\{(1 - .5a/e) - t_P(1 - a/e)\}.5a/e\}$$

This expression simplifies to (2.7) when α = 0 and to (3.3) when α = 1.

Figure 3.3 plots this expression against α for emissions reductions of 10% (upper curve) and 30% (lower curve), using our central value for the marginal excess burden. Therefore we can see the cost savings from auctioning a given portion of the carbon permits by comparing the height of these curves for a given value of α with the height at the extreme right when α = 1. For example, for an emissions reduction of 10%, auctioning 25% of the permits reduces (general equilibrium) costs by 18%, and auctioning 50% of the permits reduces costs by 35%.

Figure 3.3



Alternative Methods for Recycling Revenues from Auctioned Permits

The discussion of auctioned permits in this and the previous section has assumed that all of the revenues raised are recycled in reducing distortionary taxes. More generally, some or all of the revenues may be used to expand public spending or reduce a government budget deficit (or increase a surplus). The latter approach is equivalent to cutting the tax burden for future generations because it implies a smaller carryover of national debt. Cutting future taxes may yield a larger efficiency gain than cutting current labor taxes, although the magnitude of the efficiency difference is difficult to gauge (see Section 4).

Loosely speaking, about two-thirds of government spending might be regarded as transfer spending. This includes transfer payments (e.g., pensions) and in-kind transfers (e.g., food stamps, housing subsidies). It also includes public spending that is a close substitute for private goods (e.g., education, medical services). If all the revenues from auctioned permits were used to increase transfer spending, auctioned permits would be equivalent to grandfathered permits (with revenues from taxes on rents returned lump-sum to households). For this case, using (3.2) with $t_P = 0$, the general equilibrium cost of the policy expressed relative to the partial equilibrium cost would be:

$$(3.5) \quad 1 + M(2e/a - 1)$$

Suppose instead that the revenues were used to expand spending on public goods, such as national defense, police, and roads. We denote the social benefits per dollar of extra spending by B; hence the efficiency gain per dollar of extra spending (i.e., the social value less the opportunity cost of a dollar) is $B-1$. In the extreme case when $B = 0$, public spending is completely wasteful because it has no value to households, but if the extra spending is justified on a simple cost-benefit criterion, $B>1$. Indeed, if $B-1 > M$, the social benefits of revenue recycling exceed the social benefits from using the revenue to cut distortionary taxes. Using (2.1), (2.3) with M replaced by $B-1$, and (2.5), the general equilibrium cost of the policy, expressed relative to the partial equilibrium cost, is given by:

$$(3.6) \quad 1 + 2\{M(e/a - .5) - (B-1)(e/a - 1)\}$$

This expression collapses to 1+M, the general to partial equilibrium cost ratio for auctioned permits in equation (2.7), when the social benefits from an extra dollar of spending equal the social benefits from using that dollar to cut distortionary taxes (B−1 = M). The expression is smaller (greater) than 1+M when B−1 is greater (less) than M.[29]

Figure 3.4 shows the general to partial equilibrium cost ratio for auctioned permits using (3.6) and our central value for the marginal excess burden. The lowest curve illustrates the case when $1 of extra spending generates social benefits of $1.30. Here the overall cost of the carbon policy is actually negative for emissions reductions below 7%. If the $1 of extra spending produces $1 in social benefits, the costs are shown by the dashed curve. Finally, the upper solid curve illustrates a case when social spending is wasteful—here $1 of spending generates social benefits of only $0.80. This is the most costly policy overall; for example, the general to partial equilibrium cost ratio is 3.4 at an emissions reduction of 30%.

