

**Environmental Taxes and the Double-Dividend Hypothesis:  
Did You Really Expect Something for Nothing?**

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ABSTRACT

The "double-dividend hypothesis" suggests that increased taxes on polluting activities can provide two kinds of benefits. The first dividend is an improvement in the environment, and the second dividend is an improvement in economic efficiency from the use of environmental tax revenues to reduce other taxes such as income taxes that distort labor supply and saving decisions. In this paper, we make four main points. First, the validity of the double-dividend hypothesis cannot logically be settled as a general matter. Second, the focus on revenue in this literature is misplaced. We demonstrate that three policies have equivalent impacts on the environment and on labor supply. One of those policies raises revenue from the environmental component of the reform, another loses revenue, and a third has no revenue associated with it. Third, what matters is the creation of privately-held scarcity rents. Policies that raise product prices through some restriction on behavior may create scarcity rents. Unless those rents are captured by the government, such policies are less efficient at ameliorating an environmental problem than are policies that do not create rents. Finally, we distinguish between two types of command and control regulations on the basis of whether they create scarcity rents.

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## I. Introduction

Roughly speaking, the "double-dividend hypothesis" suggests that increased taxes on polluting activities can provide two kinds of benefits. The first dividend is an improvement in the environment, and the second dividend is an improvement in economic efficiency from the use of environmental tax revenues to reduce other taxes such as income taxes that distort labor supply and saving decisions. These income tax distortions reduce the efficiency of the market economy, as estimates suggest that an additional dollar of revenue from the income tax imposes a burden on the private sector of about \$1.35. The 35-cent difference is an "excess burden." In contrast, a tax on pollution can increase the efficiency of the private sector by making the producer face the full social costs of each polluting activity. Thus the second dividend is a reduction in excess burden.

To many, this proposition seems obvious. The policy debate has focused on specific pollutants that could readily be taxed, and specific taxes with high excess burden that could readily be reduced. Yet the academic debate has focused on the general validity of such a proposition. As described below, several important papers have shown that the environmental tax has its own distorting effects on labor supply and therefore can have the same excess burden as a tax on labor income. Thus the double-dividend hypothesis is said to fail.

In this paper, we make four main points. First, the validity of the double-dividend hypothesis cannot logically be settled as a general matter. Clearly, under some conditions, a particular reform might be able to improve the environment and improve the tax system by reducing some particularly egregious existing tax. Equally clear is that some other misguided reforms would not. Each proposal must be evaluated individually. The important point is that this evaluation must *fully specify the policies already in place as well as the reform under consideration*. If this polluting activity is already taxed at a rate higher than the "optimal" rate, taking all considerations into account, then any suggested increase is not warranted. Even if it is

taxed at a low rate, or not at all, the polluting activity might already be subject to other regulatory restrictions. Existing policies are crucial to understanding the benefits of any proposed reform. Moreover, the reform itself needs to be fully specified: is this tax added on top of existing regulatory restrictions, or does it replace those restrictions? And how will the revenue be used? In this regard, an important contribution of the double-dividend debate is that the proposal to add an environmental tax is only half of a proposal, since the reform must also specify whether the revenue goes to deficit reduction, a specific spending program, or a specific tax reduction.

Therefore, when we review some of the early and later literature pertaining to the double-dividend hypothesis, we organize the discussion around two questions: What are the existing policies in place before the reform? And what exactly is the reform? Some of the papers do not address both of these questions, which leaves the double-dividend hypothesis inadequately specified. Then, without a well-articulated proposition, they proceed to argue its validity.

Strictly speaking, the second dividend from an environmental tax reform is a reduction in excess burden from the entire tax system. As we show below, however, much of the literature has emphasized the importance of raising revenue in order to obtain this second dividend. Our second main point is that this focus on revenue is misplaced. A well-designed reform may generate environmental benefits, and it may reduce other existing distortions, but those outcomes are entirely unrelated to whether it raises revenue. We describe a non-revenue-raising type of command-and-control regulation that has identical economic effects to the combination of an environmental tax increase and income tax reduction. We also describe a revenue-losing environmental subsidy (financed by an increase in the income tax) that has identical economic effects to a revenue-raising environmental tax (with revenue used to reduce the income tax). If designed to affect behavior in the same way, all three have identical economic effects. The choice among these three policies then depends on considerations *other* than revenue, such as which

policy is easier to administer, easier to enforce, or easier to enact.

To drive home the point that revenue-raising cannot be the key to economic benefits, consider how the revenue is generated. That money must come from somewhere and impose costs on somebody. It is not free money. The impact of the reform depends on the extent to which polluting activities are discouraged and to which productive market activities are encouraged. Thus the impact of the reform depends on how it affects relative prices, incentives to work, produce, and pollute.

Our third main point relates the double-dividend literature to another earlier literature about how some types of environmental policies generate "scarcity rents" by restricting the amount of pollution. To at least some extent, a restriction on the amount of pollution is a restriction on the amount of output, which enables firms in equilibrium to charge a higher price for their output. Given this higher price of output, the right to pollute is more valuable. The "scarcity rent" is the increase in the value of the right to pollute one unit. It is reflected, for example, in the price of a tradeable permit for one ton of sulfur-dioxide emissions under the Clean Air Act Amendments of 1990. These permits are sold on the Chicago Board of Trade for about \$150 each. Other command-and-control restrictions create similar scarcity rents, even if pollution rights are not tradeable. Consider the simple case where the production technology requires a fixed amount of pollution per unit of output, and where the government requires every firm to cut pollution to 90 percent of last year's level. Then firms must cut production to 90 percent of last year's level. The price of output must rise, for the market to clear, but actual production costs have not changed. Normally firms are prohibited from agreements to restrict output, but this kind of regulation essentially requires them to restrict output. The result is super-normal profits.

The point is that environmental protection can raise the price of output for two very different reasons. First, prices may rise because of the necessary costs of environmental

technologies such as switching to the more-expensive low-sulfur fuel, switching output to the more-expensive plant with lower emission rates, or installing flue-gas desulfurization units (scrubbers). These costs can be minimized by well-designed policies, but they must ultimately offset some of the benefits of environmental improvement. Second, however, output prices may rise further, to cover scarcity rents. We argue that this second type of cost is not essential to environmental protection. Scarcity rents raise the cost of output unnecessarily, which offsets more of the benefits of environmental improvements. These costs may exceed the benefits of environmental improvements, which would turn the whole reform into a net losing proposition. This point is formalized below.

Moreover, this point about scarcity rents helps explain what was missing in the debate about the double-dividend hypothesis. When a tax on pollution raises revenue, we argue that the government is merely capturing the scarcity rent associated with restricting that pollutant. In a sense, the tax raises the cost of production by more than the minimum necessary. It requires the firm not only to install scrubbers or undertake other expensive pollution abatement, but also to pay the tax. The revenue is the scarcity rent. The difference is that the government can use those revenues to *offset* the increased costs of production, by reducing other existing taxes on production. This point can be clarified by comparing the handout of tradeable permits, as under the Clean Air Act Amendments (CAAA), with an alternative government sale of permits at auction. In both cases the permit requirement increases the cost of production, but only in the latter case does the government capture the scarcity rent in a way that allows it to reduce other tax-related costs of production.

Thus the best that can be done with the revenue from an environmental tax is to offset the extra cost of production that was caused by the tax itself. The revenue is not free money.

Finally, we make a critical distinction between two types of command-and-control (CAC)

regulations. Some regulations restrict pollution, and create scarcity rents, without capturing those scarcity rents in a way that would allow government to offset the extra costs of production (by reducing some other tax). The CAAA falls in this category. The only advantage of this type of regulation is political feasibility, since the prospects for private profits may induce firms to support the proposal. A different kind of command-and-control regulation does not create scarcity rents in the first place. Examples are policies that require all firms to use the latest technology, or otherwise to reduce pollution *per unit* of output. If properly designed, this kind of requirement can improve the environment at minimum cost, but firms are still allowed to pollute and produce as much as desired. Thus it does not restrict entry and create scarcity rents. This kind of CAC policy can have the same effects as a policy shift to a pollution tax (which further raises costs of production) while using the pollution tax revenues to cut another tax (which reduces costs of production).

Thus, in the course of this paper, we discuss not just the double-dividend hypothesis, but also related hypotheses about the importance of revenue, the creation of scarcity rents, and the choice between different policy instruments such as taxes, subsidies, tradeable permits, and command-and-control regulations. The next section develops a few analytical tools that are essential to understand these hypotheses about the interaction of environmental taxes with other tax distortions. Using these tools, the following sections proceed to sort out the validity of various propositions as stated in the literature.

## **II. Second-Best Analysis of Environmental Policy**

Much of the confusion about the double-dividend comes from an imprecise statement of the problem. The essential issue that researchers have addressed is the role of revenue from environmental levies. But other important questions that bear on the central point of the double-

dividend hypothesis are left unasked. Two questions in particular stand out. First, what is the starting point for the analysis? Most existing environmental controls in the United States are command and control (CAC) type regulations. Very few existing controls are market-based approaches, and fewer still are environmental taxes. Yet researchers occasionally evaluate the double-dividend hypothesis in the context of a pre-existing environmental tax. Or they assume no environmental controls of any sort. However, the benefits of adding an environmental levy clearly depend on where we start. For example, if existing CAC regulations are already stringent, then environmental levies may have little impact on pollution. Second, what exactly is the reform under consideration? The effects will be very different depending on whether the environmental tax is a replacement for those existing CAC regulations, or added on top of those regulations.

We will use these two questions to organize our discussion of the double-dividend literature in the next section, but first we need to clarify why these questions and their answers are so important. For this purpose, we need to develop some simple analytical tools. In fact, we need only two figures, although we will make repeated use of them.

