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ENVIRONMENTAL TAXATION AND THE "DOUBLE DIVIDEND:" A READER'S GUIDE

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ABSTRACT

In recent years there has been great interest in the possibility of substituting environmentally motivated or "green" taxes for ordinary income taxes. Some have suggested that such revenue-neutral reforms might offer a "double dividend:" not only (1) improve the environment but also (2) reduce certain costs of the tax system. This paper articulates different notions of "double dividend" and examines the theoretical and empirical evidence for each. In addition it draws connections between the double dividend issue and principles of optimal environmental taxation in a second-best setting.

A weak double dividend claim is that returning tax revenues through cuts in distortionary taxes leads to cost savings relative to the case where revenues are returned lump sum. This claim is easily defended on theoretical grounds and (thankfully) receives wide support from numerical simulations. The stronger versions contend that revenue-neutral swaps of environmental taxes for ordinary distortionary taxes involve zero or negative gross costs. Theoretical analyses and numerical results tend to cast doubt on the strong double dividend claim. At the same time, the theoretical case against the strong form is not air-tight, and the numerical evidence is mixed.

In simple models, the conditions under which the strong double dividend claim is rejected (upheld) are closely related to the conditions under which the second-best optimal environmental tax is less than (greater than) the marginal environmental damages.

The difficulty of establishing the strong double dividend claim heightens the importance of attending to and evaluating the (environmental) benefits from environmental taxes.

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I. Introduction

Economists have long favored the use of taxes as instruments of environmental protection. To many economic analysts, in situations involving serious externalities taxes are the most effective mechanism for "getting the prices right" -- that is, for helping prices closely approximate marginal social costs. The notion that taxes can improve welfare outcomes by internalizing externalities traces back at least as far as Pigou (1938) and is a central tenet of environmental economics.

Real-world economies obtain public revenues not only through environmental (corrective) taxes but also through distortionary taxes such as income, payroll, and sales taxes. What constitutes getting the prices right (or merely closer to right) is more complicated in a second-best setting where both types of taxes are present than in a world with environmental taxes alone. This is the case for at least two reasons. First, taxes interact. In particular, the *gross*[1] costs of newly imposed environmental taxes are regulated by pre-existing distortionary taxes.[2] Second, the presence of other taxes introduces the possibility of "swapping" an environmental tax for an existing tax. Consider a tax reform in which an environmental tax is introduced and its revenues are used to finance reductions in the income tax. The overall gross cost of this revenue-neutral package depends not only on the (gross) costs of the environmental tax itself but also on the efficiency benefits (avoided efficiency costs) associated with the reduction in income tax rates.[3]

These issues have come to life in recent analyses and policy debates surrounding the carbon tax

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[1] I emphasize "gross" to make clear that the discussion here concerns only the cost (or non-environmental) side of the ledger. Clearly environmental taxes generally yield both benefits (from improved environmental quality) and costs (or abatement costs). Overall efficiency reflects both sides of the ledger, that is, *net* benefits. The present discussion focuses on the cost side. Later on, the paper will connect this discussion to considerations of environmental benefits.

[2] Partial equilibrium analysis suggests that the incremental gross efficiency cost of a new tax in a given market is higher, the larger are pre-existing taxes in that market. This follows from the basic notion in public economics that the costs of a given tax tend to rise with the square of the overall tax rate. However, as emphasized later in this paper, tax interactions extend across markets: pre-existing taxes in other markets significantly affect the costs of a new tax in a given market.

[3] This idea was advanced several decades ago by Tullock (1967) and Kneese and Bower (1968), and somewhat more recently by Nichols (1984). Terkla (1984) appears to have been the first to perform a numerical assessment of the efficiency benefits associated with devoting environmental tax revenues to cuts in existing taxes.

option. Initial work on carbon taxes tended to ignore other distortionary taxes. In most of the initial studies it was assumed that the revenues from this tax would be returned to the economy in a lump-sum fashion.[4] Subsequent analyses pointed out, however, that the revenues could be used to finance reductions in ordinary, distortionary taxes.[5] Several analysts have indicated that this could significantly reduce the costs[6] of the carbon tax. Indeed, some have suggested that these costs could be zero or negative when opportunities to "recycle" the revenues through cuts in distortionary taxes are taken into account. However, some recent theoretical and empirical work points out an effect that works in the opposite direction, revealing ways that existing distortionary taxes may interact with the carbon tax and thereby enlarge the carbon tax's costs. While recognizing that recycling the revenues can reduce the costs of a carbon tax, this work shows that for any given method of recycling, pre-existing taxes augment the costs. Much of this work indicates that this *tax interaction effect* is larger than the *revenue-recycling effect*, so that, overall, a revenue-neutral carbon tax is likely to involve positive costs in a second-best setting.

The term "double dividend" relates directly to these discussions. Pearce (1991) noted that swaps of environmental taxes for distortionary taxes may produce a double dividend by not only (1) discouraging environmentally damaging activities but also (2) reducing the distortionary cost of the tax system. The double dividend concept is relevant to many important ideas in second-best environmental taxation. Unfortunately, the term is used in different ways: the dividend represented by (2) above, in particular, can have very different interpretations. This has led to some confusion. This paper will distinguish the different notions of "double dividend" and analyze the theoretical and empirical support for each. The main motivation here is not to develop a taxonomy but rather to clarify key issues relevant to the

[4]For example, in its Model Comparison Project undertaken in 1990-2, the OECD commissioned six models to investigate the costs of reducing CO_2 emissions through carbon taxes. In this investigation, costs were evaluated assuming lump-sum replacement of revenues. Only two of the six models were capable of assuming alternative forms of revenue-replacement. On this see OECD (1992).

[5]For general discussions, see, for example, Pearce (1991), Poterba (1991), Oates (1991), Pezzey (1992), and Repetto *et al.* (1992). For numerical assessments, see Shackleton *et al.* (1992) and Gaskins and Weyant (1994) for results from several models; see also Section IV's references to the models discussed in that section.

[6]For the rest of this paper, "costs" refers to the gross costs (that is, abstracting from environmental benefits) unless otherwise indicated.

formulation of environmental policy in second-best economies. The discussion is intended to help delineate the circumstances under which the substitution of "green" or environmentally motivated taxes for typical existing taxes is likely to be an efficiency-improving venture.

Before launching into the specifics of the double dividend issue, it may be useful to view this issue in a broader context. There is widespread agreement as to the ability of environmental taxes to confer the first dividend above (environmental improvement), although the magnitude of this dividend usually is highly uncertain. On the other hand, there is much debate as to what kind of additional (second) dividend, if any, might be offered by environmental taxes. The preoccupation with the possibility of a second dividend, in my view, reflects the uncertainties about the magnitudes of the first. Much of the debate about the second dividend is in terms of whether environmental taxes can be introduced in a way that is costless. The no-cost idea is highly attractive to policymakers who are interested in "green tax swaps" but are frustrated by the uncertainties as to the values of the environmental benefits that would result from such swaps. Under these conditions, the no-cost idea is especially appealing. If revenue-neutral environmental tax policies are costless, then the burden of proof facing the policymaker is much reduced: to justify the environmental tax on benefit-cost grounds, it suffices to know the *sign* of the environmental benefits -- to know that they are positive. If costs are zero (or negative), this guarantees positive net benefits. On the other hand, if one cannot be assured that the costs are zero, then before one can recommend an environmental tax swap on efficiency grounds one has to be involved in the messy business of comparing (uncertain) environmental benefits with abatement costs.

Thus the debate about the double dividend reflects the desire to be able to make safe judgments about environmental reforms in the presence of uncertainty. In my view, it makes a difference how this debate is resolved, because this could influence what policymakers view as the minimal information requirements for fruitful environmental tax reform.

The rest of this paper is organized as follows. Section II distinguishes three interpretations of the double dividend concept and comments on the implications of each. The stronger interpretations are most relevant to policy evaluation, and subsequent sections of the paper deal primarily with them. Section III examines the theoretical evidence for or against the stronger double dividend notions. Section IV presents numerical results. Section V discusses the relationship between this issue and optimal environmental taxation. The final section offers conclusions.

II. Three Double Dividend Propositions

One can distinguish several double-dividend claims that might be made about a given environmental tax initiative such as a carbon tax. Here are three:[7]

> *Weak Form:* By using revenues from the environmental tax to finance reductions in marginal rates of an existing distortionary tax, one achieves cost savings relative to the case where the tax revenues are returned to taxpayers in lump-sum fashion.
>
> *Intermediate Form:* It is possible to find a distortionary tax such that the revenue-neutral substitution of the environmental tax for this tax involves a zero or negative gross cost.
>
> *Strong Form:* The revenue-neutral substitution of the environmental tax for *typical* or *representative* distortionary taxes involves a zero or negative gross cost.