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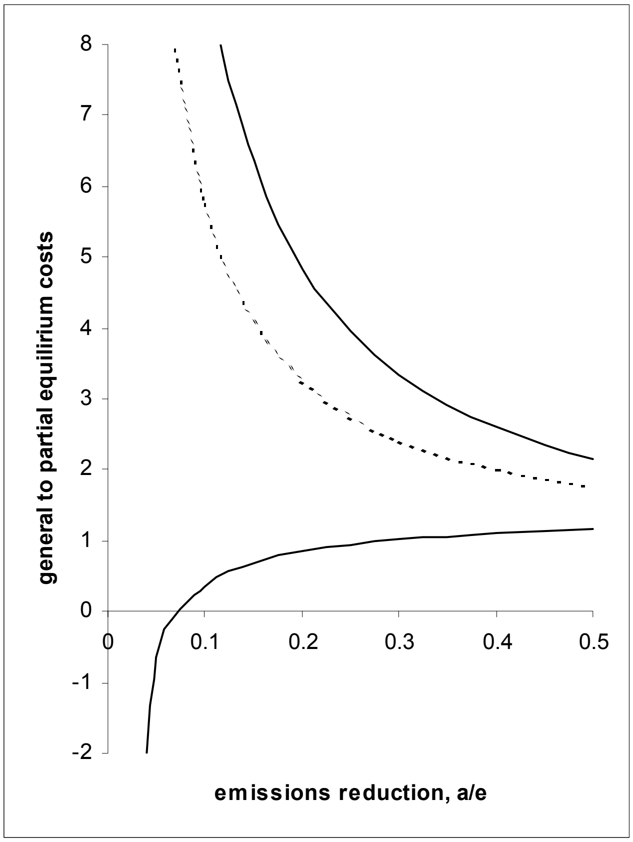
[29] A complication that we abstract from here is that labor supply effects may differ somewhat according to the degree of substitution between public spending and private spending. For more discussion, see, for example, Browning et al. (2000) and Ballard and Fullerton (1992).

Figure 3.4



4. Additional Complications of the Tax System

This section discusses various generalizations to the previous analysis. These include how the presence of tax deductions can raise the efficiency gain from revenue recycling and how carbon policies might interact with the capital market.

Tax Deductions

The analysis developed in the previous two sections assumed that households pay a uniform tax on labor earnings. As a result, the labor income tax distorts the returns from working versus nonmarket activity but not the pattern of household spending among goods. In practice however, certain types of household spending may be deducted from taxable income. The most important example in the United States is the deduction from federal and state income taxes for mortgage interest on owner-occupied housing. In addition, many forms of nonwage compensation or fringe benefits are exempt from income and social security taxes. The most important example in this category is employer-provided medical insurance.

Those types of provisions—tax deductions and tax exemptions—cause additional distortions in the economic system. In particular, they distort the pattern of household spending by effectively subsidizing certain types of expenditure (on housing, health care) relative to other (non-tax-favored) expenditure. The important point here is that these tax provisions raise the efficiency costs of the tax system.[30] In turn, this means that they raise the efficiency gain from using revenues from auctioned permits to reduce preexisting income taxes.[31]

A Closer Look at the Costs of the Tax System

Figure 4.1 shows the market for tax-favored goods, representing an aggregate of owner-occupied housing, medical insurance, other fringe benefits, and so on, where D is the demand curve, S is the supply curve, and we have normalized the producer price to unity.[32] The efficient consumption of tax-favored goods would be F_0, where the demand (or marginal benefit to consumers) intersects the supply (the marginal cost of producing output). However, if spending is partly or fully deductible against an income tax of t, then the effective price of tax-favored consumption is 1–s in Figure 3.1, where s = t if all spending is tax deductible, and 0<s<t if

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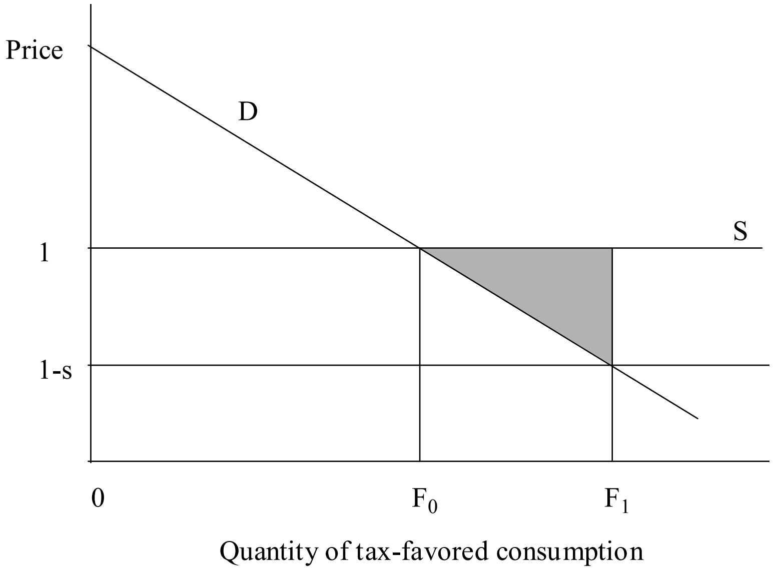
[30] The implications of tax deductions for the overall deadweight costs of the tax system have recently received a lot of attention in the public finance literature (e.g., Feldstein 1999; Auten and Carroll 1999; Slemrod 1998; Parry 2001). Parry and Bento (2000), on which this subsection is based, discuss how tax deductions affect the general equilibrium costs and welfare effects of a range of environmental policies.