In Figure 1, the horizontal axis represents the amount of pollution ( $Z$ ), which may include waste by-products that are gaseous, liquid, or solid. In order to be able to produce, firms would be willing to pay for the right to pollute. Thus their "demand" for pollution reflects the marginal benefit of pollution to production (which, in turn, reflects the benefit to consumers of being able to buy the final product). This marginal benefit (MB) curve starts out high, because some minimal level of pollution is crucial to production, and it slopes down because additional units of pollution are successively less crucial. In the absence of any regulations or taxes, firms would pollute to the point  $Z^o$ , where the marginal benefit of pollution equals its private marginal cost (PMC, which equals  $P^o$ ). These private marginal costs of pollution are just the costs of disposal through smokestacks or through storage, removal, and transportation of those wastes.



Yet the social cost of pollution is higher than the private cost, because it imposes negative external costs on others. The social marginal cost (SMC) of pollution is  $P'$ , which includes the private cost plus "marginal environmental damages." Then the optimal amount of pollution is only  $Z'$ , and the problem for policy is to cut pollution from  $Z^\circ$  to  $Z'$ .

The solution of Arthur Pigou<sup>1</sup> is to impose a tax per unit of pollution, at a rate  $t_z$ , equal to the marginal external damages per unit of pollution. This Pigouvian tax raises the private cost of pollution from  $P^\circ$  to  $P' = P^\circ + t_z$ . Then firms face costs  $P'$  and stop at  $Z'$ . The tax revenue would be the tax rate times the amount of pollution subject to tax, that is, the rectangle area A. In a first-best world, with no other distortions, welfare improves by the triangle area B. This area measures the extent to which social marginal cost (SMC) exceeds the marginal benefits, for each of those units of pollution beyond  $Z'$ , up to  $Z^\circ$ .

However, actual environmental policies typically do not employ this kind of tax. Instead, actual policies tend to employ command-and-control regulations. In this model, a CAC regulation might be represented by the mandate that "pollution shall not exceed  $Z'$ ." If designed properly, such a regulation can move the economy to the same reduced optimal amount of pollution and provide the same triangle welfare gain, area B.

In this context, one version of the double-dividend hypothesis simply states that the environmental tax would both reduce pollution (from  $Z^\circ$  to  $Z'$ ) and raise revenue. The reason this revenue is important, according to the double dividend hypothesis, is because it can be used to reduce distortions caused by other taxes such as income taxes that apply to labor supply. To clarify these other distortions, we turn to the next figure.

In Figure 2, the horizontal axis measures aggregate labor hours, and the vertical axis

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<sup>1</sup> ARTHUR PIGOU, THE ECONOMICS OF WELFARE (1936).

shows the wage rate in dollars per hour. The gross wage rate  $W_g$  is subject to tax at rate  $t_w$ , so the net wage is only  $W_g(1-t_w)$ . The upward-sloping labor supply curve indicates the extent to which people are willing to work more hours if they get to keep a higher net wage. If the initial net wage is only  $W_n^\circ$ , because of existing income taxes, then workers choose hours of labor  $L^\circ$ . This tax imposes an excess burden or "deadweight loss" on the economy, triangle area C. If the environmental problem is addressed by a pollution tax, the double-dividend hypothesis says that the revenue can be used to reduce the labor tax rate and shrink the size of this deadweight loss triangle. The first dividend is the environmental gain (area B in Figure 1), and the second dividend is a smaller cost of labor taxes (smaller area C in Figure 2).

As described in the next section, the major conceptual challenge to the double-dividend hypothesis can also be described using Figure 2. Recent authors point out that what matters to workers is the *real* net wage, defined as the gross wage  $W_g$ , times  $(1-t_w)$ , divided by the price of consumption goods ( $P_C$ ):

$$W_n = W_g(1-t_w)/P_C$$

In other words, individuals in the economy are equally affected whether government were to take half their income (through  $t_w = .5$ ) or to impose production taxes that double the price of everything (e.g. raising the price index  $P_C$  from 1 to 2). Either way, the amount one can buy is cut in half. This insight was forgotten in some of the early double-dividend literature, but it is important because pollution taxes raise the cost of production and thus raise the break-even price of output. This effect *reduces* the real net wage, which offsets the *increase* in the real net wage made possible by using the revenue to reduce the labor tax rate. Under certain simplifying assumptions that represent a reasonable approximation, the two effects exactly offset. Thus we have no general presumption that the tax shift (from labor tax to pollution tax) can have any effect on the real net wage, on labor supply, or on the deadweight loss from income taxes. The second

dividend can only be obtained by cutting some other tax that is more distorting than average.

With this analytical machinery, we are now in a position to describe some of our own challenges to this literature. As just described, some of that double-dividend literature is silent on the question of permit or command-and-control regulations, whether they exist before the pollution tax is imposed, and whether they will be removed and replaced by those proposed pollution taxes. We use the same figures to show why these questions are important.

Instead of using a tax on pollution in Figure 1, authorities could simply restrict pollution to no more than  $Z'$ , either through a CAC regulation or through a system of tradeable permits. Since the marginal benefit of pollution exceeds the marginal cost at  $Z'$ , firms will pollute up to the legal limit. At this point, a marginal unit of pollution continues to have private disposal cost equal to  $P^\circ$ , but its marginal benefit or value in production is  $P'$ . Firms are *willing* to pay the difference  $(P' - P^\circ)$  for the right to pollute, whether or not they are allowed to pay for this right. If no trades are allowed, and this value is not observed as a market price, then the difference  $(P' - P^\circ)$  is a "shadow price". Anybody who is allocated the limited rights to pollute can use a unit of pollution to create value equal to  $P'$ , at a cost of only  $P^\circ$ . The difference is a profit, or "scarcity rent."

The clearest example is the Clean Air Act Amendments of 1990<sup>2</sup>, which sets up a system of  $Z'$  tradeable permits. The right to emit one ton of sulfur dioxide sells for about \$150. Anybody who wants to buy such a permit must face a cost of pollution equal to the private marginal cost ( $P^\circ$ ) *plus* 150. The higher cost of production raises the equilibrium output price. Any permit recipient can use the permit to produce and sell its output at this new higher output price, or can sell the permit for \$150. Either way, initial recipients are handed a private profit.

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<sup>2</sup> Pub.L 101-549, November 15, 1990, 104 Stat. 2399.

The total value of the scarcity rent for  $Z'$  permits is the rectangle in Figure 1, area A.

Thus the choice between pollution restrictions and pollution taxes is essentially a choice about who gets the scarcity rents. The pollution restriction leaves those rents in private hands, which might make the whole program politically palatable to business. In contrast, the pollution tax would capture area A as tax revenue. Either way, the cost of pollution rises from  $P^\circ$  to  $P'$ , which raises the equilibrium output price ( $P_C$ ) and therefore reduces the real net wage. If the real net wage is reduced from  $W_n^\circ$  to  $W_n'$  in Figure 2, then the deadweight loss in the labor market *increases* by area D! If the only environmental protection is in the form of such quantity restrictions (CAC regulation or permits), then the benefit of environmental protection (area B in Figure 1) is at least partly *offset* by the social cost of the reduction in the real net wage (area D). As shown in the literature reviewed below, this extra cost can exceed the environmental benefits. Even starting from an uncorrected externality, where firms face only the private costs and pollute to point  $Z^\circ$ , even a small restriction on pollution can easily *reduce* overall welfare.

While this CAC regulation raises output prices, and thus exacerbates the labor supply distortion, the pollution tax instead can capture the scarcity rents and use the revenue to reduce the income tax rate and thereby *offset* the effect of output prices on the real net wage. This logic suggests no second dividend. The pollution tax revenue cannot in general be used to reduce the labor distortion, but it can be used to avoid an increase in the labor distortion. If so, welfare can still rise by the first dividend -- environmental protection.

We are now in position to describe the importance of the starting point for the double-dividend hypothesis. If the particular pollutant is not subject to *any* existing controls, then the proposed pollution tax might raise product prices, but the proposal can use the revenues to cut the labor tax and offset the adverse effect of product prices on the real net wage. That combination leaves just the first dividend, environmental protection, but no second dividend.

However, suppose that existing CAC regulations have *already* cut pollution from  $Z^\circ$  to  $Z'$  in Figure 1, raising the value of pollution above its private cost  $P^\circ$ . Somebody is getting the scarcity rent. In this world, the imposition of a small pollution tax raises the private cost of pollution above  $P^\circ$ , but that just cuts into the scarcity rent. As long as the benefits of pollution ( $P'$ ) at the restricted quantity ( $Z'$ ) exceed the private cost of pollution ( $P^\circ$  plus the tax), firms will still emit up to the legal limit ( $Z'$ ). Thus, a small pollution levy has *no* impact on pollution or on the output price. It does raise revenue, however, by taking part of the scarcity rent. In this case, the previous results are *reversed*. This proposed pollution tax does not have any first dividend, since it does nothing to improve the environment, but it *does* provide a second dividend! With a pre-existing quantity restriction, the pollution tax does not raise product prices but does provide revenue that can be used to reduce labor tax distortions.

In effect, the first dividend - increased environmental protection - was generated by the existing regulations. The second dividend comes by shifting to an environmental policy that preserves that first dividend while raising revenue that can be used to finance a reduction in other taxes. The magnitude of this second dividend depends on the relative size of the tax increase versus the stringency of the existing environmental regulations. If the tax rate is set to the full difference ( $P'-P^\circ$ ), then all of the scarcity rents will be captured.

Second, we ask, what is the reform under consideration? Are environmental levies being enacted to supplement existing pollution restrictions (such as CAC regulations) or are they being used to replace existing restrictions? Again, Figure 1 illustrates the importance of this question. Consider a proposed environmental levy that is smaller than the scarcity rent ( $P'-P^\circ$ ). If that levy is added on top of existing CAC regulations that reduce pollution to  $Z'$ , then it has no impact on pollution. On the other hand, if the small pollution tax is to replace the CAC regulations, then pollution could actually increase. Whether pollution would increase or decrease depends on the

size of the tax relative to the stringency of the existing CAC regulations. We do not mean to argue that the outcome of this example is general but merely to point out that different experiments lead to different outcomes.