A. The Weak Form

These hypotheses differ in terms of what they propose about the costs of revenue-neutral environmental tax policies. Let "gross cost" refer to the cost of a given tax initiative, abstracting from whatever environmental benefits apply. Let $C(t_E, \Delta T_L)$ denote the gross cost of the new environmental tax t_E accompanied by lump-sum tax reductions ΔT_L sufficient to make the policy revenue-neutral. Similarly, let $C(t_E, \Delta t_X)$ denote the gross cost of the new tax t_E accompanied by cuts in the distortionary tax Δt_X sufficient to achieve revenue-neutrality. The first proposition asserts that:

$$C(t_E, \Delta t_X) < C(t_E, \Delta T_L). \tag{1}$$

[7] Other notions have appeared. In European discussions, reduced unemployment and increased profits are often referred to as the potential extra dividends (in addition to improved environmental quality) from environmental taxes. See, for example, Bovenberg and van der Ploeg (1993a), Carraro, Galeotti, and Gallo (1994), and Nielsen, Pedersen, and Sorensen (1994). In this paper, the extra dividend is more fundamental: it relates to gross welfare costs rather than specific economic variables (such as employment or profits) that contribute to welfare.

The gross cost is lower when revenues are replaced through cuts in the distortionary tax than when revenues are replaced lump-sum. Under this proposition, the "second" dividend is the lower distortionary cost in the former case (left-hand side) relative to the cost in the latter case (right-hand side).

The weak double dividend notion is relatively uncontroversial. This is fortunate, because the key assumption on which it depends is relatively innocuous. The weak double dividend claim can be shown to be equivalent to the claim that replacing, at the margin, a lump-sum tax for a distortionary tax entails a positive welfare cost (apart from environmental considerations).[8] This latter claim is not difficult to uphold, since the idea that swapping a distortionary tax for a lump-sum tax has a positive welfare cost is part of the usual definition of "distortionary." So long as the tax t_X deserves its title as a distortionary tax, it will have a positive efficiency cost and the weak double-dividend claim will hold.

One important clarification is in order here. Consider the case where t_X is negative in the *status quo ante*. Starting from a negative value (or subsidy), a further reduction in this tax (financed through lump-sum taxes) may be efficiency-worsening. Under these circumstances, if a new environmental tax is employed to finance reductions in a "distortionary" tax whose value is already negative, the weak double-dividend will not obtain. This does not contradict the claim from the previous paragraph. In the situation described here, the key requirement of the weak double-dividend notion -- that the tax t_X have a positive marginal excess burden -- is missing.

The weak form can related to the elements of Figure 1. The figure offers the typical partial equilibrium and first-best framework for analyzing welfare effects of an environmental tax.[9] MC denotes the private marginal costs of producing the given commodity, which in this example is coal. MC_{soc}

[8] This can be shown as follows. Consider the two post-reform situations associated with (1). One (associated with the left-hand side) involves a reduction in a distortionary tax; the other (associated with the right-hand side) involves a lump-sum tax reduction. The two post-reform situations are alike in other important respects: they involve the same tax revenue and all other tax rates (including t_E) are the same. One can write the levels of welfare associated with the two post-reform situations as $W(t_E, t_X', T_L)$ and $W(t_E, t_X, T_L')$, where $t_X' = t_X + \Delta t_X$ and $T_L' = T_L + \Delta T_L$. (Note that $\Delta t_X<0$, $\Delta T_L<0$.) The weak double dividend assertion is equivalent to the assertion that $W(t_E, t_X', T_L) > W(t_E, t_X, T_L')$. This, however, is equivalent to the assertion that the gross efficiency cost of raising the distortionary tax from t_X' to t_X, where the change is financed through a reduction in lump-sum taxes from T_L to T_L', is positive. Thus, the weak double dividend claim is upheld so long as the distortionary tax considered has a positive gross efficiency cost or excess burden.

[9] In this example, the tax is a strict Pigovian tax in that it applies to a commodity with which pollution is associated rather than directly to pollution emissions. The basic lessons apply to emissions taxes as well.

represents the social marginal cost curve, incorporating the marginal external damage (marginal external cost), MED. MB represents the marginal benefit (demand) curve. If a tax is imposed on coal equal to the marginal external damage, social and private marginal costs become aligned. The usual textbook analysis regards the welfare gain as area B.[10] This is the value of the environmental improvement (A+B) minus the *gross* efficiency costs of the tax (A).

This simple analysis suggests that the tax revenue R is transferred costlessly from those who pay the coal tax to the government and back to the private sector[11], with no efficiency consequences. The weak notion of the double dividend recognizes the fact that this "recycling" of the revenues (R) may indeed have efficiency consequences. The assertion is that when revenues are used to cut existing distortionary taxes, in particular, they help reduce the overall (gross) distortionary costs of the tax system. *If* the gross costs under *lump-sum* replacement are given by area A, then under *distortionary-tax* replacement they are less than A.[12]

It is important to recognize, however, that other important cost considerations may be obscured by the first-best, partial equilibrium framework embodied in Figure 1. In particular, when other taxes (such as income taxes) are present, the area A in Figure 1 is not a good indicator of the gross costs of the tax on coal. The weak double dividend notion correctly claims that rebating revenues through cuts in distortionary taxes reduces gross costs relative to their level under lump-sum replacement, but the reference level from which the reduction occurs is generally quite different from that suggested by area A in the diagram. We return to this issue below.

B. The Stronger Forms

The intermediate and strong double-dividend notions involve assertions about the *sign* of the gross

[10]In the case with non-constant private marginal costs or non-constant marginal external costs, the presentation is slightly more complicated, but the results are essentially the same.

[11]In the simplest case, the revenues are returned to the private sector in a lump-sum fashion.

[12]Of course, the government could waste the revenues -- for example, by applying them to government projects with benefit-cost ratios below one. In this case the gross costs will be greater than A. In this paper I do not consider which use of revenues is most likely; I leave that to political scientists.

cost of a revenue-neutral policy in which an environmental tax replaces (some of) an existing distortionary tax. The assertion is:

$$C(t_E, \Delta t_X) < 0. \tag{2}$$

The assertion here is that swapping an environmental tax for a distortionary tax involves a negative gross cost overall.

The intermediate and strong double dividend notions differ in the strength of the claim as to the extensiveness of the class of distortionary taxes for which (2) holds. The intermediate notion affirms that there exists at least one distortionary tax t_X for which (2) applies; the strong notion claims that (2) holds for typical or representative existing taxes. For any given distortionary tax (t_X) involved in the tax swap, condition (2) is stronger than (1) assuming $C(t_E, \Delta T_L) > 0$.

One can decompose the overall gross cost $C(t_E, \Delta t_X)$ into that which is "directly attributable" to the environmental tax and that which is "directly attributable" to the reduction in the distortionary tax.[13] The intermediate and strong double dividend notions can be interpreted as claims that the first cost -- the cost resulting from to the environmental tax -- is smaller in absolute magnitude than the second cost -- the cost associated with the cut in the distortionary tax. In other words, when the taxes are scaled to imply the same revenue impact, the environmental tax introduces a smaller cost than an equal-revenue change in the distortionary tax.

It is important to be clear about what is meant by "costs." In conditions (1) and (2), costs (C) are the monetary equivalents to the policy-induced changes in individual welfare (abstracting from welfare effects associated with policy-related changes in environmental quality). In the related theoretical work, welfare depends directly on individual consumption of goods and services and enjoyment of leisure. It should be recognized that, measured this way, economic cost can differ in sign and magnitude from changes in other important macroeconomic variables such as GNP or the growth of GNP. The question

[13] Since taxes interact, the attribution of the cost of the revenue-neutral policy change into "direct" effects of t_E and "direct" effects of Δt_X is not automatic. A reasonable decomposition is to split $C(t_E, \Delta t_X)$ into $C(t_E, \Delta T_{L1})$ and $C(\Delta t_X, \Delta T_{L2})$, where ΔT_{L1} and ΔT_{L2} are the lump-sum tax changes necessary to make the component changes t_E and Δt_X revenue-neutral.

whether a given revenue-neutral tax swap entails positive costs is different from the question whether the swap entails a reduction in GNP or its growth rate.[14]

Relative to the strong version, the intermediate double-dividend version makes a more modest claim about the circumstances in which gross costs will be zero or negative. It asserts the existence of at least one particularly burdensome distortionary tax whose replacement by an environmental taxes would involve negative costs. It should be noted that the case for removing or reducing an unusually costly existing tax can be made without introducing environmental considerations. Even without bringing in the environmental dimension, there would be strong reasons for replacing this tax with other taxes on narrow (non-environmental) efficiency grounds.[15] Correspondingly, although the presence of this highly inefficient tax may supply a target for general tax reform, by itself it does not offer support for introducing the new environmental tax.

As mentioned in the introduction, the validity of the strong form of the double dividend would significantly reduce information hurdles associated with the evaluation of environmental taxes. If the strong double-dividend obtained, policymakers would not need to establish magnitudes of environmental benefits to justify the tax swap on overall benefit-cost grounds. Instead, it would only be necessary to confirm that environmental benefits are positive. In light of the substantial uncertainties surrounding the magnitudes of environmental benefits from green taxes, the appeal of the strong form is quite understandable. Much of the debate about the potential for environmental tax reform revolves around whether the strong form holds. The remainder of this paper gives particular attention to this double-dividend notion.

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[14]GNP is an imperfect indicator of gross welfare for several reasons. One is that it only reflects the marginal welfare contributions of goods and services (to the extent that these are reflected in market prices); inframarginal surpluses are not incorporated. A second reason is that it disregard welfare contributions from non-marketed goods and services such as leisure.