[31] Tax subsidies are sometimes defended on the grounds that they correct for market imperfections. For example, homeownership might confer external benefits if people take better care of houses when they own their homes rather than rent. Medical insurance might be suboptimal because of adverse selection problems: if insurance companies cannot distinguish between people with different health risks, then high-risk people will tend to crowd out low-risk people from the market in the same way that "lemons" crowd out high-quality cars in Akerloffs (1970)'s used-car market. However, it seems unlikely that these types of market imperfections are large enough to justify the quite substantial subsidies for housing and health insurance, which amount to roughly 30%–40% of expenditure on these items (e.g., Rosen 1985; Pauly 1986). Moreover, there are other distortions that operate in the opposite direction. For example, housing development contributes to problems of urban sprawl and congestion and is also subsidized through public provision of new schools, roads, etc. Expenditure on medical care for those with insurance can be excessive when insurance companies pay the marginal cost of prescriptions, hospital stays, and so on. Most likely, medical insurance and housing do, on balance, receive a large net subsidy, although the magnitude of the distortion in these markets is difficult to pin down accurately, given the complicating factors.

[32] Again, for simplicity we assume that the long-run supply curve is flat, which might be a reasonable approximation for housing and medical insurance (e.g., King 1980; Rydell 1982).

spending is partially deductible. Consumption is F_1 and the shaded triangle is the deadweight loss of the tax subsidy. It equals the gap between the marginal cost of producing tax-favored goods and the marginal benefit, integrated between F_0 and F_1.

Figure 4.1



With tax deductions, the marginal excess burden of the labor income tax is now given by (see Appendix):

$$(4.1)\qquad M_D = \frac{\dfrac{t}{1-t}\varepsilon + \pi_F \dfrac{s}{1-s}\eta}{(1-\pi_F) - \left\{\dfrac{t}{1-t}\varepsilon + \pi_F \dfrac{s}{1-s}\eta\right\}}$$

where η is the (absolute value of the) elasticity of demand for tax-favored consumption and π_F is the production share of tax-favored consumption in GDP. Comparing equations (4.1) and (2.2), the additional term in the numerator reflects the deadweight loss in the market for tax-favored goods from the increase in consumption of F when the tax-subsidy is increased. In the denominator, increasing the income tax rate generates less extra revenue because the base of the income tax is smaller and because the erosion of the tax base in response to a higher t is larger when there is an increase in tax-favored consumption.

At first glance, it is not obvious why the presence of tax subsidies should have much effect on the marginal excess burden of labor income taxes. In particular, the tax-favored sector is only around 10% to 15% of the labor market, $\pi_F = 0.1$ to 0.15 (e.g., Parry 2001), suggesting that the additional expressions in (4.1) should be relatively small.[33] However, the welfare effect of an increase in the tax subsidy also depends on the induced increase in the quantity of tax-favored consumption, reflected in η. As mentioned above, the empirical literature on labor supply elasticities suggests that labor supply is only moderately sensitive to changes in labor tax rates. In contrast, empirical studies suggest that the demand for owner-occupied housing and for medical insurance is relatively more responsive to price changes.[34] Therefore, because η is significantly larger than ε in (4.1), the presence of tax deductions can still have a significant effect on the marginal excess burden of labor income taxes, even if π_F is a small number.

Implications for the Revenue-Recycling and Tax-Interaction Effects

If revenues from the auctioning of carbon emissions permits are used to reduce income taxes, the recycling will (marginally) reduce distortions in both the labor market and the market for tax-favored consumption. Analogous to equation (2.3), the welfare gain from the revenue-recycling effect is now:

(4.2) $M_D\tau(e-a)$

where the marginal excess burden M_D is now defined by equation (4.1).[35]

As before, carbon emissions permits drive up product prices and reduce the real household wage, and hence labor supply. However, if for the moment we assume that fossil fuels are used in the same intensity in both the tax-favored and non-tax-favored sectors, the carbon policy does not exacerbate the subsidy to tax-favored consumption. In other words, the prices of tax-favored consumption and ordinary consumption increase in the same proportion. The efficiency loss from the tax-interaction effect under carbon permits is given by (Parry and Bento 2000):

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[33] In other words, the absolute welfare effect in the labor market should swamp the absolute welfare effect in the market for tax-favored consumption, because the labor market is six to ten times the size of the market for tax-favored consumption.