Also, when we ask “what exactly is the reform under consideration?”, we mean that the proposal needs to specify how the revenue will be used, or how the required revenue will be raised. In this connection, an interesting result is that an environmental subsidy can have exactly the same effects as an environmental tax -- even though one policy raises revenue and the other costs revenue. The reason is because of effects on the real net wage (see Figure 2). We showed above that a tax on pollution raises the cost of production, which lowers the real net wage and would exacerbate the labor supply distortion *unless* the revenue is used to cut the labor tax rate. The two effects on the real net wage offset each other. For a subsidy to pollution abatement, the effects are symmetric. The subsidy effectively reduces the cost of production, which would tend to reduce the equilibrium (break-even) price of output. The lower price  $P_C$  serves to raise the real net wage *except* that the subsidy must be financed by raising the labor tax. Again the two effects offset, and the real net wage is unaffected. Neither policy has a second dividend, but both policies can have the same first dividend -- environmental improvement.

For these reasons, we conclude that revenue is not the key to understanding the efficacy of environmental policy. The key is to avoid policies that create scarcity rents left in private hands. Such a policy raises the cost of production unnecessarily, and exacerbates the labor tax distortion. Certainly pollution tax revenue might be important as a way to capture those scarcity rents, but a 100% profits tax would do just as well. The point is not to leave rents in private hands.

Yet not all CAC regulations create scarcity rents in the first place. Later sections below will use these same analytical tools to describe a “technology restriction” that has the same net benefits of environmental protection (area B), without exacerbating the labor distortion. This

policy has no revenue consequences, but can perform just as well as the pollution tax with revenue used to reduce the labor tax rate. The key is that it does not create scarcity rents.

Before we proceed to those new results, we use this analytical machinery to review some of the existing literature. In particular, we consider how other authors address the two key questions.

### III. The Early Literature

Tullock<sup>3</sup> might be the first to recognize the potential significance of the revenue from environmental levies, even before the “double-dividend” terminology. He notes that he and other economists had ignored an essential fact about pollution taxes: "Governments need money, and the return from charges on externality is a possible source of such funds."<sup>4</sup> Tullock frames his hypothesis as follows: "If the external cost [associated with the externality] is large, it is quite possible that the government revenue will be 'free,' that is, that the private sector will be as large, or larger, after the government has taken its revenue as it was before."<sup>5</sup> Tullock notes that this point had never occurred to him before, nor to a number of other economists including "... a member of the President's Council of Economic Advisers, a holder of the John Bates Clark medal, and an economist who is a recognized leader in research in both [environmental economics and public finance]."<sup>6</sup>

For Tullock, the starting point appears to be the existing system of non-environmental taxes and environmental regulations. He quotes Whipple to say: "The American tradition is

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<sup>3</sup> Gordon Tullock, *Excess Benefit*, 3 WATER RESOURCES RESEARCH 643 (1967).

<sup>4</sup> *Ibid*, at 643.

<sup>5</sup> *Ibid*.

<sup>6</sup> *Ibid*.

inclined toward placing upon private industry the cost of processing industrial effluents to reduce the quantity of wastes, but it relies upon stream flow standards and specific orders rather than the economic pressure of prices to control the process."<sup>7</sup> Tullock recognizes that we already have environmental regulations in place, and that we rely on distorting taxes to raise revenue for essential government activities. In fact, the title of his paper, "Excess Benefit" is designed to contrast directly with the notion of excess burden. The idea is that properly-designed environmental levies do not generate excess burden but rather excess benefits.

The experiment that underlies Tullock's statement of the double-dividend hypothesis is less clear. At one point, the reform appears to introduce a tax that would improve environmental quality and provide the first dividend (area B in Figure 1): "If some activity imposes an external cost, then a properly calculated tax on it will reduce the total output of the private sector by less than the revenue received by the government."<sup>8</sup> Later Tullock suggests that environmental levies could replace regulations: "The removal of these [polluting] activities from the criminal code and their listing as heavily taxed items in the revenue act would not only increase freedom by widening the individual's opportunity set [by making pollution legal but costly], it would also contribute at least some revenue to the government."<sup>9</sup> Now the experiment does not affect environmental quality, but simply raises revenue by capturing the scarcity rent (area A in Figure 1). He is right that this revenue can be used to cut the labor tax, but it does not provide any additional environmental protection.

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<sup>7</sup> William Whipple, *Economic Basis for Effluent Charges and Subsidies*, 2 WATER RESOURCES RESEARCH 159 (1967), at 159.

<sup>8</sup> Tullock, *supra* note 3, at 643.

<sup>9</sup> *Ibid*, at 644.



The scope of the experiment is also unclear. At times he appears to suggest a large scale replacement of pre-existing taxes with environmental levies. At other times he suggests a more piecemeal approach: "A careful inspection of our legal prohibitions to see if there are not some activities that would be better taxed would almost certainly turn up at least some cases where the change would be desirable."<sup>10</sup>

Terkla<sup>11</sup> is one of the first to estimate the revenues that could be raised by shifting to a system of national effluent taxes in lieu of command and control regulations. He focuses on particulates and sulfur oxide emissions from stationary sources, and he estimates that taxes on just these two pollutants would provide enough revenue to reduce excess burden from labor taxes by an amount between \$1 to 5 billion (1982 dollars). Terkla answers both of our two key questions. The starting point for his analysis is the existing system of environmental controls, and the experiment he undertakes is to levy a tax at precisely the level to mimic the existing system of environmental regulations: "The taxes are chosen so as to equal the marginal cost of reducing emissions of each pollutant at the level of emissions currently allowed by the national standards."<sup>12</sup> In effect, Terkla's reform is both environmentally-neutral and revenue-neutral.

In terms of Figure 1, Terkla assumes that regulations are in place that reduce pollution to  $Z'$ . He then sets the tax rate so that the marginal cost of pollution (including the tax) rises to  $P'$ . Thus firms will choose to maintain pollution at  $Z'$ , regardless of whether they are legally limited to only  $Z'$ . He designs a conceptual experiment such that environmental quality is unaffected.

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<sup>10</sup> *Ibid.*

<sup>11</sup> David Terkla, *The Efficiency Value of Effluent Tax Revenues*, 11 JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT 107 (1984).

<sup>12</sup> *Ibid.*, at 109.

He does not indicate whether the existing environmental regulations will be eliminated, but the experiment is designed to make them irrelevant.

Because Terkla designs the experiment to leave environmental quality unchanged, the only benefits from this policy are the revenues that are available to reduce other distorting taxes. To quantify the benefits from this reform, Terkla uses estimates from the existing literature of the excess burden per dollar of additional tax revenues. For labor income taxes, Terkla estimates an excess burden of \$0.35 per dollar of additional labor income tax revenues. For the corporate income tax, he uses an estimate of \$0.56. Terkla estimates that anywhere from \$1.8 to \$8.7 billion can be raised nationally from taxes on particulates and sulfur dioxide emissions. Thus, Terkla argues, if \$1.8 billion of environmental taxes are raised, and used to lower the corporate income tax, the reform will provide  $(\$1.8 \text{ billion})(.56) = \$1 \text{ billion}$  of reduced excess burden in the U.S. economy. At his high-end, a \$8.7 billion revenue estimate would translate into \$4.9 billion of reduced excess burden.

Caution is necessary before extrapolating from Terkla's efficiency findings. Terkla has carefully designed an experiment so that the efficiency costs of the environmental taxes are zero. His tax has no effect on output prices, because it just captures the scarcity rent. Other environmental tax proposals *do* affect output prices, but some subsequent researchers attempting to follow Terkla simply ignore those effects and the efficiency costs of environmental taxes. Recall that Terkla's environmental tax has no efficiency cost since he begins with regulations that have already reduced pollution to  $Z'$  and then implements a tax chosen so that the equilibrium level of pollution is unchanged. Thus the efficiency loss associated with environmental policy arises from the pre-existing set of environmental regulations; the shift from regulations to taxes will not alter that distortion. Put differently, Terkla's reform is environmentally-neutral and revenue-neutral, while other reforms in the double-dividend literature are only revenue-neutral.

The change in environmental quality in these latter studies has both benefits (less pollution) and costs (lower real net wage).

Terkla does not attempt to estimate the optimal tax on pollutants in a second-best world.<sup>13</sup> However, he does speculate that the optimal environmental tax rate exceeds the social marginal damage because of the revenue that the tax generates.<sup>14</sup> But this conclusion does not follow from his analysis, since his experiment has been carefully designed to eliminate any excess burden from the environmental tax by having it replace an otherwise equivalent regulatory system.

Lee and Misiolek<sup>15</sup> take as given Terkla's argument that environmental levies confer a positive benefit by raising revenue, and they extend the analysis to consider the optimal environmental tax rate.<sup>16</sup> This is a new direction in the analysis, as previous researchers had not considered the relationship between the social marginal damage from pollution and the optimal tax rate in an economy with pre-existing distortions. In part, the motivation for their analysis is the speculation by Terkla that the optimal environmental tax rate might exceed the social marginal

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<sup>13</sup> "...the purpose of this paper is not to select the optimal effluent tax, but to provide an estimate of the order of magnitude of revenues which can be raised from a tax designed to achieve the current national standards..." Terkla *supra* note 11, at 111.

<sup>14</sup> "...given the relatively large excess burden associated with other tax revenues, there may be a net efficiency gain by raising the effluent tax rate beyond the optimal level, if this were to raise more revenue." Terkla *supra* note 11, at 115.

<sup>15</sup> Dwight Lee and Walter Misiolek, *Substituting Pollution Taxation for General Taxation: Some Implications for Efficiency in Pollution Taxation*, 13 JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT 338 (1986).