[15]If efficiency were the only consideration, optimal tax reform would achieve equality in the marginal efficiency costs of all taxes with non-zero rates. Of course, efficiency is not the sole policy objective. A highly inefficient tax may be worth keeping if it has important virtues along other dimensions such as distribution.

III. Does the Strong Form Hold? Theoretical Considerations

A. A Key Result

This section examines the theoretical evidence related to the strong interpretation of the double dividend idea. An important theoretical investigation of this issue was provided by Bovenberg and de Mooij (1992, 1993). These authors develop a simple general equilibrium model with one primary factor of production -- labor -- and three produced commodities -- a "clean" consumption good, a "dirty" consumption good, and a public good (nonrival in consumption). Production exhibits constant returns to scale, and the rates of transformation between the three produced commodities are constant and equal to unity. Environmental quality is negatively related to aggregate production of the dirty consumption good. A representative household derives utility from leisure, from consumption of the three produced goods, and from environmental quality. The two private goods and leisure are weakly separable from the public good and environmental quality in the utility function.

Bovenberg and de Mooij begin with the situation where the only tax is a labor income tax with a constant marginal tax rate. They then consider the effects of a revenue-neutral policy change in which a tax is imposed on the dirty consumption commodity and the revenues are devoted to a reduction in the labor tax rate. The commodity tax is non-infinitesimal[16]. The strong double dividend claim is that this policy would yield an increase in non-environment-related welfare, that is, in the utility from the composite of consumption and leisure enjoyed by the representative household.[17] These authors find that this claim is substantiated if and only if the uncompensated wage elasticity of labor supply is negative, that is, if and only if the labor supply function is backward-bending. Most empirical studies of labor supply yield positive values for the uncompensated elasticity[18]; thus, the Bovenberg-de Mooij results tend

[16]Alternatively, the tax is incremental but superimposed on an existing non-infinitesimal tax on the dirty consumption commodity. The significance of the "non-infinitesimal" assumption is discussed in Section V.

[17]The separability assumption enables the authors to evaluate utility from the consumption-leisure composite apart from the utility from public goods or environmental quality.

[18]See, for example, Hausman (1985).

to reject the double dividend proposition in its strong form.[19]

What lies behind the Bovenberg-de Mooij result? There are two key components. First, the tax on the environmentally harmful consumption good lowers the after-tax wage and generates distortions in the *labor* market, and these labor market distortions are at least as great in magnitude as the labor market distortions from a labor tax increment of equal revenue yield. Hence, the revenue-neutral swap in which the environmental tax replaces (some of) the labor tax leads to no reduction (and usually an increase) in labor market distortions. Second, the tax on the environmentally damaging commodity induces changes in the commodity market -- "distorting" the choice among alternative commodities.[20] These two distortionary effects -- in labor and commodity markets -- imply that, apart from environmental considerations, the revenue-neutral combination of an environmental tax and reduction in labor tax involves a reduction in the non-environmental component of welfare. In fact, the distortions in the commodity and labor markets are connected. To the extent that the environmentally motivated commodity tax leads households to substitute other commodities for the taxed commodity, there is a reduction in the gross revenue yield of the tax. This *tax base erosion effect* limits the extent to which the environmental tax can finance a reduction in the labor tax, and augments the overall gross cost of the tax initiative.

The intuition for this result is as follows.[21] Consider a static model in which there is one labor market (no labor heterogeneity). Let Case 1 refer to the situation where there is just one produced commodity. Suppose that initially there is a tax on labor but no commodity tax. Under these circumstances the commodity tax (even an infinitesmal one) produces a non-infinitesimal excess burden. This occurs because, under the circumstances just described, the introduction of a commodity tax is formally identical to an increase in the labor tax. It reduces the real wage in precisely the same way an

[19]At the same time, Bovenberg and de Mooij's analysis supports the weak notion of double dividend. Their paper concludes with "Hence, there exists a 'double dividend' in the sense that a cost reduction can be achieved by using revenues from pollution taxes to cut distortionary taxes rather than returning these revenues in a lump-sum fashion."

[20]It should be kept in mind that we are concerned with "distortions" in the *gross* sense -- abstracting from environmental considerations. Clearly environmental taxes can improve overall resource allocation -- reduce overall distortions -- when the environmental dimensions is considered. We return to this issue below.

[21]See Poterba (1993) for a complementary discussion.

increase in a labor tax would.[22] Now suppose, in contrast to this first case, that there are many distinct produced commodities. As before, suppose that the initial situation involves only a tax on labor. Now consider (Case 2) the effect of introducing a uniform but small tax on *all* commodities, and (Case 3) the effect of introducing a small tax on just *one* of the commodities. Case 2 is formally similar to Case 1; it will generate non-infinitesimal excess burdens because this tax is equivalent to an increase in the wage tax.[23] Case 3 is relevant to the imposition of an environmental tax on one commodity. Bovenberg and de Mooij show analytically that, for a given revenue yield, the excess burden in Case 3 is non-infinitesimal and in fact is larger than in Case 1 or 2. The reason is that Case 3 generates the same or larger labor market distortion as in the other cases and a larger distortion in the commodity markets.[24]

A fundamental lesson from Bovenberg and de Mooij's analysis is that partial equilibrium analyses of the gross costs of environmental taxes can be highly misleading. They show that environmental taxes importantly affect resource use in markets other than the market in which the tax is applied -- with significant implications for gross costs. These general equilibrium impacts are especially important if there are prior taxes in "other" markets such as the labor market.[25]

These results indicate that there are *two* important omissions in Figure 1. They work in opposite

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[22]The after-tax real wage is (1) the after-tax nominal wage divided by (2) the gross of tax price of consumption. Income taxes directly affect the after-tax real wage by reducing (1), whereas energy taxes directly influence this wage by raising (2).

[23]A uniform commodity tax does not avoid distorting the commodity market in all circumstances. A sufficient set of conditions for its optimality is that commodity consumption be separable from leisure in utility and that the utility function be homothetic. See Bovenberg and de Mooij (1993).

[24]The gross cost is greater in Case 3 than in Case 2 under the stated assumption that the environmental tax is non-infinitesimal. With an infinitesimal environmental tax, the commodity market gross distortion is negligible, and the net distortionary impact in the labor market is zero (the effect of the new environmental tax just compensates for the effect of the reduction in the labor tax). With the "large" environmental tax, in contrast, the commodity market distortion is non-incremental. So long as there is some substitutability across commodities, the tax on the environmental commodity leads to substitution away from this commodity in consumption. This implies a loss of tax base (relative to the case of no substitution) and, importantly, a reduction in the absolute magnitude of the cut in labor taxes which can be financed by the environmental tax. Because of this tax base erosion effect, the environmental tax is unable to finance a reduction in labor taxes large enough to compensate for the implicit increase in labor taxes represented by the environmental tax itself. Thus, when environmental taxes are "large," the revenue-neutral combination of environmental tax and labor tax cut involves a gross distortionary cost for two reasons: (1) labor market distortions are enlarged, and (2) a non-negligible distortion is generated in the commodity market.

[25]On the other hand, the partial equilibrium welfare analysis is apt for a first-best world with no prior taxes.

directions. First (as emphasized by the weak double dividend claim), the revenues R can be used to reduce gross distortionary costs. This suggests that the partial equilibrium analysis would overstate the cost of the environmental tax initiative. At the same time, the presence of other (labor) taxes implies that, for any given use of the tax revenues, the gross distortion from the environmental tax will be larger than implied by Figure 1. This implies the opposite bias from the partial equilibrium analysis. Bovenberg and de Mooij show that the latter effect is larger in magnitude than the former: overall, the presence of prior taxes implies higher gross costs from the environmental tax -- even when revenues are recycled through cuts in the distortionary tax. These two effects are schematized in Figure 2. Adopting terminology similar to that introduced by Parry (1994) in a recent paper, I call the former effect the *revenue-recycling effect* and the latter the *tax-interaction effect*.[26] (The tax base erosion effect, mentioned three paragraphs above, contributes to the more general tax interaction effect.) Using a different analytical approach, Parry obtains results that conform to those of Bovenberg and de Mooij, showing that the tax interaction effect is of greater magnitude than the revenue-recycling effect under plausible values for parameters.[27,28]

B. How General Are These Results?

The analytical results from Bovenberg-de Mooij and Parry stem from simplified models. What are the key simplifying assumptions of these models, and to what extent are these simplifications critical to the results?

1. Intermediate Inputs

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[26]Parry terms these the "revenue effect" and "interdependency effect."

[27]In Parry's analysis, the revenue-recycling effect is greater than the tax-interaction effect only when two conditions simultaneously hold: (1) output from the polluting industry (which produces the good subject to the environmental tax) is a weaker than average substitute for leisure, and (2) the tax elasticity of emissions is well below unity.

[28]Figure 2 shows that to uphold the strong double dividend claim, the magnitude of the revenue-recycling effect must in fact be *larger* than that of the tax-interaction effect -- by enough to bring the gross costs to zero. In Bovenberg-de Mooij and Parry's analyses, since the tax-interaction effect is larger than the revenue-recycling effect, environmental taxes not only involve positive gross costs, but larger gross costs than would result from the same tax in a first-best setting where there are no pre-existing taxes and where revenues are returned lump-sum.