[34] See, for example, Rapaport (1997), Rosen (1985), Pauly (1986), Phelps (1992), and Hoyt and Rosenthal (1992).

[35] The revenue-recycling effect would not be as large if permit revenues were used to reduce payroll taxes rather than income taxes. This is because only a portion of tax-favored items (fringe benefits but not expenditures on, for example, mortgage interest) is exempt from payroll taxes, while essentially all the items are deductible from income taxes.

$$(4.3)\qquad \frac{M}{1+M}(1+M_D)\cdot\tau\left\{e-\frac{a}{2}\right\}$$

Comparing equations (4.3) and (2.5), the tax-interaction effect increases by *less* than in proportion to M_D because it does not directly exacerbate the subsidy distortion. (The tax-interaction effect does increase somewhat because of the efficiency loss attached to the reduction in labor tax revenues increases.) Dividing the revenue-recycling effect in (4.2) by the tax-interaction effect in (4.3) gives:

$$(4.4)\qquad \frac{M_D/(1+M_D)}{M/(1+M)}\left\{\frac{1\text{ - }a/e}{1-.5a/e}\right\} \qquad (\textit{revenue-recycling effect to tax-interaction effect})$$

Empirical studies of the marginal excess burden of income taxes when the role of tax deductions is taken into account are very preliminary at this stage. Nonetheless, in my view a reasonable illustrative range of values to consider for M_D would be 0.3, 0.4, and 0.5, based on evidence about π_F and η.[36]

The lower, middle, and upper curves in Figure 4.2 plot the formula in (4.4) for M_D equal to 0.3, 0.4, and 0.5 and using $M = 0.25$. In most cases the curves lie above unity, except in the case of our low value for M_D and when the emissions reduction is above 23%. In other words, in most scenarios the revenue-recycling effect dominates the tax-interaction effect and the imposition of revenue-neutral carbon permits decreases the efficiency cost of preexisting taxes. The intuition for this result is that the preexisting tax system is inefficient along a nonenvironmental dimension, and the carbon policy works to mitigate this source of inefficiency. By effectively taxing an input into both tax-favored and non-tax-favored sectors, and using the revenues to reduce (slightly) the tax subsidy, the impact of the carbon policy is to slightly shift the burden of the tax system onto the tax-favored sector, hence producing an efficiency gain from interactions with preexisting taxes.[37]

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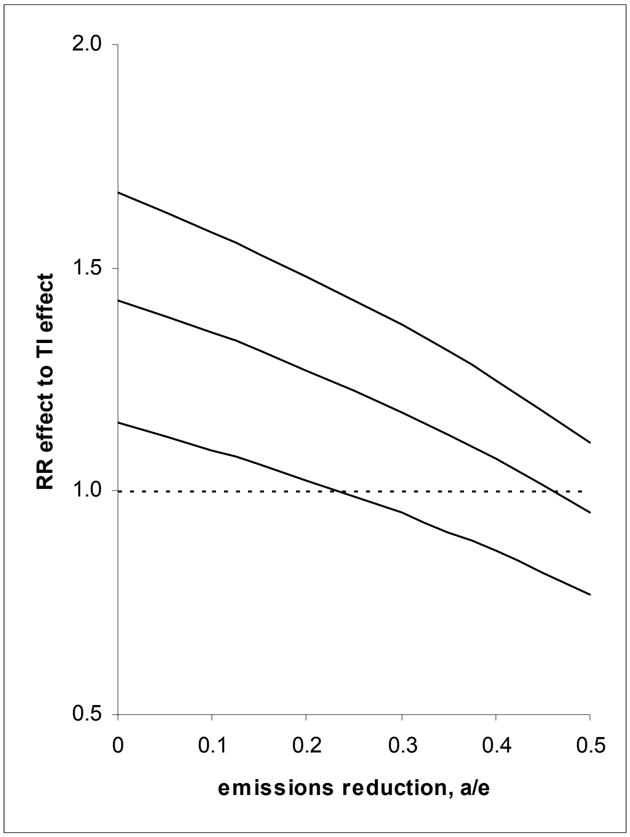
[36] See Parry (2001), Table 2a.