<sup>16</sup> "Our purpose is to take explicitly into consideration the nonenvironmental benefit generated by pollution taxation and to examine the impact which this benefit has on the analysis of the efficient pollution tax." Lee and Misiolek *supra* note 15, at 339.

damage of pollution.<sup>17</sup> However, this speculation was not at the center of Terkla's analysis, nor does it relate particularly to the experiment that he carries out.

Lee and Misiolek construct a simple benefit-cost framework to analyze whether the pre-existing tax distortions make the optimal environmental tax rate higher or lower than the Pigouvian prescription (which would set the tax rate equal to the social marginal damage from pollution). The tax reform is revenue-neutral, since tax revenues are used to lower other distorting taxes, but the paper is silent on the presence of any pre-existing environmental regulations. If this silence indicates the absence of other regulations, then this paper proposes an experiment that is very different from the one in Terkla. This difference has contributed to the confusion over the nature of the double-dividend. Whereas Terkla carefully constructed an experiment so that environmental taxes have no deadweight loss, Lee and Misiolek simply ignore the fact that the environmental tax might well have deadweight loss (by reducing the real net wage). They just focus on the revenue potential.

Their model is very simple, and much like the model underlying Figure 1. Pollution provides benefits to producers, with declining marginal benefits (like the MB curve in Figure 1). Private marginal costs of pollution can be represented here by  $P^\circ$ , and social marginal costs ( $P'$ ) are higher than private marginal cost. In the absence of governmental intervention, firms would pollute to the point where the incremental benefit from additional pollution is driven down to the level of private marginal cost (at point  $Z^\circ$ ). With a Pigouvian tax  $t_z$  equal to marginal environmental damages, firms would face a cost of pollution equal to  $P' = P^\circ + t_z$ . At this price  $P'$ , firms would reduce pollution to  $Z'$ .

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<sup>17</sup> Terkla *supra* note 14. Terkla cautions that this would need to be tested in a general equilibrium model which would account for all relevant price changes.

Lee and Misiolek then consider an increase in the tax above the Pigouvian rate. This increase has multiple effects. First, if the small increase in the environmental tax rate raises additional revenue, then the other tax can be reduced and welfare raised. Second, the small increase in the tax rate above the Pigouvian rate will decrease pollution. This decrease in pollution itself has both costs and benefits. The social cost of reducing pollution is the value of what it produces (the height of the MB curve), while the social benefit of reducing pollution is the averted damages (the height of the SMC curve). Since the optimal point Z' was found where these two heights were equal, a small cut in pollution from this point provides no net gain or loss. Thus, for Lee and Misiolek, the whole case for a tax rate greater than the Pigouvian rate rests on whether the higher tax rate will raise additional tax revenue.<sup>18</sup> In their words, the revenue “provides an efficiency benefit by offsetting revenues raised by other taxes and reducing the distortions associated with these taxes.”<sup>19</sup> They assume that this “tax substitution” benefit is positive, and that it falls as environmental tax revenues increase.

Lee and Misiolek's approach focuses attention sharply on the revenue-raising potential of the environmental tax, but in the process it entirely ignores potential efficiency costs (through effects on the real net wage).<sup>20</sup> Recall that an environmental tax raises the price of goods that generate pollution as a by-product of production, and that these increased prices exacerbate pre-existing distortions from commodity or wage taxes. This effect calls into question the very premise that the tax substitution benefit is positive.

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<sup>18</sup> Specifically, the increase in the tax rate will raise revenue if the tax elasticity of pollution demand is less than one. The tax elasticity of pollution demand is the percentage change in demand for pollution by firms as the tax on pollution is raised by one percent.

<sup>19</sup> Lee and Misiolek *supra* note 15, at 340.

<sup>20</sup> Oates also stresses these revenue considerations for the choice of the optimal tax rate on pollution. Wallace Oates, *Pollution Charges as a Source of Public Revenues*, in *ECONOMIC PROGRESS AND ENVIRONMENTAL CONCERNS* 135 (Herbert Giersch ed., 1993).

The fundamental flaw in the Lee and Misiolek paper is that their tax substitution function is not derived from underlying economic theory. It led them to an erroneous conclusion that has been perpetuated by proponents of the double-dividend notion, namely, that the optimal tax on pollution exceeds the Pigouvian tax rate whenever increasing the environmental tax beyond the Pigouvian level would raise revenue.<sup>21</sup>

Our interpretation is that this early literature emphasizes the revenue from environmental levies. Tullock raised the possibility that the government revenue will be "free," while Terkla estimated the amount of revenue and the efficiency gains from using it. For Lee and Misiolek, the whole benefit of raising the pollution tax depends on whether it raises revenue. We now show how this emphasis on revenue continues in the double-dividend literature.

#### **IV. The Double Dividend Hypothesis**

In the late 1980s, concern was growing over global warming and other environmental problems. Concern was also growing over the federal budget deficit in the United States, and

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<sup>21</sup> As pointed out by A. Lans Bovenberg and Fredrick van der Ploeg, *Environmental Policy, Public Finance and the Labour Market in a Second-Best World*, 55 JOURNAL OF PUBLIC ECONOMICS 349 (1994), a close reading of Agnar Sandmo, *Optimal Taxation in the Presence of Externalities*, 77 SWEDISH JOURNAL OF ECONOMICS 86 (1975) exposes the fallacy of this argument. Sandmo calculates the optimal tax rate on pollution for a system in which other distorting taxes are required to meet revenue needs. Consider a set of preferences such that, ignoring pollution, the optimal tax structure is a uniform tax on all goods. Such a tax can be imposed by explicitly taxing all commodities at the same rate or by simply implementing a wage tax. Sandmo shows that, in such a world, the optimal tax on pollution would equal the social marginal damages divided by the cost to the private sector of having the government raise an additional dollar. Using's Terkla's estimate described above, the cost to the private sector is \$1.35 for the government to raise one dollar by a tax on personal income. Thus, so long as distorting taxes are necessary, this private cost exceeds \$1, and the optimal tax rate on pollution is less than the marginal social damage from pollution.

environmental levies seemed a painless way to raise funds to ease the deficit burden. Pearce<sup>22</sup> is perhaps the first writer to use the term "double-dividend:"

Governments may then adopt a fiscally neutral stance on the carbon tax, using revenues to finance reductions in incentive-distorting taxes such as income tax, or corporation tax. This 'double-dividend' feature of a pollution tax is of critical importance in the political debate about the means of securing a 'carbon convention'.<sup>23</sup>

Notice the continued emphasis on revenues from the environmental tax. Pearce explicitly had in mind an emerging environmental problem with no current regulations, and a new carbon tax that would generate revenues that could be used to lower other distorting taxes. Since carbon emissions are not currently regulated, however, this experiment is qualitatively different from Terkla's experiment in which emissions were held constant. Indeed, Pearce acknowledges that the carbon tax may indeed have efficiency costs: "Carbon taxes themselves will impose a deadweight loss which has to be set against the gain from the reduced externality from global warming."<sup>24</sup> Unlike the tax in Terkla's experiment, Pearce's carbon tax is intended to change behavior. It reduces carbon use by raising the cost of carbon, but that necessarily raises the cost of production and thus reduces the real net wage.

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<sup>22</sup> David Pearce, *The Role of Carbon Taxes in Adjusting to Global Warming*, 101 THE ECONOMIC JOURNAL 938 (1991).

<sup>23</sup> *Ibid*, at 940.

<sup>24</sup> *Ibid*, at 943. Pearce cites work by John Whalley and Randall Wigle, *The International Incidence of Carbon Taxes*, in GLOBAL WARMING: ECONOMIC POLICY RESPONSES 233 (Rudiger Dornbusch and James Poterba eds., 1991) which suggests that a large carbon tax (based on the consumption of carbon embodied in products) would create economic losses on the order of 1.2% of GNP. These results come from a large scale numerical simulation model that does not explicitly recycle the revenues (as would the double-dividend hypothesis). Rather, each country receives tax proceeds and presumably distributes them in some lump-sum fashion.

Repetto et al. take up this theme in a book titled *Green Fees: How a Tax Shift Can Work for the Environment and the Economy*.<sup>25</sup> While the book title suggests a revenue-neutral shift, the idea is extended both to revenue-neutral shifts and to green fees that are used to reduce the federal deficit. In either case, the argument for the policy can be summed up as follows:

Taxes on these environmentally damaging activities [resource waste, pollution, and congestion] would not distort economic decisions, but rather would correct existing distortions.<sup>26</sup>

Elsewhere, the authors quantify the two dividends and add them together:

Reducing tax rates on income and profits would reduce the marginal excess burden by \$0.40 to \$0.60 per dollar of reduced tax revenue. If those revenues were regained through environmental charges, the *additional* net economic savings would range from \$0.05 to \$0.20 per dollar of revenue. These additional net savings are the averted environmental damages less the incremental costs of environmental protection. Putting these parts together yields the striking conclusion that the total possible gain from shifting to environmental charges could easily be \$0.45 to \$0.80 per dollar of tax shifted from "goods" to "bads" with no loss of revenues.<sup>27</sup> [emphasis in the original]

This quote also emphasizes revenue. Repetto et al. fall into the same trap as Lee and Misiolek, by ignoring the efficiency costs associated with driving up the price of products that produce pollution as a by-product. As shown above, those costs offset the efficiency gains from reducing reliance on income taxes. Under certain reasonable assumptions regarding consumer preferences, the environmental tax reduces the real net wage by exactly the same amount as the income tax reduction can raise the real net wage. Again, the key issue is that Repetto et al. have in mind a new environmental protection, which is an experiment very different from the one in Terkla. When Terkla uses the pollution tax to replace existing environmental controls, the switch has *no*

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<sup>25</sup> ROBERT REPETTO, ROGER DOWER, ROBIN JENKINS, AND JACQUELINE GEOGHEGAN, *GREEN FEES: HOW A TAX SHIFT CAN WORK FOR THE ENVIRONMENT AND THE ECONOMY* (1992).