One simplification of the models is that they disregard intermediate inputs. However, in Bovenberg and Goulder (1994a), the Bovenberg-de Mooij model is extended to incorporate intermediate inputs, and the results above prevail in the extended model. Bovenberg and Goulder analyze the effects of environmentally motivated taxes on "dirty" intermediate goods and on "dirty" consumption goods. In each case, the strong double dividend claim fails to materialize when the uncompensated wage elasticity of labor supply is positive. The economic basis for the result in the case of the intermediate good tax is the same as that provided above for the commodity (consumer good) tax. Similar results are obtained in Bovenberg and de Mooij (1993a).

2. Capital

Another simplification in the above models is their static nature. How would consideration of capital affect the results? Including capital introduces the possibility that a revenue-neutral environmental tax could shift the burden of taxation from one factor to another. This has efficiency implications to the extent that, in the initial tax system, the marginal efficiency costs of capital taxation and of labor taxation are different.[29] To assess the importance of including capital in the analysis, two considerations are important. First, one needs to consider the extent to which the marginal efficiency costs of capital taxation differ from those of labor taxation under the *status quo ante*. On what do these marginal efficiency costs depend? While labor taxes distort the labor-leisure margin -- the margin of choice between enjoying leisure and enjoying consumption (by earning labor income) -- capital taxes distort the intertemporal margin -- the margin of choice between consuming today and consuming in the future (by saving). For a given labor tax, the distortion in the labor-leisure margin is greater the larger is the (compensated) wage elasticity of labor supply. For a given capital income tax, the distortion along the intertemporal dimension

[29]The discussion here is not formal. To my knowledge, no one has yet examined the double dividend issue analytically in a dynamic, closed-model with capital and labor. Bovenberg and van der Ploeg (1994) develop an analytical model for a small open economy that employs labor and capital. The efficiency issues I shall discuss here apply to an economy that is "large" in the sense that it influences the return to capital; these issues are largely absent in the Bovenberg-van der Ploeg model of a small, open economy, where the return to capital is given by the world market and the burden of domestically imposed green taxes is fully borne by labor. Ligthart and van der Ploeg (1994) develop a static model with labor and a fixed factor, capital. The issues I shall discuss here are only of interest when capital is not fixed in supply.

is greater the larger is the intertemporal elasticity of substitution in consumption. Thus, the relative marginal efficiency costs of labor and capital income taxes depend on these elasticities and on the magnitudes of labor and capital income tax rates.

The second consideration is whether the burden or incidence of the environmental tax falls largely on labor or on capital. As is well known,[30] taxes on consumption commodities (such as a consumer gasoline tax) are implicitly taxes on labor.[31] On the other hand, the burden of taxes on intermediate inputs (such as a tax on fossil fuels) could potentially fall primarily on capital. This can occur because such taxes can raise the cost of producing capital goods and thereby lower the rate of return. If this effect is large enough, the burden of the tax will fall primarily on capital.[32]

These considerations indicate that the gross costs of a revenue-neutral environmental tax will be lower to the extent that:

(1) in the initial tax system, the difference in marginal efficiency costs (marginal excess burdens) is large,

(2) the burden of the environmental tax falls primarily on the factor with relatively low marginal efficiency cost,

(3) the base of the environmental tax is relatively broad, so that the gross distortions it generates in intermediate good and consumer good markets are small, and

(4) revenues from the tax are devoted to reducing tax rates on the factor with relatively high marginal efficiency cost.

These considerations raise the possibility of a zero or negative cost tax swap. For example, if the marginal excess burden of capital taxes is higher than that for labor, and if the burden of a new environmental tax falls primarily on labor, then introducing this new tax in combination with a revenue-preserving cut in

[30]For a general discussion, see Auerbach and Kotlikoff (1987).

[31]Indeed, this phenomenon underlies the Bovenberg-de Mooij result. The environmental (commodity) tax is an implicit labor tax which produces both labor and commodity market distortions.

[32]Specifically, capital income will fall by a larger percentage than labor income. Labor income falls because the tax raises costs of production, leading to an increase in the prices of consumer goods and a reduction in the real wage.

capital taxes can involve zero or negative gross costs.

Would this result, if it occurred, resurrect the double dividend in its strong form? Or would it only confirm the intermediate double dividend claim? The issue is semantic: the answer depends on whether one classifies a (pure) tax on capital as a typical or representative tax. A more clear-cut confirmation of the strong double dividend notion would occur if the gross costs were negative in a case where revenues are returned through a general income tax cut (that is, through cuts in the marginal rates applicable to capital and labor). Returning the revenues through a general income tax cut "dilutes" the gain associated with revenue-replacement, because it involves a reduction in the relatively efficient factor tax as well as the more inefficient one. This method of revenue-replacement does not exploit the potential contribution of item (4) above; but foregoing (4) enables the policy to test unequivocally the strong double-dividend claim. The above considerations indicate that if the capital tax is extremely costly relative to the labor tax, the gross costs can be negative even if the potential contribution of (4) is not exploited.

Thus, once capital is considered, the theory gives more scope for the possibility of the strong double dividend. Is it likely empirically? Most empirical studies for the U.S. indicate that capital taxes have higher marginal excess burdens than do labor taxes.[33] Under these circumstances, the prospects for a strong double dividend become more favorable to the extent that:

(1') in the initial tax system, there is large difference in the marginal excess burden (MEB) per dollar of revenue for capital taxation, as compared with the MEB per dollar for labor taxation,

(2') the burden of the environmental tax falls primarily on labor, and

(3') the base of the environmental tax is broad.

Are these conditions met in the real world? Condition (2') indicates that the strong double dividend claim could potentially be upheld for an environmentally motivated commodity tax, because such taxes tend to be borne largely by labor. An example of an environmentally motivated commodity tax is a tax on consumer purchases of gasoline. In a world where capital taxes have much higher excess burdens than labor taxes, the gasoline tax (with revenues returned through cuts in income taxes or, even better,

[33]See Ballard, Shoven, and Whalley (1985), and Jorgenson and Yun (1990).

through cuts in capital taxes) is appealing because it helps shift the burden of taxation from capital to labor. Intuitively, this consumer-level tax functions like a consumption tax and shares the appeal of a consumption tax in reducing intertemporal distortions, or distortions in capital markets. On the other hand, a tax on consumers' gasoline purchases is obviously much narrower than a general consumption tax. As indicated by condition (3'), the narrowness of the base is a liability. To the extent that substitution from gasoline is easy, a given gasoline tax will generate less revenue and introduce larger gross distortions in commodity markets, worsening the prospects for zero or negative gross costs.[34,35]

The prospects for the strong claim are worse in the case of a tax on intermediate inputs. Certain intermediate input taxes -- for example, a tax on fossil fuel inputs -- may have a strong justification when environmental benefits are taken into account. But the double dividend issue relates only to the cost side, and intermediate input taxes do not have much promise on this side of the ledger. The reason is that these taxes are often borne to a significant degree by capital. To the extent that fossil fuels are employed more intensively in the production of capital goods than in the economy in general, an environmentally motivated tax on fossil fuels will raise the relative price of these goods and be borne more by capital. In the data set employed in my general equilibrium energy-economy-environment model of the U.S. (see Goulder [1994a]), capital goods production is highly energy intensive. Consequently, in policy simulations the burden of fossil fuel (intermediate input) taxes falls primarily on capital, virtually ruling out the possibility of the double dividend in the strong form.

The new dimension that arises when capital is considered is that of shifting the burden of taxes between factors and thereby exploiting differences in the marginal excess burdens of factor taxes. This dimension has force only insofar as the existing tax system is inefficient in the sense that the marginal

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[34]Paradoxically, the very feature -- a narrow base -- that contributes to larger gross costs is the feature that often makes environmental taxes attractive in terms of overall efficiency. The narrower these taxes are, the closer they often are to the source of the externality (for example, certain types of emissions). Hence, even though the narrower base tends to amplify gross costs, it also tends to expand gross benefits and overall efficiency (gross benefits minus gross costs). To the extent that the objective is overall efficiency, large gross costs should not stand in the way of environmental taxes.

[35]This implicitly assumes that a uniform commodity tax is optimal (see footnote 23). Optimal commodity tax principles indicate that, other things equal, there is an efficiency rationale for relatively higher taxes on commodities that are highly complementary to leisure. See, for example, Atkinson and Stiglitz (1980), chapter 12.

excess burdens of different taxes are not equal. Arguably, the case for reducing these inefficiencies is independent of the case for a new environmental tax. The possibility of a double dividend in the strong form is more difficult if one considers only situations where the "rest of the tax system" is optimal in some sense. We return to this issue in Section V.

3. Pre-Existing Subsidies

The issue just raised also is relevant to evaluating the strong double dividend claim in the presence of prior subsidies: there may be independent reasons for revoking the subsidies. Still, it is worthwhile noting that prior subsidies clearly offer scope for the strong double dividend. For example, a carbon tax can serve to undo prior subsidies on fossil fuels and thereby reduce or eliminate the gross distortionary costs in fuels markets. Shah and Larsen (1992) emphasize this point in considering the potential for carbon taxes in developing countries.