[37] However, the policy is still less efficient at raising revenue in the sense that auctioned carbon permits have a narrow base relative to economy-wide income taxes. This inefficiency becomes relatively more important the greater the extent of abatement; hence the curves in Figure 4.2 are downward sloping.

Figure 4.2



Revisiting the Costs of Auctioned Permits and the Double Dividend

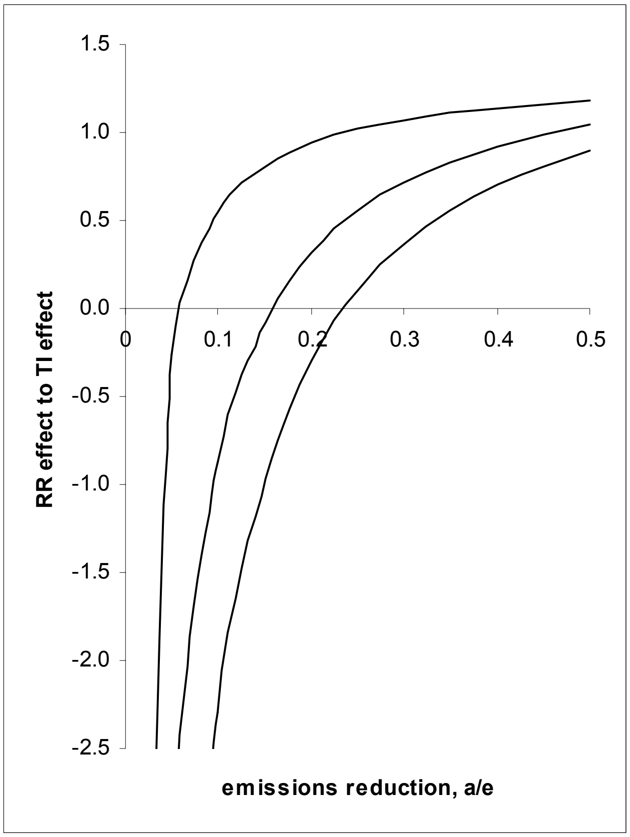
The partial equilibrium costs of the auctioned carbon permit policy are still given by equation (2.1). Adding the partial equilibrium cost to the tax-interaction effect (4.3), subtracting the revenue-recycling effect (4.2), and dividing by the partial equilibrium cost gives:

$$(4.5) \quad 1+2\left\{\frac{M(1+M_D)}{1+M}\left(\frac{e}{a}-.5\right)-M_D\left(\frac{e}{a}-1\right)\right\}$$

Figure 4.3 plots this expression where the lower, middle, and upper curves correspond to $M_D = 0.3$, 0.4, and 0.5 (we use the central value of $M = 0.25$ from Section 2).

The presence of tax deductions substantially reduces the general equilibrium costs of the auctioned carbon policy relative to the partial equilibrium cost, particularly for modest levels of abatement. For example, the general equilibrium costs are now negative for emissions reductions below 17% in the central case when $M_D = 0.4$. This means that—ignoring environmental benefits—the overall cost of the carbon policy is negative, since the net gain from the revenue-recycling and tax-interaction effects more than offsets the partial equilibrium cost of the policy. This has been referred to as the "strong" double dividend in the literature (Goulder 1995a). For most other scenarios (except when $M_D = 0.3$ and emissions reductions exceed 23%), the curves lie below unity, implying that the general equilibrium costs of the policy are lower than the partial equilibrium costs. For example, in the central case general equilibrium costs are less than 50% of the partial equilibrium costs for emissions reductions below 24%.[38]

Figure 4.3



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[38] Returning to the example in footnote 16 of emissions reductions under the Kyoto Protocol, in the \$50 permit price scenario, partial equilibrium costs, the revenue-recycling effect, and the tax-interaction effects are now \$13 billion, \$25 billion, and \$21 billion, respectively. In the \$150 permit price scenario, these figures are \$40 billion, \$75 billion, and \$64 billion, respectively.

Grandfathered versus Auctioned Permits

Analogous to equation (3.1) for grandfathered permits, the indirect revenue-recycling effect is given by:

$t_P M_D \tau(e-a)$

The tax-interaction effect is given by equation (4.3).

Using (2.1), (4.3), and (4.6), it can be shown that with the above range of values for M_D and the central values for M, the general to partial equilibrium cost ratio for grandfathered permits is similar to that in Figure 3.2 of Section 3. The indirect revenue-recycling effect is larger, but so is the efficiency loss from the reduction in tax revenues due to the erosion of the income tax base: these two effects are roughly offsetting.