<sup>26</sup> *Ibid*, at 2.

<sup>27</sup> *Ibid*, at 11.



effect on the amount of pollution, the cost of production, the real net wage, or labor supply distortions.

In the progression from Terkla to Repetto et al., a crucial change occurred in the experiment under consideration. No longer was the experiment an environmentally-neutral switch from CAC regulation to pollution taxes (an experiment that yields only the second dividend). Instead, the experiment is stated in terms of revenue-neutrality: the environmental taxes are implemented to reduce distorting taxes. Meanwhile, this "new" experiment increases both environmental protection and the cost of producing goods that generate pollution. If the increase in the real net wage from the cut in the labor tax is exactly offset by the decrease in the real net wage from the higher price of goods, then this new experiment yields only the first dividend. Neither experiment yields both dividends.

Goulder<sup>28</sup> reviews this early double-dividend literature, but concentrates on this new type of experiment in his taxonomy. His perspective helps explain the movement away from Terkla's experiment. Goulder notes that quantifying the benefits from improving the environment is very difficult. Thus the public case for the policy is much easier to make if green taxes do not require an exact numerical value for the environmental improvement:

Policymakers who are interested in green tax swaps are often 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 policy maker 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.... Thus the debate about the double-dividend reflects the

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<sup>28</sup> Lawrence Goulder, *Environmental Taxation and the Double Dividend: A Reader's Guide*, 2 INTERNATIONAL TAX AND PUBLIC FINANCE 157 (1995).

desire to be able to make safe judgments about environmental reforms in the presence of uncertainty.<sup>29</sup> [emphasis in the original]

Goulder has in mind a revenue neutral-experiment that raises environmental quality. Within the context of the experiment he has in mind, his distinction among various double-dividend hypotheses is very useful.<sup>30</sup> However, Goulder does not really discuss a version of the double-dividend hypothesis that involves the Terkla experiment.

The focus on revenue has been emphasized further by a number of authors, including Ballard and Medema.<sup>31</sup> They build a numerical simulation model with multiple industries, variable pollution per unit of output, and effects of pollution both on consumers and on other producers. Using this model, they compare a tax on pollution with a subsidy to pollution abatement. The tax raises revenue that is used to lower a labor income tax, while the subsidy is financed by raising the labor income tax. They find that the welfare gains from the pollution tax are roughly 3 times as great as the gains from the subsidy, and thus conclude that the revenue explains the different welfare findings:

Pigouvian taxes are usually more efficient than Pigouvian subsidies, since the tax revenue can be used to reduce other taxes.<sup>32</sup>

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<sup>29</sup> *Ibid*, at 158.

<sup>30</sup> Goulder distinguishes among three double-dividend claims: 1) a weak form, 2) an intermediate form, and 3) a strong form. The weak form argues that it is always preferable to return environmental revenues by reducing a distorting tax rather than by returning them in a lump sum fashion. This weak form of the proposition has not been disputed. The intermediate and strong forms consider whether excess burden increases or decreases as a result of a shift towards environmental taxation. The intermediate form says that some existing tax is distorting enough that excess burden would fall by shifting from that tax to an environmental tax. The strong form says that excess burden will fall when environmental taxes are substituted for typical taxes in use.

<sup>31</sup> Charles Ballard and Steven Medema, *The Marginal Efficiency Effects of Taxes and Subsidies in the Presence of Externalities*, 52 JOURNAL OF PUBLIC ECONOMICS 199 (1993).

<sup>32</sup> *Ibid*, at 199.

While Ballard and Medema's model and results are major contributions, and undoubtedly correct, we would like to propose a different interpretation of their results. The two policies differ in a subtle but important way. The Pigouvian tax reduces pollution through two channels. First, it encourages abatement activities through a "substitution effect," as clean inputs replace pollution as an input to production. This effect reduces the pollution per unit of output. Second, it raises the overall cost of production through an "output effect" that discourages production and consumption of goods associated with pollution. Even without abatement activities, this output effect would reduce pollution. In contrast, the Pigouvian subsidy reduces pollution only through the first abatement channel, not through the second output channel. In fact, the reduction in production costs (due to Ballard and Medema's abatement subsidy) has the effect of *raising* output.

An alternative subsidy experiment would lead to the same results as their pollution tax experiment. Suppose the government were to subsidize pollution abatement (to get the substitution effect) and simultaneously subsidize the consumption of goods that do not produce pollution. The decrease in the relative price of clean goods would induce consumers to shift away from polluting goods in a way that is exactly analogous to the output effect described above. The combination of the two subsidies reduces pollution in precisely the same manner as the pollution tax. Lower product prices (resulting from the subsidies) reduce the price level  $P_C$  and so offset the effect on the real net wage of the higher income tax  $t_w$  required to finance the subsidies.<sup>33</sup> This combination of subsidies in the Ballard and Medema model would have the same effects as the pollution tax.

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<sup>33</sup> Like several of the models reviewed here, the model of Ballard and Medema assumes "separability." While labor supply is affected by the overall real net wage, it is not affected by the price of any particular consumption good, by the quality of the environment, or by the government's provision of a public good.

This subsidy to all clean goods might be difficult to implement, but it highlights the important conceptual point that revenue differences do not matter if the two policies are designed to have the same effects on all relative prices. In fact, other subsidy schemes might be more feasible. Another policy that would mimic the effects of the pollution tax is the combination of a subsidy to all clean inputs to production (to get the substitution effect) and a tax on the output of that industry (to get the output effect).<sup>34</sup> The abatement subsidy of Ballard and Medema performed less well than the pollution tax, not because it cost revenue but because it did not discourage pollution through the output effect as well as the substitution effect.

### **V. Challenges to the Double-Dividend Hypothesis**

The first serious challenge to the double-dividend hypothesis was raised by Bovenberg and de Mooij.<sup>35</sup> They posit a double-dividend in which environmental levies not only increase environmental quality but also produce a less distortionary tax system. Using a simple general equilibrium model with competitive firms, they show "that environmental taxes typically exacerbate, rather than alleviate, preexisting tax distortions - even if revenues are employed to cut preexisting distortionary taxes."<sup>36</sup> The model of Bovenberg and de Mooij has two goods, one of which adversely affects the environment as it is consumed (a "dirty" good). Taxes are assessed on

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<sup>34</sup> Don Fullerton, *Environmental Levies and Distortionary Taxation: Comment*, 87 AMERICAN ECONOMIC REVIEW 245 (1997) calls either of these combinations a "two-part instrument" and shows equivalence to a pollution tax. Explicit derivations of several two-part instruments are provided by Don Fullerton and Ann Wolverton, *The Case for a Two-Part Instrument: Presumptive Tax and Environmental Subsidy*, Cambridge, MA: National Bureau of Economics Research Working Paper No. 5993 (1997).

<sup>35</sup> A. Lans Bovenberg and Ruud de Mooij, *Environmental Levies and Distortionary Taxation*, 84 AMERICAN ECONOMIC REVIEW 1085 (1994).

<sup>36</sup> *Ibid.*, at 1085.

labor income and on the dirty good. The starting point is where the tax rate equals the social marginal damage from pollution (the Pigouvian tax rate).

Bovenberg and de Mooij then consider a small increase in the tax on the dirty good, and show that a revenue-neutral change in the tax mix might affect utility for a typical member of society in two ways. First, this tax change can affect the real net wage and labor supply. Second, it can affect pollution through consumption of the dirty good. As in the discussion above, regarding Lee and Misiolek, this decrease in pollution itself has both costs and benefits: the social cost of reducing pollution is the value of what it produces (the height of the MB curve in Figure 1), while the social benefit of reducing pollution is the averted damages (the height of the SMC curve). Since the optimal point  $Z'$  was found where these two heights were equal, a small cut in pollution from this point provides no net gain or loss. Thus, for Bovenberg and de Mooij, the whole case for a tax rate greater than the Pigouvian rate rests on how the tax change affects labor supply. If the tax reform reduces labor supply then society is worse off, while if the reform increases labor supply then society is better off. The intuition for this result is straightforward from Figure 2. The pre-existing labor tax is already reducing labor supply below the socially optimal amount, with excess burden equal to area C. Anything that reduces labor supply further has a first order cost in terms of welfare, area D. Even though the tax change and the effect on the real net wage may be quite small, the effect on deadweight loss (area D) is relatively large. Conversely, if the tax reform induces an increase in labor supply, then the size of the excess burden triangle (area C) would be reduced.

Before proceeding further, it is useful to consider the experiment of Bovenberg and de Mooij a bit more carefully. First, the experiment does not hold environmental quality constant (as in Terkla's case). Second, the starting point has taxes on the dirty good currently in place and equal to the social marginal damage of pollution. Third, no consideration is given to the

possibility of other environmental controls. Thus, Bovenberg and de Mooij's experiment differs significantly from much of the previous literature. Tullock and Terkla each have in mind the substitution of environmental taxes for other non-tax controls, so that revenue is raised without altering environmental quality. Both of these prior authors begin from a position where no environmental taxes are in place. Then Repetto et al. have in mind an improvement in environmental quality, but like Tullock and Terkla they assume little current reliance on environmental levies. Strictly speaking, these authors all differ from Bovenberg and de Mooij by assuming that existing environmental levies are set below social marginal damage. In contrast, it was Lee and Misiolek who claimed that the optimal tax rate on a dirty good would exceed the social marginal damage so long as it raises revenue starting at that point. Thus Bovenberg and de Mooij really provide a response just to Lee and Misiolek, by showing that the pollution tax is *less* than social marginal damage.<sup>37</sup> Note, however, that any claims about the size of the tax rate relative to social marginal damage is something altogether different from the original hypotheses of Tullock and Terkla *or* the double-dividend hypothesis of Pearce or Repetto et al. Those authors never said "therefore the tax on pollution ought to exceed environmental damages."