4. Emissions Taxes

The analytical models discussed above consider taxes on commodities (consumer goods or intermediate inputs) whose production or use generates pollution. Other things equal (abstracting from monitoring costs, etc.), it is most efficient to tax the source of the externality, that is, emissions. Relative to commodity taxes, emissions taxes can yield higher *overall* efficiency gains. But the results concerning the double dividend are not changed. One can think of emissions as another intermediate input. As with taxes imposed on an ordinary intermediate input, emissions taxes alter the mix of all intermediate inputs and distort factor markets. The same mechanisms as discussed earlier indicate that emissions taxes will involve larger gross costs per dollar of revenue than the income (labor) taxes they replace. Whether they are more or less attractive in terms of gross costs than intermediate input taxes depends on the production technology. It may seem counterintuitive that emissions taxes do not automatically fare better than ordinary input taxes in terms of the double dividend. It helps to keep in mind that the issue here is gross costs per dollar of revenue, not overall gross costs. The same feature that makes emissions taxes attractive in terms of overall efficiency -- their ability to induce larger emissions reductions per dollar of revenue than ordinary intermediate input taxes -- curtails their attractiveness in terms of gross costs.

5. Exhaustible Resources and Decreasing Returns

To this point we have only considered taxes on produced goods. In assessing the gross costs, we needed to consider the distortions produced in the markets for the factors that produced these goods. In particular, in examining the costs of a tax on fossil fuels, we regarded fossil fuels as produced intermediate goods and attended to the related distortions in the markets for labor and capital.

Of course, fossil fuels in their original form are primary resources, not produced goods. They are exhaustible resources whose reserves are given by nature.[36] The essential scarcity of natural resource stocks gives rise to scarcity rents. A basic result from the literature on the taxation of natural resources is that a constant tax on these rents does not alter the intertemporal allocation of these resources and has no efficiency cost.[37] This suggests that an environmentally motivated tax on, say, fossil fuels, might not have a significant (gross) efficiency cost after all, given the exhaustible nature of these fuels. If this were the case, then swapping a tax on these fuels for ordinary income taxes might be a negative cost option, upholding the double dividend claim in its strong form.

Should the previous results be discarded because they derive from models that ignored exhaustible resources? Not necessarily. It should be recognized that in most cases, the environmentally motivated taxes under actual consideration are not taxes on scarcity rents. The base of a carbon tax, for example, is not the scarcity rent but rather the quantity of fuel purchased (since carbon combustion and the amount of CO_2 emitted are functions of the quantity of fuel consumed). In contrast with a tax on pure rent, the tax on fuel output affects intertemporal choice and introduces a gross efficiency cost.[38] Despite the exhaustible nature of fossil fuels, a carbon tax does not attain the non-distortionary ideal.

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[36] *Known* reserves, of course, are endogenous, a function of exploration activity. This does not alter the main points discussed here.

[37] See, for example, Sweeney (1977, 1993), and Dasgupta and Heal (1979).

[38] This is the case because, in general, the present value of the tax payment per unit of fuel is not constant through time. On this see, for example, Sweeney (1977).

Of course, this does not entirely disprove the significance of exhaustibility to the double dividend issue. Even if the environmental taxes in question are related to fuel output rather than rent, it is possible that the gross efficiency costs of these taxes might be considerably lower when these "outputs" are extracted exhaustible resources. To continue with the fossil fuels example, *extracted* fossil fuels are the product of several primary factor inputs: natural resource stocks (fuels in the ground), capital and labor. The gross efficiency cost from taxes on these fuels will be a weighted average of the gross efficiency cost generated by the tax in the exhaustible resource market, the capital market, and the labor market.[39] To discern this efficiency cost, one would need to know the extent to which the tax is borne by each of these factors and the marginal efficiency cost associated with reductions in scarcity rents, the return to capital, and the wage. This information is not easy to obtain, to say the least. Ascertaining the marginal efficiency cost in the resource market alone is exceedingly difficult. Despite these difficulties, further empirical work aimed at gauging these magnitudes might be of considerable value.

6. Involuntary Unemployment

The above models assume all markets clear. However, introducing involuntary unemployment in the models by way of a fixed real wage above the market-clearing value would not change the basic results, assuming no other structural changes. In the original models, introducing the (revenue-neutral) environmental tax reduces labor productivity and shifts leftward the labor demand function. The same phenomenon occurs in a model in which the real wage is fixed above the original market-clearing level; the result is higher involuntary unemployment. The gross costs of this revenue-neutral policy are positive for the same reasons as in the market-clearing models. However, the results differ when a further structural change is introduced. Bovenberg and van der Ploeg (1993a) develop a model with involuntary unemployment (resulting from a fixed real wage) and three factors of production: labor, resources, and

[39]Whether the strong double dividend arises depends on whether the government has already taxed fixed-factor rents. In a model with three factors of production – labor, resources, and a fixed factor, Bovenberg and van der Ploeg (1993a) show analytically that a tax on a "dirty" consumption commodity fails to yield a double dividend (in the strong sense) if all the rents from the fixed factor are already taxed. On the other hand, if fixed factor rents are not taxed, the same type of tax offers the double dividend. In the latter case the commodity tax proxies for the tax on fixed factor rents, and enjoys much of its efficiency potential.

a fixed factor. In this model, under some circumstances the revenue-neutral combination of an environmental tax and a labor tax cut boosts employment and raises the non-environmental component of welfare (that is, the gross welfare cost is negative). This occurs when the production share of the fixed factor is large and substitution between labor and resources is easy. Under these circumstances a large share of the tax burden from the environmental tax is borne by the fixed factor, with relatively little efficiency cost. Hence the revenue-preserving cut in the labor tax yields a gross efficiency gain that more than offsets the gross efficiency cost attributable to the environmental tax.[40]

7. The Environment As a Capital Good

In the analytical models discussed so far, environmental quality, if it is represented at all, enters as an argument of the utility function. It is a nonrival consumption good. The models that incorporate environmental quality usually assume that utility from consumption of "ordinary" goods and services is separable from utility from environmental quality. This permits a clean separation of gross costs and environmental benefits in the welfare analysis.

Environmental quality may also function as a capital good. That is, a cleaner environment may contribute positively to output, holding other inputs constant. Accounting for the productive contribution of environmental quality is a key element in developing truly integrated economy-environment models. Such integration permits models to capture an important potential benefit from environmental taxes: namely, the avoidance of the adverse impact of environmental deterioration on production.[41]

Once the capital goods aspect of environmental quality is included in an economic model, it becomes more difficult to separate cleanly the gross costs and (environmental) benefits of tax policies. "Gross costs" signifies the effect of the environmental tax on welfare, abstracting from welfare changes

[40]The same qualitative result would obtain if there were no involuntary unemployment in this model. In this model, the environmental tax serves as an implicit way to tax the rents from the fixed factor in the absence of a more direct instrument to do so.

[41]This is an important dimension of the environmental benefits from a carbon tax. To the extent that a carbon tax slows the accumulation of greenhouse gases and reduces global warming, it avoids productivity losses in agriculture and other climate-sensitive sectors.

linked to changes in environmental quality. In a model with environment as a capital good, it is difficult (though not impossible) to perform this abstraction. In a very recent paper, Bovenberg and de Mooij (1994) develop a model in which environmental quality functions both as a capital good and consumption good. They show that, under certain circumstances, an environmental tax produces the two "dividends" of a cleaner environment and faster economic growth. In my view, their result, strictly speaking, does not provide support for the strong double dividend notion because it involves *benefit*-side issues; this is not a case of negative gross costs. Rather, their result supports the notion that *when production-related environmental benefits are taken into account*, environmental taxes sometimes can lead to faster growth as well as a cleaner environment.[42]

8. Terms of Trade Effects

All of the analyses discussed above adopt a closed-economy framework. In open economies, another economic dimension -- changes in the terms of trade -- can affect welfare. In certain cases an open economy can employ environmental taxes as a means of improving its terms of trade. Specifically, if the economy in question is a net importer of the good on which the environmental tax is imposed, and if this economy is large enough to exert monopsony power (that is, large enough to influence world prices of this good), then imposing the environmental tax can improve this enonomy's terms of trade. By taxing this imported good, this economy reduces national (and thus global) demands for the good and induces a reduction in good's before-tax price in world markets. This shifts some of the burden of the domestic environmental tax onto foreigners, assuming that the revenues from the tax are devoted to cuts in taxes paid by domestic consumers or domestically owned firms. If the terms of trade gains are large enough, they could offset the other gross costs associated with the domestically imposed environmental tax and produce the strong double dividend from the point of view of the domestic economy.[43]

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[42]Consideration of the capital good aspect of environmental quality seems to be very important in the *overall* benefit-cost evaluation of environmental tax options and may help justify the replacement of ordinary taxes by environmental taxes in several instances. But the strength of the case for the strong double dividend claim, as defined here, seems largely independent of whether the capital good function of environmental quality is accounted for.