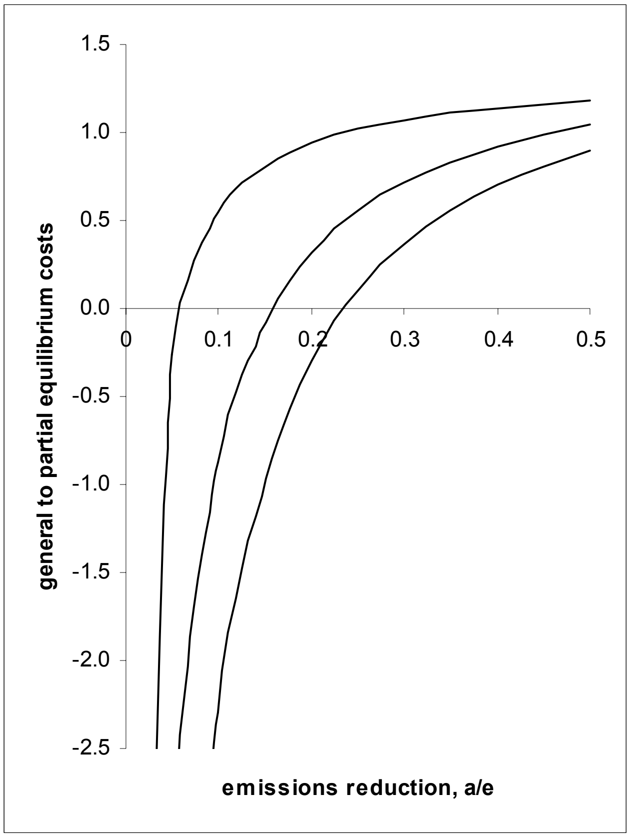
Subtracting the indirect revenue-recycling effect under grandfather permits (4.6) from the revenue-recycling effect under auctioned permits (4.3) and dividing by partial equilibrium costs (2.1) gives:

$$(4.7) \qquad 2(1-t_P)\left(\frac{e}{a}-1\right)M_D$$

This expression is the cost savings from using auctioned permits instead of grandfathered permits, expressed relative to the partial equilibrium cost.

The curves in Figure 4.4 plot the formula in (4.7) for our low, central, and high values for M_D, (with $M = 0.25$ and $t_P = 0.35$). The cost savings from auctioning carbon permits amount to 3.2–5.4 times the partial equilibrium costs at a 10% emissions reduction, and 0.8–1.4 times the partial equilibrium costs at a 30% emissions reduction.

Figure 4.4



Interactions with the Capital Market

Expanding the analysis of Sections 2 and 3 to incorporate capital accumulation over time, taxes on capital, and interactions between carbon policies and the capital market is theoretically very complicated—most of the analytical models in the literature are static and exclude capital.[39] Moreover, there is considerable uncertainty over the magnitude of the excess burden of capital taxes because estimating the price sensitivity of capital is difficult, which in turn makes it difficult to expand previous calculations of the proportionate changes in the costs of carbon

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[39] Two notable exceptions, on which this subsection draws, are Bovenberg and Goulder (1997) and Williams (2000).

policies due to interactions with the tax system. Nonetheless, we can still obtain some useful qualitative insights.

To do this, it is helpful to use a simplified framework. Consider a static model with two primary factors of production, labor and capital, which are both supplied by households and used by firms. In addition, suppose that all industries in the economy use capital and labor in the same proportion and have constant returns to scale production functions. Assume a uniform tax on labor and capital income and no tax deductions. We take the share of labor income in GDP to be 75%, and the share of capital income, 25%—figures roughly representative of the U.S. economy. Under these conditions, changes in income tax rates do not cause firms to substitute labor for capital, or vice versa. The marginal excess burden of the income tax with respect to labor will be the same as before, and the marginal excess burden with respect to capital will be greater than that for labor if the supply of capital is more elastic than the supply of labor. There is a consensus that the marginal excess burden is higher for capital than for labor, but by how much is highly uncertain (e.g., Judd 1987). In Bovenberg and Goulder (1997) the marginal excess burden of capital is about 30% higher for capital than for labor, but in Jorgenson and Wilcoxen (1992) it is much larger. To be generous about the significance of capital market interactions, we assume the marginal excess burden for capital is twice that of labor.[40]