Starting at a point where the tax on the dirty good equals social marginal damage, Bovenberg and de Mooij show that an increase in the tax on the dirty good increases welfare if and only if it increases labor supply. To investigate employment effects, they make a series of

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<sup>37</sup> As shown in Fullerton, *supra* note 34, Bovenberg and de Mooij's proof depends on the particular normalization that they use in their model. A more precise statement of their result is that the optimal *difference* between the tax rate on the dirty good and the tax rate on the clean good is less than the social marginal damage from pollution.

assumptions about consumption preferences that imply that in the absence of environmental externalities, the optimal tax would be a uniform commodity tax or equivalently a wage tax.<sup>38</sup> Thus the experiment begins at a point that would be the optimal tax in the absence of an externality, but where the tax on the dirty good is set equal to social marginal damage. Starting at this point, they show that an increase in the pollution tax would induce a decrease in labor supply. Despite the fact that the revenues from the environmental tax are used to lower the tax on labor supply, the real net wage falls. The increase in the after-tax nominal wage cannot entirely make up for the increase in the price of goods (resulting from the environmental tax increase), because the tax base erodes as consumers substitute away from the dirty good. Since raising the tax above social marginal damages reduces welfare, lowering the tax below its Pigouvian level will raise welfare, proving Bovenberg and de Mooij's point that "[i]n this 'second-best' case with distortionary taxation, therefore, the optimal environmental tax lies below the social damage from pollution."<sup>39</sup> At the end of the paper, the authors return to the double-dividend debate and point out that if revenues from the environmental levy are returned lump-sum rather than through a

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<sup>38</sup> Specifically, they assume that private goods are weakly separable from public goods and environmental quality in the utility function. Furthermore, the two consumption goods enter utility through a homothetic sub-utility function from which leisure is weakly separable. Yew-Kwang Ng, *Optimal Corrective Taxes or Subsidies when Revenue Raising Imposes an Excess Burden*, 70 *AMERICAN ECONOMIC REVIEW* 744 (1980) investigated the optimal environmental tax when the polluting good is not separable from leisure. He finds that it may be optimal to provide a subsidy to the polluting good, financed by a higher wage tax, in the case where the cross price effect of the higher wage on reducing consumption of the polluting good is more important than the own price effect of the subsidized price on increasing consumption of the polluting good. Ng emphasizes that this an unusual but not impossible outcome. Ian Parry, *Pollution Taxes and Revenue Recycling*, 29 *JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT* S64 (1995) has also allowed for leisure to be more or less substitutable with the dirty good than with the clean good. J. Andres Espinosa and V. Kerry Smith, *Measuring the Environmental Consequences of Trade Policy: A Non-Market CGE Analysis*, 77 *AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS*, 772 (1995) emphasize the importance of non-separability.

<sup>39</sup> Bovenberg and de Mooij *supra* note 35, at 1088.

reduction in the labor tax, then the reduction in employment is larger. "Hence, there exists a 'doubled [*sic*] dividend' in the sense that a cost reduction can be achieved by using revenues from pollution taxes to cut distortionary taxes rather than returning those revenues in a lump-sum fashion."<sup>40</sup> This is a statement of Goulder's "weak form" of the double-dividend.

Parry<sup>41</sup> considers similar questions to those asked by Bovenberg and de Mooij using an analytical framework developed by Harberger.<sup>42</sup> Like Bovenberg and de Mooij, Parry ignores any environmental regulations and assumes the presence of a tax on labor income. Unlike those authors, Parry considers an experiment of implementing a new tax on the polluting good where the tax is no greater than the marginal social costs of pollution. He shows that the benefits from the increased revenue from the new tax (the "revenue effect" in his terminology) is only greater than social costs arising from reduced labor supply (the "interdependency effect") if the polluting good is a relatively weak substitute for leisure. To interpret Parry's result, recall the explanation of Bovenberg and de Mooij for their result: the higher tax on the polluting good induces consumers to substitute away from the polluting good, which erodes the tax base, which requires a higher tax on labor, which reduces employment. This tax base effect is reduced to the extent that the polluting good is a complement with leisure, because then a tax on the polluting good discourages *both* that good and leisure, which increases labor supply. If the relative complementarity is strong enough, the revenue effect will be greater than the interdependency effect and social costs from the tax system fall (ignoring improvements in the environment).

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<sup>40</sup> Bovenberg and de Mooij *supra* note 35, at 1089.

<sup>41</sup> Parry *supra* note 38.

<sup>42</sup> Arnold Harberger, *The Measurement of Waste*, 54 AMERICAN ECONOMIC REVIEW 58 (1964).



Parry proceeds to estimate the ratio of the optimal tax rate on the polluting good to the social marginal damages from pollution. Estimates of this ratio range widely, depending on parameter assumptions, but rarely do they exceed one. His central case estimate is that the optimal pollution tax is 63% of marginal environmental damages.<sup>43</sup>

In a series of papers, Lawrence Goulder and various co-authors have used numerical simulation models to investigate the double-dividend hypothesis, along with the related issue of instrument choice, in more realistic economies.<sup>44</sup> Consider, for example, the model and experiment described in Bovenberg and Goulder.<sup>45</sup> Production occurs in 13 competitive industries, from which 17 consumption goods are produced. Households choose labor supply, saving, and consumption goods, and the model extends over an 80 year horizon. The government can employ energy and output taxes, corporate and personal income taxes, property taxes, and sales taxes. The model is calibrated to 1990 as a benchmark year. In this paper, the authors consider a carbon tax with revenues used to lower various other taxes.

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<sup>43</sup> In the case where pollution is associated with an input in the production process, he finds that the optimal tax as a fraction of marginal environmental damages is slightly higher. The tax to damages ratio rises with increased substitutability between factors of production. The reason is that the ability to substitute factors mitigates the rise in the price of the input that is associated with pollution. See Don Fullerton and Gilbert Metcalf, *Environmental Controls, Scarcity Rents, and Pre-Existing Distortions*, Cambridge, MA: National Bureau of Economics Research Working Paper No. 6091 (1997) for further discussion of the importance of factor substitution.

<sup>44</sup> The papers include, among others, Lawrence Goulder, *Effects of Carbon Taxes in an Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis*, 29 JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT 271 (1995), A. Lans Bovenberg and Lawrence Goulder, *Optimal Environmental Taxation in the Presence of Other Taxes: General Equilibrium Analyses*, 76 AMERICAN ECONOMIC REVIEW 985 (1996), Lawrence Goulder, Ian Parry, and Dallas Burtraw, *Revenue-Raising vs. Other Approaches to Environmental Protection: The Critical Significance of Pre-Existing Tax Distortions*, RAND JOURNAL (forthcoming), and Ian Parry, Robertson Williams III, and Lawrence Goulder, *When Can Carbon Abatement Policies Increase Welfare? The Fundamental Role of Distorted Factor Markets* (1997).

<sup>45</sup> Bovenberg and Goulder *supra* note 44.

Table 1 below indicates the type of results obtained. Column (1) represents alternative assumptions about the marginal environmental damages from carbon emissions, in 1990 dollars per ton. The magnitude of environmental damages is highly uncertain, and so Bovenberg and Goulder consider a wide range of estimates. In a first-best world where lump-sum taxes are feasible and distortionary taxes are unnecessary, the Pigouvian tax rate would simply equal the marginal environmental damages. The next column reports the model's calculation for the optimal tax rate, starting from the existing tax structure and levying a carbon tax, with the proceeds returned lump sum to households. For low levels of marginal environmental damages, these tax rates are *negative*. This result indicates that, given the sub-optimal nature of the tax system, welfare would be raised by *subsidizing pollution*. Only when marginal environmental damages exceed \$50 does the tax rate turn positive. Negative tax rates provide higher welfare than positive tax rates in this case, for two reasons. First, "lump sum rebate" means that any revenue from a positive tax is not used to reduce other distorting taxes, and that when the tax on pollution turns negative, the "lump sum rebate" becomes a lump sum tax. Second, the subsidy to pollution reduces the cost of production and therefore acts indirectly as a subsidy to labor and capital that are in sub-optimal quantities due to the pre-existing tax system. The first point is important because a pollution subsidy financed by a lump-sum tax effectively allows the use of a lump-sum tax to reduce pre-existing distortions. Given a low level of marginal environmental damages, this subsidy is welfare enhancing. As damages rise, the tax rate in column (2) rises, but it is never more than 28% of the marginal environmental damages.

Column (3) demonstrates that the optimal environmental tax is substantially higher when the proceeds are used to replace a distorting tax. Now the optimal tax rate is positive at all levels

of marginal environmental damages.<sup>46</sup> Moreover, the ratio of the tax rate to marginal environmental damages for realistic damages is consistent with the estimates of Parry.<sup>47</sup>

The last column reports the optimal environmental tax rate in an economy where the tax system is chosen optimally in all respects. Given that distortions are minimized, then the social cost of raising a dollar is minimized, and the optimal tax rates approach the marginal environmental damages.<sup>48</sup>

Bovenberg and Goulder's experiment is similar in spirit to Parry's. They increase environmental quality with the carbon tax in a revenue-neutral experiment, starting from zero environmental taxes and no environmental regulation.<sup>49</sup> This type of experiment is probably appropriate in the case of carbon emissions, but it still differs from Tullock and Terkla in that it assumes no pre-existing environmental regulations.

In a new paper, Parry<sup>50</sup> does consider environmental regulations and their welfare effects. His point can be demonstrated using our two figures. If the starting point is no environmental controls, in Figure 1, then firms pollute to  $Z^{\circ}$  (where marginal benefits equal private marginal cost of pollution). A restriction in the quantity of pollution to  $Z'$ , either through quotas or tradeable permits, can provide area B as an environmental welfare gain. Those controls also raise the cost of production, however, so they raise the price of consumption goods  $P_C$  and thus lower

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<sup>46</sup> The comparison of results in columns (2) and (3) provide numerical support for Goulder's weak form of the double-dividend hypothesis.