[43]Terms of trade effects do not support the strong double dividend claim in global terms.

For the U.S., an environmentally motivated tax on imported oil could fall in this category.[44] On the other hand, it is difficult to make the case that the U.S. would enjoy terms of trade gains from a (unilateral) carbon tax because this tax applies largely to coal, of which the U.S. is a net exporter.

C. A Common Theme

A unifying theme emerges from these considerations. Although the above analysis reveals circumstances in which the strong double dividend can occur, with one exception (the terms-of-trade case) these circumstances involve an essential inefficiency in the existing tax system on non-environmental dimensions. That is, the strong double dividend can arise only if the initial tax system involves inefficiencies in the form of differences in the marginal excess burdens of various taxes. If the environmental tax shifts the tax burden from factors associated with high MEB's to factors with relatively low MEB's, it can thereby reduce the non-environmental inefficiencies of the tax system and (if this effect is large enough) yield the strong double dividend. Thus, the strong double dividend presumes a need, based on non-environmental considerations, for factor tax reform. It is reasonable to ask why these inefficiencies cannot be addressed directly (through changes in factor tax rates) rather than through an environmental tax. It seems more natural to address these inefficiencies directly as part of general tax reform than indirectly as part of environmental policy.

One qualification to this last remark might be offered: there may be political opposition to reforms that directly alter the relative taxation of factors. Under these circumstances one could regard a revenue-neutral environmental tax policy as a more feasible alternative to direct reforms which are politically less palatable. The empirical support for this political argument is far from clear. Even if there were an empirical basis for the argument, one might feel uncomfortable rallying behind it since it essentially exploits the inability of voters to recognize the true incidence of environmental taxes.

[44] The analysis is made more complicated by the existence of the OPEC cartel and the imperfectly competitive nature of the world oil market.

IV. Numerical Findings

This section presents some numerical results applicable to the double dividend issue. Here I consider only the results that bear on the strong double dividend notion defined above: the issue under investigation is the gross costs (non-environment-related welfare costs) of revenue-neutral tax swaps. As mentioned earlier (see footnote 7) some other studies define reductions in unemployment or increased profits as additional "dividends" from green taxes. I do not report results from these studies here because I do not have the information necessary to combine the reported changes in unemployment, profits, and other economic variables into the more general welfare notion expressed by "gross costs."[45]

Table 1 presents results from five numerical models. These are the Goulder and Jorgenson-Wilcoxen intertemporal general equilibrium models of the U.S., the DRI and LINK econometric macroeconomic models of the U.S., and the Shah-Larsen partial equilibrium model, which has been applied to five countries, including the U.S.[46] The results in Table 1 are for the revenue-neutral combination of an environmental tax (usually a carbon tax) and reduction in the personal income tax, except in cases where this combination was not available. I have focussed on the case where revenues are returned through cuts in the personal income tax because this tax seems "typical" and "representative;" hence this case is relevant to the strong double dividend claim.

All welfare changes are *gross* welfare changes: they abstract from changes in welfare associated with improvements in environmental quality (reductions in greenhouse gas emissions), and thus they correspond to the gross cost concept discussed above. In the Goulder and Jorgenson-Wilcoxen models, welfare changes are reported in terms of the equivalent variation; in the Shah-Larsen model, the changes

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[45]Nor do I consider the evidence for the weak double dividend notion. As mentioned earlier, there is virtually unanimous numerical support for this notion, so a weighing this evidence seems unnecessary.

[46]For a more detailed description of these models, see Goulder (1994a), Jorgenson and Wilcoxen (1990, 1994), Shackleton *et al.* (1992), and Shah and Larsen (1992). The Shah-Larsen model is by far the simplest of the five models, in part because it takes pre-tax factor prices as given. Despite its simplicity, the model addresses interactions between commodity and factor markets and thus incorporates some of the major efficiency connections discussed earlier.

are based on the compensating variation.[47] In the DRI and LINK macroeconomic models, the percentage change in aggregate real consumption substitutes for a utility-based welfare measure.[48]

In most cases, the revenue-neutral green tax swap involves a reduction in welfare, that is, entails positive gross costs. This militates against the strong double dividend claim. Results from the Jorgenson-Wilcoxen model, however, support the strong double dividend notion.[49] To what might the differences in results be attributed?

A thorough examination of the differences in structure of these models, and an extensive test of how these differences account for differences in model outcomes, is beyond the scope of this paper. However, one potential explanation lies in the differences between the Jorgenson-Wilcoxen and Goulder models in the marginal excess burden of capital taxation.[50] The interest elasticity of saving is higher in the Jorgenson-Wilcoxen model than in the Goulder model. In addition, the Jorgenson-Wilcoxen model assumes that capital is fully mobile across sectors, while the Goulder model includes adjustment costs, which limit the speed at which capital can be reallocated and lower the elasticity of capital demand. Thus, elasticities of capital supply and capital demand are higher in the Jorgenson-Wilcoxen model; correspondingly, the marginal excess burden of capital taxation is considerably higher in the Jorgenson-Wilcoxen model than in the Goulder model, and the difference in the marginal excess burdens of capital

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[47]The equivalent variation is the lump-sum change in wealth which, under the "business-as-usual" or base case, would leave the household as well off as in the policy-change case. Thus a positive equivalent variation indicates that the policy is welfare-improving. The compensating variation is the lump-sum change in wealth which, in the policy-change scenario, would cause the household to be as well off as in the base case. In reporting the Shah-Larsen results I adopt the convention of multiplying the compensating variation by -1, so that a positive number in the table signifies a welfare improvement here as well.

[48]The demand functions in these models are not derived from an explicit utility function. Hence they do not yield utility-based measures. A difficulty with using consumption as a proxy for welfare is that it disregards welfare changes linked to changes in leisure.

[49]It might also be noted that the Shah-Larsen model yields negative gross costs for four of five countries in simulations which combine a carbon tax and reduction in the corporate income tax. (Such results do not appear in Table 1.) Only in the case of the U.S. is such a tax swap a gross-welfare-reducing venture.

[50]Of the five models in Table 1, these two are the most similar and allow for the most straightforward comparisons.

and of labor is larger. In the Goulder model, the difference in MEB's per dollar is $0.10;[51] the difference in the Jorgenson-Wilcoxen model appears to be considerably higher.[52] As indicated in the previous section, a large deviation in the MEB's on capital and labor taxes works in favor of the strong double dividend (particularly if the burden of the environmental tax falls on labor). This helps explain why, in the Jorgenson-Wilcoxen model, a revenue-neutral combination of carbon tax and reduction in *capital* tax involves negative gross costs (that is, a positive change in gross welfare). It is more difficult to account for the fact that substituting a carbon tax for a *labor* tax involves negative gross costs in the model.

Table 1 also includes GNP impacts. These are included simply because they may be of interest. As mentioned above, conceptually they bear no systematic relationship to welfare impacts. Indeed, in some of the numerical simulations the GNP and welfare changes are of opposite sign.

Like the theoretical results, the numerical outcomes in Table 1 tend to weigh against the strong double dividend claim. But there is less than perfect agreement among the numerical results. Divining the sources of differences in results across models is difficult and frustrating, in large part because of the lack of relevant information on simulation outcomes and parameters. Relatively few studies have performed the type of analysis that exposes the channels underlying the overall impacts. There is a need for more systematic sensitivity analysis, as well as closer investigations of how structural aspects of tax policies (type of tax base, narrowness of tax base, uniformity of tax rates, etc.) influence the outcomes. In addition, key behavioral parameters need to be reported. Serious attention to these issues will help explain differences in results and, one hopes, lead to a greater consensus on likely policy impacts.

[51]The MEB's per dollar are $0.22 and $0.12 for the tax on individual capital and individual labor income, respectively.

[52]This assumption is based on reported values in Jorgenson and Yun (1990). The Jorgenson-Yun and Jorgenson-Wilcoxen models have some similarities in structure and parameters, but there are important differences as well. Marginal excess burden numbers from the Jorgenson-Wilcoxen model were not yet available.

V. Relationship to Optimal Environmental Taxation

A. The Optimal Tax Rate and the Strong Double Dividend Claim

The previous discussions concerned the effects of "incremental" tax reforms. How do these issues relate to the optimal levels of environmental taxes?

The basic partial equilibrium analysis of the optimal environmental tax invokes the "Pigovian" principle: the optimal environmental tax is at a rate equal to the marginal external costs, or marginal environmental damages (MED). This principle implicitly assumes that the gross marginal cost (or marginal abatement cost) associated with an environmental tax is equal to the tax rate. Hence if the tax is set equal to MED, gross costs and environmental benefits will be equated at the margin, assuring optimality.[53]

The foregoing discussion indicates, however, that in a second-best setting a given environmental tax may give rise to marginal gross costs that differ from the tax rate. As indicated above, the revenue replacement effect tends to reduce the gross costs; other things equal, it tends to imply a higher optimal tax rate, that is, a rate above MED. On the other hand, the tax interaction effect tends to raise gross costs; other things equal, it implies an optimal rate below MED. A central question underlying the strong notion of double dividend is whether the revenue replacement effect is strong enough to outweigh the tax interaction effect. The answer to this question also determines the relationship between the optimal tax rate and MED in a second-best setting. The previous discussion indicated that, under plausible conditions, the tax interaction effect is of greater magnitude than the revenue recycling effect. This implies that, under these conditions, the optimal environmental tax rate is below the rate implied by the Pigovian rule.