In this more general model, the aggregate tax-interaction effect is now a weighted average of the tax-interaction effect in the labor and capital markets (Williams 2000), and we are using weights of 0.75 and 0.25, respectively.[41] The tax-interaction effect in the labor market for auctioned and grandfathered permits is the same as discussed in Sections 2 and 3 (equation (2.5)), and the tax-interaction effect in the capital market is analogous, except that the marginal excess burden for labor is replaced by the marginal excess burden for capital. Thus, if the marginal excess burden for labor and capital were the same, the size of the aggregate tax-interaction effect relative to the partial equilibrium costs would be the same as before. But in the

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[40] Using a static analysis, with capital treated as another factor input like labor, obviously simplifies the analysis. However, the same qualitative results carry over to a dynamic model with capital accumulation over time. In these dynamic models the marginal excess burden of capital tends to exceed that for labor: the former distorts the allocation of consumption between current and future periods, in addition to distorting the labor-leisure decision in each period; the latter distorts just the labor-leisure decision (e.g., Lucas 1990).

[41] The increase in product prices brought about by the carbon policy reduces the real returns to capital income in the same way that it reduces the real returns to labor income; hence it discourages saving in addition to labor supply.

example when the marginal excess burden of capital is twice that of labor, the aggregate tax-interaction effect increases by 25% relative to partial equilibrium costs.

Suppose that the revenue from auctioning permits finances proportional cuts in both labor and capital taxes. The welfare gain from revenue recycling will be a weighted average of the marginal excess burden of labor and capital, times the amount of revenue raised (Williams 2000). Using our weights of 0.75 and 0.25, and taking the example when the marginal excess burden of capital is twice that of labor, the revenue-recycling effect increases by 25% (compared with Section 2). Thus, since both the revenue-recycling and the tax-interaction effects increase by 25% in this example, the general to partial equilibrium cost ratio for auctioned permits increases from 1.25 to 1.31 under our central parameter values. Similarly, since the indirect revenue-recycling effect under grandfathered permits also increases by 25%, the general to partial equilibrium cost ratio curves in Figure 3.2 would all shift up by 25%.

Suppose instead that revenues from auctioned permits are used entirely to reduce capital taxes rather than to reduce capital and labor taxes in the same proportion. For this case the revenue-recycling effect would be proportional to the marginal excess burden of capital taxes. This creates the possibility of a double dividend, as in the case of tax deductions. Indeed, the general equilibrium to partial equilibrium cost curves for auctioned permits would be lower than those in Figure 4.3 if the marginal excess burden of capital exceeded the marginal excess burden of income taxes with tax deductions (0.4).

The reason for the double dividend is that, as in the case of tax deductions, the tax system is inefficient along a nonenvironmental dimension: capital is overtaxed relative to labor in efficiency terms. By concentrating all of the permit revenues in capital tax reductions the policy generates a slight shift in the burden of taxation at the economy-wide level away from capital and onto labor.

There are several caveats to this result, however. First, when we relax the assumption that the capital to labor ratio is constant across industries, the prospects for a double dividend weaken. Energy-intensive industries tend to be capital-intensive (Bovenberg and Goulder 1997). This means that relatively more of the tax-interaction effect will be felt in the capital market and less in the labor market, implying a larger tax-interaction effect. Second, shifting the burden of taxation off capital by means of a carbon policy is a very indirect and inefficient way to address the fiscal distortion. A much better policy would simply be to cut capital taxes and increase labor taxes. Third, however, such a tax shift, engineered directly or indirectly through carbon policy, would have adverse distributional effects because capital income tends to be a greater share of income for better-off households than for poorer households. For this reason, using revenues from carbon permits exclusively to cut capital taxes might be viewed as undesirable.

Further Issues

Two other issues that have received some attention in the "double dividend" literature are worth mentioning. First, it has been pointed out that when environmental quality enters the utility function in a nonseparable fashion, then changes in pollution can have feedback effects on labor supply—for example, by improving worker health (e.g., Williams 2000). These types of feedback effects can have a moderate effect on the costs and optimal level of emissions control policies for local air pollutants if the environmental damages occur quickly. However, since potential climate-related benefits from current emissions reductions are unlikely to be felt for several decades, it seems reasonable to exclude them when assessing the costs to today's economy from carbon policies.