<sup>47</sup> Parry *supra* note 38.

<sup>48</sup> See note 21.

<sup>49</sup> Pre-existing energy taxes in their model act indirectly as environmental taxes to the extent that they discourage the use of coal in production.

<sup>50</sup> Ian Parry, *Environmental Taxes and Quotas in the Presence of Distorting Taxes in Factor Markets*, RESOURCE AND ENERGY ECONOMICS (forthcoming).

the real net wage in Figure 2. With any slope to the labor supply curve, then labor falls (from  $L^\circ$  to  $L'$ ). For reasonable parameter values, the extra cost from labor tax distortions (area D) is larger than the environmental gain (area B). We return to this point below.

We began this discussion by raising two questions. First, what is the starting point for any reform intended to provide a double-dividend? Second, what is the reform under consideration? The earliest reform envisioned was both environmentally-neutral and revenue-neutral (Tullock and Terkla). By positing a shift from existing command and control regulations to a system of environmental taxes (no first dividend), this reform ensures no increase in excess burden caused by distortions of production decisions. The revenues from the emissions taxes could then be used to lower other distorting taxes, thereby providing only the second dividend of environmental policy. Later papers abandoned the environmental-neutrality assumption and focused on the revenue potential of environmental taxes (e.g. Lee and Misiolek). In the process, they often ignored the excess burden that arises from distorting production decisions in the effort to improve environmental quality (as pointed out by Bovenberg and de Mooij).

The discussion in this section has emphasized the concern with revenue in the double-dividend literature. In the next section, we show that this focus on revenue is misplaced.

## **VI. Revenue and Rents**

All of the papers discussed in the last two sections consider a new environmental tax with the revenues used to lower other distorting taxes. In a recent paper,<sup>51</sup> we consider a number of other environmental policies in a general equilibrium model similar to the one employed by Bovenberg and de Mooij. Two goods are produced, one of which is associated with pollution. In

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<sup>51</sup> Fullerton and Metcalf *supra* note 43.

the simplest version of the model, pollution occurs in the consumption of the good, and both goods are made with one factor of production (labor). The initial equilibrium has a tax on labor income to finance government spending, and it has no environmental controls. We then restrict the production of the polluting good and measure the welfare impact. Like Bovenberg and de Mooij, we find that a restriction in production will affect labor supply if it reduces the real net wage. Welfare falls if labor supply falls. Unlike Bovenberg and de Mooij, we start from a position with no controls on pollution, so we find a second welfare effect from the direct impact of the newly-introduced restriction on pollution. That is, reductions in pollution raise welfare. In terms of Figure 1, if the private marginal cost of pollution is  $P^0$ , then firms set pollution to  $Z^0$ . Any reduction in pollution from  $Z^0$  then raises welfare, but any reduction in labor supply reduces welfare. The net impact depends on the relative sizes of these two effects.

Consider a restriction in the form of a pollution tax. The tax raises the private marginal cost of pollution and thus induces the firm to cut back its pollution. We show that if the environmental tax revenue is used to lower the labor income tax, then the real net wage is unaffected by the tax reform. The increase in the nominal wage (due to the reduction in taxation of wage income) is exactly offset by the increase in the price of consumption goods (due to the environmental tax). Using the same separability assumptions as in most of the rest of the literature, we show that labor supply is unaffected.<sup>52</sup> Thus the only welfare impact of the policy is the reduction in pollution, and welfare unambiguously rises. Note, however, that this experiment

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<sup>52</sup> When Bovenberg and de Mooij start with a pre-existing pollution tax, an increase in that pollution tax rate reduces the tax base. This effect requires a slightly higher labor tax rate, which reduces the real net wage. Thus their increase in the pollution tax decreases labor supply. Starting from a pollution tax rate of zero, however, our small increase has no "tax base effect" and thus no labor supply effect.

yields no "double-dividend" in any sense. The increase in the net wage due to the reduction in the wage tax is exactly offset by an increase in prices due to the environmental levy.

An alternative policy to reduce pollution would simply be to restrict pollution to some amount less than  $Z^0$ . This experiment and its results corresponds to the second paper by Parry,<sup>53</sup> but our interpretation emphasizes the role of scarcity rents. If firms in Figure 1 can emit no more than  $Z'$  of pollution, they will have to rearrange production somehow. The incremental value of the one more unit of pollution will equal  $P'$ , and a firm would be willing to pay any amount up to  $P'$  to pollute one more unit of pollution beyond  $Z'$ . Since  $P'$  exceeds  $P^0$ , the private marginal cost of pollution, pollution has now become more valuable and the firm is earning scarcity rents for the right to pollute  $Z'$ . The value of the scarcity rents equals  $(P'-P^0)$  times  $Z'$ , which is area A. Even though firms are still competitive, these scarcity rents are profits from the higher product price. The price is not bid down, because entry is limited: new competitors must buy expensive permits or expensive new abatement technology. The rents go to initial permit recipients, or to any firm with grandfathered rights to use some old technology.

If the government imposes a 100% tax on the firm's profits, and uses the revenue to reduce the labor tax, then the result is exactly equivalent to the previous policy of the pollution tax.<sup>54</sup> The 100% tax on the scarcity rents arising from the restriction on pollution provides the same revenue as would be collected from the pollution tax. Thus, the decrease in the net wage from the reduction in the labor income tax is again exactly offset by the increase in product price, and the reform increases welfare only by reducing pollution.

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<sup>53</sup> Parry *supra* note 50.

<sup>54</sup> Alternatively, the government could sell the permits rather than give them away.

Economists have long understood that price and quantity strategies are equivalent in a world with perfect information.<sup>55</sup> Our point about the quantity approach (restrictions on emissions) is that it highlights the important role played by scarcity rents. If the government does not tax away the privately-held scarcity rents, the real net wage and labor supply will fall. The real wage falls because product prices rise following the restriction on pollution emissions, with no offsetting decrease in the tax on labor income. The nominal wage is unaffected, but the real wage falls as prices rise. The consequent fall in labor supply has a first-order effect on excess burden (area D in Figure 2), so overall welfare may either rise or fall. The benefits of the restriction (reduced pollution) are offset by costs (an increase in labor market distortions). Indeed, numerical calculations with reasonable parameter values indicate that the costs exceed the benefits -- even from the first small restriction on pollution.

While our focus has shifted from revenue to rents, the story above suggests that revenue is still the determinate factor to be able to cut the labor tax and offset the effect of prices on the real net wage. We next show that revenue is really not even relevant. Consider a policy where the consumption of non-polluting goods is subsidized by the government, with the cost paid by *increasing* the tax on labor income. Regardless of whether it is difficult to implement, we show that this policy produces the same outcome as either the policy of levying a tax on the polluting good or the policy of restricting emissions with all scarcity rents taxed away by the government. Because the "clean" good becomes less expensive than the "dirty" good, consumers reduce their consumption of the dirty good. While the nominal net wage is reduced by the increase in tax on labor income, this effect is offset by a decrease in the price of consumer goods (due to the subsidy

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<sup>55</sup> The equivalence breaks down in the presence of uncertainty. See Martin Weitzman, *Prices vs. Quantities*, 41 REVIEW OF ECONOMIC STUDIES 477 (1974) or Robert Stavins, *Correlated Uncertainty and Policy Instrument Choice*, 30 JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT 218 (1995).

on the clean good). As with the pollution tax example, the two effects exactly cancel. The real net wage — and hence labor supply — is unaffected.

Since a tax on the polluting good and a subsidy to consumption of non-polluting goods have diametrically opposed revenue consequences, something else must be at work that leads these two policies to the same welfare effects. What they have in common is that neither policy leaves scarcity rents in private hands.<sup>56</sup>

Once the focus is turned from revenues to rents, a number of other policies become possible that have the same positive benefits of reduced pollution without exacerbating pre-existing distortions. As an example, consider the following modification of the model described above. Rather than assuming that pollution is associated with consumption of a good, assume that it is associated with some input to production.<sup>57</sup> Production now is assumed to depend on multiple factors, where one of these factors is linked to pollution. A technology restriction could be implemented that requires a reduction for all firms in the ratio of pollution-linked ("dirty") inputs to other ("clean") inputs. We show that, for small restrictions, such a policy has insignificant impact on costs for these firms and hence does not increase product prices. Thus the policy reduces pollution without exacerbating the pre-existing wage distortion.<sup>58</sup>

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<sup>56</sup> Neither the tax nor the subsidy create scarcity rents. Restrictions on output (e.g. tradeable permits) do create rents, but do not leave them in private hands if the government taxes the rents away (or sells the permits at a market price).

<sup>57</sup> In fact, one can view pollution itself as an input in the production process.

<sup>58</sup> In our model, because of competition and constant returns to scale, all firms have access to the same production technology. Thus all firms have the same abatement cost function, and the same restriction can apply to all of them. When abatement costs differ, and when regulators have imperfect information about these differences, then imperfect CAC policies can be six to ten times as expensive as the minimum abatement cost made possible by incentive-based policies like taxes or permits. See the review in Maureen Cropper and Wallace Oates, *Environmental Economics: A Survey*, 30 JOURNAL OF ECONOMIC LITERATURE 675 (1992). Thus, heterogeneity can certainly raise the cost of CAC policies, but we abstract from such excess costs here in order to make an entirely different point: all else equal, the cost of permits or CAC quantity restrictions that create



The intuition for the lack of a cost effect is quite simple. The restriction requiring a reduction in the ratio of dirty to clean inputs makes the dirty input more valuable to the firm (moving up its marginal benefit curve) while simultaneously making the clean input less valuable (moving down its marginal benefit curve). In effect, the firm earns scarcity rents on the polluting factor of production while it incurs *losses* on the clean factor. The firm is cross-subsidizing production, with an implicit tax on the dirty input used to pay for an implicit subsidy to the clean factor of production. The cross-subsidization means that no net rents are being earned by the firm, while pollution is reduced.