This result is supported by analytical work by Bovenberg and van der Ploeg (1993b) and by Parry (1994).[54] From Bovenberg and van der Ploeg's analysis, in a second-best setting the optimal

[53]Assuming the appropriate second-order conditions apply.

[54]The seminal contribution in this area was by Sandmo (1975), who analyzed the optimal configuration of commodity taxes when one of the commodities generates an externality.

Parry derives analytically the conditions under which the tax interaction effect will be greater than the revenue replacement effect. Conducting broad sensitivity analysis, he finds that under plausible parameter values the tax environmental tax rate, t^*, is given by:

$$t^* = MED / \mu$$

where μ is the marginal cost of public funds.[55] In their model, μ exceeds unity if and only if the uncompensated wage elasticity of labor supply is positive. This is precisely the condition that denies the double dividend in its strong form.

Bovenberg and van der Ploeg offer the following intuition for their optimal tax formula. Environmental quality can be viewed as a good which the public sector provides by obtaining public revenues through the environmental tax. The higher the value of μ, the more costly it is to provide environmental quality. Thus, the higher is μ, the lower the optimal amount of environmental quality and the lower the value of t^*, other things equal.[56]

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interaction effect is of greater magnitude. Parry suggests that in the U.S. the optimal environmental tax rate is "typically" between 60 and 90 percent of the MED.

[55]The marginal cost of public funds (MCPF) is the welfare cost of an incremental increase in government spending financed by taxes. For an explication of this concept and its relationship to the notion of marginal excess burden, see Ballard and Fullerton (1992). For an analysis of how aggregate activity influences the MCPF, see Ligthart and van der Ploeg (1994). Brendemoen and Vennemo (1993) develop and assess numerically a broader notion of the MCPF that includes the environmental benefits from public projects.

[56]The Bovenberg van der Ploeg formula may appear to contradict an optimality requirement articulated by Lee and Misiolek (1986). In fact, the results are consistent. (For a close examination of this issue, see Schob [1994].) The Lee-Misiolek requirement for an optimal environmental tax is that the difference between marginal abatement costs and marginal environmental benefits per marginal dollar of revenues must equal the marginal excess burden of existing distortionary taxes. This can be written as:

$$\frac{\partial C/\partial \tau_E}{\partial R/\partial \tau_E} - \frac{\partial B/\partial \tau_E}{\partial R/\partial \tau_E} = \lambda(\tau_D)$$

where $C(\tau_E, \tau_D)$ is total abatement cost, B is total environmental benefit, R is revenue, λ is the marginal excess burden of other taxes, and τ_E and τ_D are the rates of the environmental and existing distortionary tax. Note that C is a function of both τ_E and τ_D. If τ_D is zero, λ is zero and the equation above reduces to:

$$\partial C/\partial \tau_E = \partial B/\partial \tau_E$$

the Pigovian rule. Let $\tau_E{}^*$ represent the tax rate that satisfies the above equation. Now consider the case where there are pre-existing taxes ($\tau_D > 0$). How does $\tau_E{}^{**}$, the optimum when other taxes are present, differ from $\tau_E{}^*$? Oates (1991) points out that the tax elasticity at the Pigovian optimum is relevant here. If the derivative $\partial C/\partial \tau_E$ were independent of τ_D, one could determine from this elasticity whether $\tau_E{}^{**}$ is greater or less than $\tau_E{}^*$. However, as discussed above, higher pre-existing taxes raise the value of $\partial C/\partial \tau_E$ evaluated at a given levels of τ_E. This means that in the presence of other taxes, a *lower* value of τ_E may be required to satisfy the Lee-Misiolek requirement.

These issues are highly relevant to considerations of the optimal carbon tax. Nordhaus (1993) calculates the optimal carbon tax in the case where revenues are returned lump sum, and compares that with the optimal tax when revenues are returned through cuts in distortionary taxes. In the former case, the optimal tax begins at about $5 per ton, while in the latter case it begins at $59 per ton! This seems to contradict the notion, indicated by the optimal tax formula above, that second-best considerations should *reduce* the optimal tax rate. It turns out, however, that although Nordhaus's experiments attend to the revenue-replacement effect, they do not capture the tax interaction effect because the model did not include pre-existing taxes. Including pre-existing taxes in the benchmark data would likely reverse the Nordhaus results. In this connection, simulations by Bovenberg and Goulder (1994b) indicate that the optimal carbon tax declines with the level of pre-existing taxes.

B. Caveats

These models indicate that in the presence of other taxes, the optimal environmental tax rate is lower than MED. Although these results seem intuitive, they are no more compelling than the case against the strong double dividend idea. To the extent that more complex models might expand the possibilities for a strong double dividend, they also offer scope for an optimal environmental tax above MED.

It is also important to recognize that the optimal tax formulae by Bovenberg-van der Ploeg and Parry assume that the optimal environmental tax is part of an optimal tax system. These formulae do not address the *constrained* second-best problem: how best to establish environmental taxes when the rest of the tax system is suboptimal. Much depends on how the rest of the system departs from optimality. Simulation experiments by Bovenberg and Goulder (1994b) for the U.S. economy indicate that the "suboptimality"[57] of the U.S. tax system implies a constrained second-best optimal carbon tax which is lower than that suggested by the Bovenberg-van der Ploeg formula. The intuition is that a given environmental tax generates a larger gross cost in a suboptimal setting than in a setting where other taxes are set optimally.

[57]The tax system is suboptimal in the sense that marginal gross efficiency costs of different taxes are not equal. To the extent that the tax system is meeting other objectives, this need not be suboptimal in a broader sense.

C. "Is a Small Tax Efficiency-Improving?" and Related Theoretical Issues

The cost-side-oriented discussion of the double dividend is driven by the broader question as to whether the substitution of environmentally motivated or "green" taxes for ordinary taxes might be a welfare-improving venture. It is important to recognize that the difficulty of substantiating the strong double dividend claim is not an indication that green tax swaps are ill-advised. Even if gross costs are positive, the environmental benefits could outweigh these costs, possibly by a substantial margin.

But in light of the uncertainties, are positive net benefits likely? There is a line of reasoning that suggests that policymakers can be assured that benefits will exceed costs provided that the environmental tax is sufficiently "small." The argument is that the gross costs of an incremental environmental tax (with revenues devoted to reducing ordinary taxes) is infinitesmal; in contrast, the gross benefits from an incremental environmental tax are non-incremental. This argument prompts two questions: (1) Does a "small" environmental tax indeed have a "small" gross cost? And (2) If so, is this of practical value to policymakers?

A result from Bovenberg and de Mooij (1992, 1993) is relevant to the first question. In their framework, an *incremental* environmental tax, with revenues returned as a reduced labor tax, indeed has a zero gross cost. When the environmental tax is small, it yields the same labor market distortion as the labor tax it replaces, and the gross distortion in the commodity market is infinitesmal. Hence the overall gross cost is zero. So long as the tax yields a non-incremental environmental benefit, it offers an overall welfare improvement.[58]

However, the claim that a small tax yields an overall efficiency improvement may not apply in more general circumstances such as the case where the initial tax system is highly inefficient. The issue is an example of the general second-best tax problem investigated by Lipsey and Lancaster (1956), Bertrand and Vanek (1971), Dixit (1975), and others: In a suboptimal tax system, under what circumstances does introduction of a tax in one market that helps bring prices closer to marginal cost in

[58]A similar result appears in Bovenberg and van der Ploeg (1993b). The authors begin with a situation where households have no concern for environmental quality, and the tax system is optimized conditional on those preferences. They then assume a shift in preferences: the emergence of a concern for environmental quality. It is shown that, in this new setting, raising a tax on the "dirty" commodity improves welfare.

that market yield an overall efficiency improvement? Although a number of authors have shown particular conditions under which this will occur (see, for example, Dixit [1975]), this cannot be guaranteed for tax systems that simultaneously involve labor, capital, and commodity taxation. These notions are reinforced by results from simulations of a carbon tax by Bovenberg and Goulder (1994b) and by Parry (1994). In these simulations, an incremental carbon tax has incremental gross costs when the initial tax situation is efficient in the sense that marginal excess burdens of taxes are equated. However, the incremental tax involves large gross costs when the initial situation reflects inefficiencies of the U.S. tax system.

This suggests that, in many cases, one cannot be assured that a small environmental tax will produce small gross costs. Moreover, even if this were the case, the knowledge that gross costs will be small seems to be of limited practical value. In my view, it cannot substitute for information about the magnitudes of environmental benefits. In the extreme case where analysts have virtually no information about the magnitudes of these benefits -- except perhaps that they are non-negative -- one cannot tell how small is small enough. No matter how small the tax, it's possible that the (small) gross costs exceed the (even smaller) gross benefits. Although it is useful to know that incremental taxes produce negligible costs, to be of practical value this knowledge needs to be coupled with information about benefits.