Second, using jargon from the theoretical literature on optimal tax systems, the above analysis assumes that carbon or energy-intensive consumption goods are average leisure substitutes. Put another way, the reduction in labor supply from the effect of higher energy prices on reducing the real household wage is proportional to the effect of lower nominal household wages on labor supply.[42] More generally, if energy-intensive consumption goods were relatively weak (strong) substitutes for leisure, the tax-interaction effect would be smaller (larger), and the general equilibrium costs of carbon policies, lower (higher). However, econometric evidence is lacking on the relative sensitivity of labor supply to energy prices, compared with the labor supply effects of higher product prices in general. Thus it is difficult to assess the direction of this effect, let alone its magnitude.

5. Summary

This report uses a series of simple diagrams and formulas to illustrate how the costs of carbon control policy change when allowance is made for how they interact with the tax system. In the simplest model with a preexisting tax on labor, auctioned carbon permits slightly reduce

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[42] Technically, this amounts to assuming that leisure is weakly separable from consumption goods in the household utility function, and that preferences over consumption goods are homothetic (i.e., all goods have unitary income elasticities).

labor supply, even when permit revenues are used to cut labor income taxes. The general equilibrium costs are about 25% higher than the partial equilibrium costs. However, when allowance is made for additional distortions of the tax system—namely the distortion between tax-favored and ordinary spending—the efficiency gains from recycling permit revenues are larger. The general equilibrium costs of the policy are below the partial equilibrium costs; indeed, they can be negative for modest amounts of abatement.

If carbon permits are grandfathered rather than auctioned, the government forgoes the efficiency gains from revenue recycling (although it still receives some revenue from the taxation of rent income). The general equilibrium costs of this policy are much higher than the partial equilibrium costs. In fact, there can be much more at stake in terms of economic efficiency in the choice of policy instrument (whether to use auctioned or grandfathered permits) than the entire costs of the policies within the energy sector.

Although the mechanisms highlighted in the above discussion would be at work in more sophisticated computable general equilibrium models of carbon permits, the general to partial equilibrium cost ratio might differ somewhat. For example, more general models relax the assumption of linear marginal abatement cost curves. Moreover, tax interactions are more complex in a dynamic setting with capital accumulations and preexisting taxes on investment and savings.

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Appendix

Labor Market Parameters and the Marginal Excess Burden

The labor supply elasticity underlying the formula in (2.3) reflects the effect of changes in net of tax wages on the labor force participation decision and the amount of hours worked per employee, averaged over all male and female workers in the economy. Looking at only the hours-worked elasticity (holding participation rates fixed) or looking only at male labor supply elasticities can be very misleading. Based on reviews by Fuchs et al. (1998), Blundell and MaCurdy (1999), and Russek (1996), and attaching weights of 0.55 and 0.45 to the male and female elasticities, respectively, a reasonable range of values to use for the economy-wide compensated labor supply elasticity seems to be about 0.2 to 0.5.

Several taxes combine to drive a wedge between what firms pay for labor and what goods households are able to buy with their labor earnings. These include federal and state personal income taxes, payroll taxes paid by employers and employees, sales taxes, and excise taxes. Together these taxes amount to about 36% of net national product (e.g., Parry 2001). This is the average rate of labor tax and it is relevant for the participation decision. The marginal rate of labor tax for the average household is about 43%, according to Browning (1987), and this is relevant for the hours-worked decision. Roughly two-thirds of the economy-wide labor supply elasticity is due to the participation decision (mainly of secondary workers) and one-third is due to the hours-worked decision. Applying these weights gives a weighted-average labor tax rate of 38%. Using $t = 0.38$ and $\varepsilon = 0.2–0.5$ in (2.2) gives a marginal excess burden of about 0.15 to 0.4.

Deriving Equation (4.1)

Assuming ds/dt = 1, the deadweight loss from the tax increase is now

$$-t\frac{\partial L}{\partial t} - s\frac{\partial F}{\partial(1-s)}$$

This is the incremental welfare loss in the labor market plus the welfare loss in the market for tax- favored consumption, equal to the increase in F from a unit reduction in price times the subsidy wedge s. Government revenue is $tL - sF$—that is, labor tax revenue net of the tax subsidy. Differentiating gives:

$$L + t\frac{\partial L}{\partial t} - F + s\frac{\partial F}{\partial(1-s)}$$

Dividing the former expression by the latter and making the following substitutions

$$\varepsilon = \frac{\partial L}{\partial(1-t)}\frac{1-t}{L}; \qquad \eta = -\frac{\partial F}{\partial(1-s)}\frac{1-s}{F}; \qquad \pi_F = \frac{F}{L}$$

we can obtain (4.1).