This argument — like that of many of the papers in this literature — holds for small changes in pollution policy only. For larger changes, the technology restriction just gets the "substitution effect" defined above, since it reduces pollution per unit of output. Thus this policy alone may not minimize the cost of large cuts in pollution. To achieve the "output effect", however, the technology restriction could be combined with a tax on output of the polluting good.<sup>59</sup> In any case, to evaluate the impact of large policy changes, one must turn to numerical simulation analyses along the lines of those undertaken by Goulder and various co-authors.

The important point about the technology restriction for present purposes is that these firms cannot make net profits, in equilibrium, or else competitors would enter and bid those profits away. Entrants would only be subject to the same technology restrictions on the ratio of dirty inputs to clean inputs. In contrast, scarcity rents arise in the earlier type of CAC restriction

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scarcity rents may exceed the cost of a CAC technology restriction that does not create rents.

<sup>59</sup> See Karen Palmer and Margaret Walls, *Upstream Pollution, Downstream Waste Disposal, and the Design of Comprehensive Environmental Policies*, Washington, DC: Resources for the Future (1997).

because competitors cannot enter the industry on the same terms as existing firms who are handed initial allocations of permits or grandfathered rights to use old technology.

The importance of rents in environmental policy making has long been understood, but for reasons different than those we identify here. Buchanan and Tullock<sup>60</sup> argued that industry would prefer regulation in the form of direct controls rather than pollution taxes, since the former would create scarcity rents by erecting a barrier to entry. Their paper provided a positive explanation for the type of environmental controls that were popular in the 1960s and 1970s, and it emphasized the distributional implications of different policies. Maloney and McCormick<sup>61</sup> provide empirical support for this argument, using stock market event analyses of the textile and smelting industries.<sup>62</sup> In both industries, they find evidence of abnormally high stock returns following the increase in environmental regulation. Neither Buchanan and Tullock nor Maloney and McCormick consider the efficiency impact of the regulations, but simply view the regulations as a device that redistributes wealth by creating scarcity rents. In contrast, we have shown that scarcity rents also have efficiency implications, by raising the cost of output.

In fact, the pollution restriction creates scarcity rents equal to area A in Figure 1, and it redistributes that amount from consumers who pay higher product prices to private parties who receive the rights to pollute (i.e., the permits). This policy is thus equivalent to a tax on pollution

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<sup>60</sup> James Buchanan and Gordon Tullock, *Polluters' Profits and Political Response: Direct Controls Versus Taxes*, 55 AMERICAN ECONOMIC REVIEW 139 (1975).

<sup>61</sup> Michael Maloney and Robert McCormick, *A Positive Theory of Environmental Quality Regulation*, 25 THE JOURNAL OF LAW AND ECONOMICS 99 (1982).

<sup>62</sup> For the textile industry, cotton-dust standards were formulated beginning in 1974. These standards were significantly more stringent than previous standards and could discourage entry into the industry. The nonferrous metal smelting industry was affected by a 1973 Supreme Court decision that required the Environmental Protection Agency to "prevent significant deterioration" (PSD) of air quality under the mandate of the 1970 Clean Air Act. The PSD ruling effectively made entry into this industry very difficult.

that raises product prices, where the revenue is rebated lump-sum to particular private parties (or where the revenue is used to reduce a lump-sum tax on some fixed factor of production). In all of these cases, the government has essentially enacted a lump-sum transfer to some private party rather than using the revenue to reduce distorting taxes.<sup>63</sup>

In this section we've shown that the focus in the double-dividend literature on revenue is misplaced. Environmental policies that raise revenue used to reduce other distorting taxes have effects that can be exactly mimicked by policies that lose revenue (subsidies to abatement and to clean consumption) or that do not raise any revenue at all (technology restrictions). Rather than focus on revenues, we argue that the appropriate focus is on the creation of privately-held scarcity rents. Finally, we show that not all command-and-control regulations are equivalent. Regulations that effectively restrict output or otherwise create entry barriers (e.g., distinctions between new and old capital that arise from grandfathering provisions) will create scarcity rents and raise product prices, while technology-based regulations can be designed that avoid creating scarcity rents. In the latter case, environmental protection can be purchased without the additional cost of exacerbating distortions from the existing tax system.<sup>64</sup>

## VII. Conclusion

Using environmental taxes to reduce the reliance on other distorting taxes has become a very popular idea. The double-dividend hypothesis — the idea that environmental taxes can both

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<sup>63</sup> This point is made by Goulder and his co-authors, *supra* note 44.

<sup>64</sup> This point is not an argument against market-based approaches and in favor of regulation. Many economists feel that properly-functioning markets are a good approach to dealing with environmental problems. They may find efficiency gains, for example, from the abatement-cost-minimizing features of the tradeable permits program established by the Clean Air Act Amendments of 1990. We simply add consideration of efficiency losses from exacerbating labor tax distortions when the permits are given away rather than sold.

improve the environment and reduce excess burden — is the intellectual foundation for this type of tax reform. We began our paper by noting that the evaluation of this hypothesis has often been confused because writers have not fully specified the economic environment in which the reform is being considered and have not fully specified the reform itself. Thus we have organized our survey around the following two questions: What environmental policies are in place prior to the environmental reform? and What is the complete reform being proposed?

We have made four points in this paper. First, the validity of the double-dividend hypothesis can not be settled as a general matter. Under certain circumstances, a shift to environmental taxes may improve the environment and reduce the overall burden of the tax system. In other circumstances, such a shift may increase the burden of the tax system. Each reform must be evaluated on its own merits. Second, the emphasis in the literature on the importance of revenue is misplaced. We have demonstrated that three types of policies can have equivalent impacts on the environment and on labor supply. One of these policies raises revenue from the environmental component of the reform, another loses revenue, and a third has no revenue associated with it. Third, what does matter is the creation of scarcity rents. Policies that create scarcity rents and leave those rents in private hands will exacerbate pre-existing distortions to a greater extent than do policies that do not create privately-held scarcity rents. Policies that create privately-held scarcity rents raise costs of production beyond what is necessary to mitigate environmental problems. Finally, we show that different regulatory approaches are available and that not all regulation need create scarcity rents. Thus, policy makers have available to them more policy options than is suggested by the previous literature that focuses only on revenue. Environmental levies may be desirable on a number of other grounds such as compliance, administration, or political viability. On the other hand, these non-economic considerations may

make regulation the preferred policy response. If so, an important additional consideration is whether the regulatory response in question creates privately-held scarcity rents.

Table 1. Carbon Tax Rates			
Marginal Environmental Damages, i.e., the Pigouvian Tax Rate (\$ per ton) (1)	Optimal Tax Rate When Revenues are Used for Lump Sum Grant to Households (\$ per ton) (2)	Optimal Tax Rate When Revenues are Used to Reduce Distorting Personal Income Tax (\$ per ton) (3)	Optimal Tax Rate in an Optimized Tax System (\$ per ton) (4)
25	-19	8	22
50	-10	30	46
75	11	52	70
100	28	73	93

Source: Table 2, Bovenberg and Goulder (1996)

Figure 1

The "Demand" for Pollution

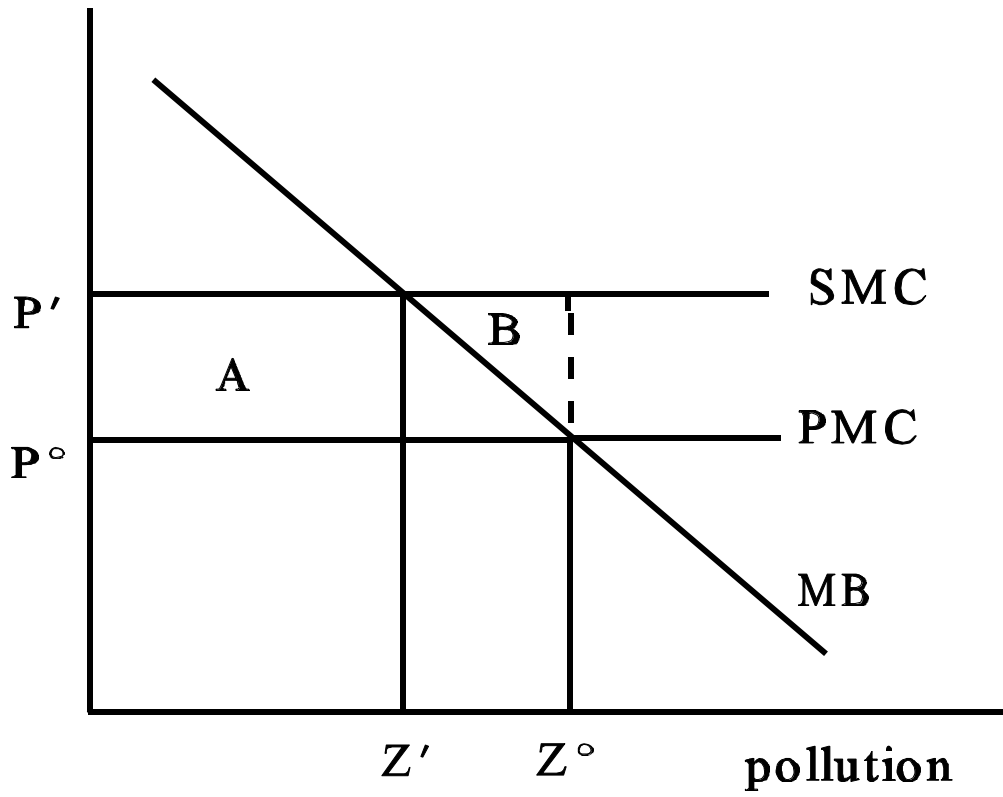


Figure 2

The Real Net Wage Rate, Labor Supply, and Excess Burden