This discussion was not meant to lead to pessimism. Rather, it was intended to serve the constructive purpose of drawing attention to significant issues in policy evaluation. The key implication of this discussion is that in evaluating possible green tax swaps, information about environmental benefits is indispensable. Much of the interest in the possibility of a double dividend was fueled by a hope that benefits considerations could be pushed aside. This seems to have been a false hope. The benefits side is critical, and further research to reduce the uncertainties about environmental benefits is likely to be of great value to policy analysts.

VI. Summary and Conclusions

This paper has articulated different senses of the potential "double dividend" from environmental taxes and examined the theoretical and empirical support for each.

The weakest double dividend claim is that returning tax revenues through cuts in distortionary taxes leads to cost savings relative to the case where revenues are returned lump sum. This claim is easily defended on theoretical grounds and (thankfully) receives wide support from numerical simulations.

The stronger versions contend that the costs of revenue-neutral swaps of environmental taxes for ordinary distortionary taxes involve zero or negative gross costs. The strongest version affirms that this is typically the case. An intermediate version asserts that this is the case in at least one instance. The existing theoretical analyses of this issue cast doubt on the strong double dividend claim. At the same time, the theoretical case against the strong form is not air-tight. In simple models the strong version would obtain if the uncompensated wage elasticity of labor supply were negative. In more elaborate models, it could arise if the initial tax system were highly inefficient in factor markets (leading to significant differences across factors in marginal value products per dollar) and the environmental tax served to shift the burden of taxes to more efficient factors. These inefficiencies may offer more of a justification for direct attention to these inefficiencies than for indirect approaches through a revenue-neutral environmental tax.

Although the evidence is mixed, numerical results tend to militate against the strong double dividend claim. There is a need for more systematic numerical investigations of revenue-neutral environmentally motivated tax policies. More extensive policy analyses and broader sensitivity analyses would help identify the channels driving the results and reveal the sources of differences in model outcomes. The extent to which the burden of environmentally motivated taxes is imposed on exhaustible resources (and on resource rents) remains a very interesting empirical issue, and greater attention to this issue in numerical models could generate important insights.

The difficulty of establishing the strong double dividend does not contradict the common numerical finding that an environmental tax can promote higher levels of national income when revenues are earmarked for capital formation. National income is distinct from welfare, and the double dividend notions (at least as defined here) concern welfare costs.

The presence or absence of a strong double dividend is directly relevant to the issue of the optimal environmental tax. In simpler models, the conditions under which the strong double dividend claim is absent (present) are closely related to the conditions under which the second-best optimal environmental tax is lower than (greater than) the marginal environmental damages. Existing analytical models, in casting doubt on the strongest double dividend claim, also indicate that the optimal environmental tax is lower than the rate suggested by the simple Pigovian rule.

The keen interest in the double dividend -- particularly in its strong form -- reflects the uncertainties faced by policymakers concerning environmental benefits. The strong double dividend notion, if true, would reduce significantly the amount of information that policymakers need to make a benefit-cost case for green tax swaps. The difficulty of establishing the strong claim implies, unfortunately, that assessing magnitudes of environmental benefits remains a crucial task in policy evaluation. This conclusion cannot be dodged by appeals to the net benefits from "small" environmental taxes. One never knows *a priori* how small is small enough, and, moreover, even small environmental taxes may have "large" gross costs when the existing tax system is suboptimal (in some sense).

The critical importance of attending to the environmental benefits may the most fundamental message from this examination. Research that helps establish the environmental benefits associated with various environmental tax options will have considerable value to policy analysts. While research can reduce the uncertainties, they will remain a basic fact of life in environmental policymaking. Policymakers cannot afford to wait until circumstances permit riskless policy choices; they would wait forever. A better approach is to recognize the uncertainties and endorse environmental tax reforms when the prospects for gain make the risks worth taking.

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Figure 1

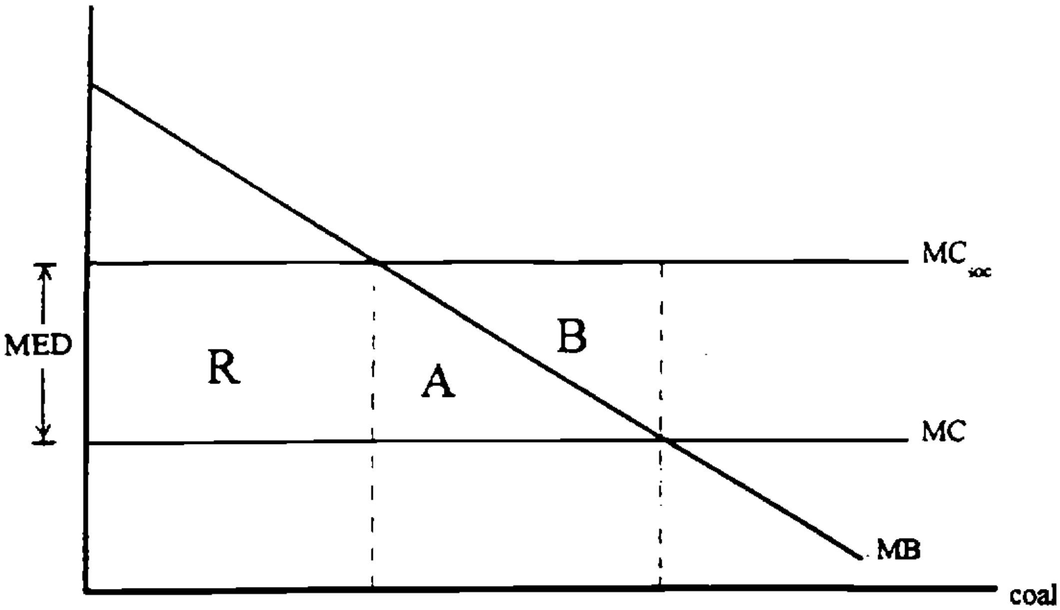

Figure 2

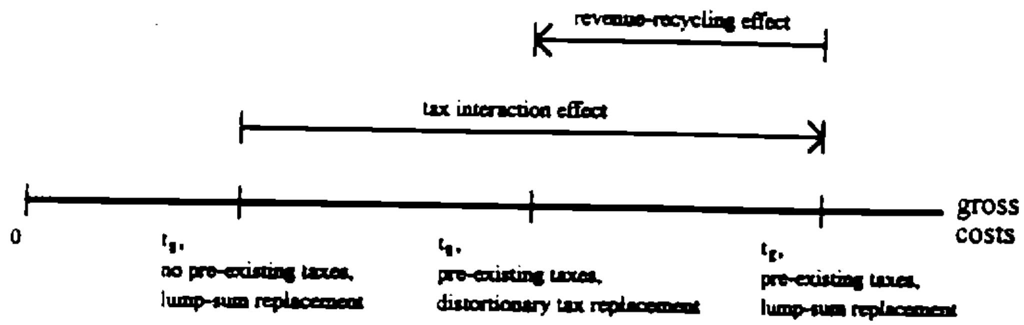
revenue-recycling effect
tax interaction effect
gross
costs
0
no pre-existing taxes,
lump-sum replacement
pre-existing taxes,
distortionary tax replacement
pre-existing taxes,
lump-sum replacement

Table 1
Comparative Numerical Results

Model	Reference	Country	Type of Environmental Tax	Form of Revenue Replacement	Results: Welfare Change	Results: Pct. Change in Real GNP pd. 1	Results: Pct. Change in Real GNP pd. 21
DRI	Shackleton et al. (1992)	U.S.	Phased-in Carbon Tax[a]	Personal Tax Cut	-0.39[b]	-0.00	-0.76
Goulder	Goulder (1994a)	U.S.	$25/ton Carbon Tax	Personal Tax Cut	-0.33[c]	-0.15	-0.22
"	Goulder (1994b)	U.S.	Fossil Fuel Btu Tax	Personal Tax Cut	-0.28[c]	-0.09	-0.18
Jorgenson-Wilcoxen	Shackleton et al. (1992)	U.S.	Phased-in Carbon Tax[a]	Labor Tax Cut	1.01[d]	0.03	-0.41
"	"	"	"	Capital Tax Cut	0.19[d]	0.20	0.95
LINK	Shackleton et al. (1992)	U.S.	Phased-in Carbon Tax[a]	Personal Tax Cut	-0.51[b]	0.00	-0.35
Shah-Larsen	Shah and Larsen (1992)	U.S.	$10/ton	Personal Tax Cut	-1049.[e]	-0.020[f]	
"	"	India	"	"	-129.	-0.060	
"	"	Indonesia	"	"	-4.	-0.005	
"	"	Japan	"	"	-269.	-0.008	
"	"	Pakistan	"	"	-23.	-0.070	

Notes: (a) Beginning at $15/ton in 1990 (period 1), growing at five percent annually to $39.80 per ton in 2010 (period 21), and remaining at that level thereafter. (b) Percentage change in the present value of consumption; the model does not allow for utility-based welfare measures. (c) Welfare cost per dollar of tax revenue, as measured by the equivalent variation. (d) Equivalent variation as a percentage of benchmark private wealth. (e) Compensating variation in levels (millions of U.S. dollars). (f) Percentage change in GDP (not GNP). This is a one-period model.