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CONSIDERABLE CONTROVERSY SURROUNDS THE double-dividend hypothesis that a pollution tax can improve both the environment and the tax system (e.g,. Oates, 1995; and Goulder, 1995a). A carbon tax could help reduce greenhouse gas emissions, for example, and the revenues could be "recycled" by reducing other distorting taxes on labor or capital income.

In this paper, we argue that much of the debate is misplaced. We describe problems with both analytical models and computational models that have been used to substantiate or refute the hypothesis. These fundamental problems essentially make the current debate irrelevant.

ANALYTICAL PROBLEMS WITH THE DOUBLE-DIVIDEND HYPOTHESIS

Among academic economists, the debate about the double-dividend hypothesis (DDH) began with models that were primarily static analytical general equilibrium models of a single period with a limited number of commodities, such as a clean good, a dirty good, and labor supply. In this section, we discuss several problems with this literature. First, the double-dividend hypothesis is not well defined, or at least not commonly stated. Second, the hypothesis is debated as a theoretical proposition, when its very nature is empirical. Under any consensus definition, the hypothesis *must* be valid for certain circumstances, that is, for certain starting points and certain parameter values. It is an empirical issue when and where those circumstances pertain. Third, the hypothesis is debated as a probabilistic statement, when the models are deterministic. Each side says the DDH is "likely" or "unlikely," when these models have no random variables, no variance, and no concept of probability. Fourth, some of this debate focuses on the number of dividends instead of the net social gain. Analysts can count three or four dividends from a particular reform, but that information is useless if some other reform with one dividend provides a larger net gain to society. Fifth, these simple analytical models cannot address the complexity of actual environmental tax policies in the United States. For current policy, it is irrelevant whether two dividends arise in a two-good static model. For these reasons, we later discuss larger dynamic computational models.

The Double-Dividend Hypothesis Is Not Well Defined

To clarify, perhaps we should say that the double-dividend hypothesis is too well defined, since each author seems to use a different definition. The concept first appeared in Pearce (1991):

> 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." (p. 940)

More specifically, the usual definition follows Bovenberg and de Mooij (1994), who state the hypothesis by saying:

> In particular, governments can use the revenues from pollution taxes to decrease other, distortionary taxes. In this way, environmental taxes may yield a "double dividend"—not only a cleaner environment but also a less distortionary tax system. This argument suggests that one may wish to push the role of environmental taxes beyond that of solely an instrument for environmental protection and employ these instruments also as a revenue-raising device. (p. 1085).

The way they analyze this hypothesis is by comparing the second-best environmental tax rate (in the presence of preexisting distortionary taxes) to the first-best Pigovian rate (the marginal social damage from pollution) in a static model with a clean good, a dirty good, and labor supply. The tax on the dirty good can improve the environment,

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but it raises product prices and therefore reduces the real net wage, which reduces labor supply and exacerbates preexisting labor tax distortions. The tax on the dirty good also distorts the mix between the two consumption goods. Therefore, they find that "the optimal pollution tax typically lies below the Pigovian tax" (p. 1085).

In effect, Bovenberg and de Mooij define the double-dividend hypothesis to say that the second-best pollution tax is higher than the first-best Pigovian tax rate. They then reject that hypothesis. But they do not cite any prior author who had previously stated the double dividend hypothesis in that way. Indeed, it's is not clear that saying the "second-best pollution tax is higher than the first-best Pigovian tax rate" is the same as saying that "environmental taxes provide both a cleaner environment and a less distortionary tax system."

To be explicit about definitions, Goulder (1995a) suggests three forms:

> *Weak form.* By using revenues from the environmental tax to finance reductions in marginal rates of an existing distortionary tax, one achieves cost savings relative to the case where the tax revenues are returned to taxpayers in lump-sum fashion.
>
> *Intermediate form.* It is possible to find a distortionary tax such that the revenue-neutral substitution of the environmental tax for this tax involves a zero or negative gross cost.
>
> *Strong form.* The revenue-neutral substitution of the environmental tax for *typical* or *representative* distortionary taxes involves a zero or negative gross cost. (p. 159)

No subsequent authors have tried to refute the weak form since reducing distortionary taxes always raises welfare by more than lump-sum handouts to the same taxpayers. Note that the intermediate form of the double-dividend hypothesis is the form supported in policy debates using large complex intertemporal models, as discussed below, since those models often find that capital taxes are particularly distorting. That is, they can find a tax distorting enough that pollution taxes are a better way of raising revenue, but those results do not imply that pollution taxes are a *good* way of raising revenue. Those results also do not support the strong form, namely, that the *typical* or *representative* tax could be replaced beneficially by pollution taxes. A review of the double-dividend literature is provided by Fullerton and Metcalf (1998).

Is the second-best pollution tax rate above the first-best rate? Does a pollution tax have two dividends? Can we find a tax that can be replaced beneficially by a pollution tax? Each of these questions may be interesting in its own right, but the multiple statements of the hypothesis make the debate confusing. There is no such thing as "the" double-dividend hypothesis.

By the Very Nature of the Debate, Theoretical Models Cannot Resolve It

The model of Bovenberg and de Mooij (1994) is beautiful in its simplicity and extremely useful for its intuition. Their results fundamentally altered academic thinking about second-best environmental tax policy. With two goods and preexisting labor tax distortions, they clearly demonstrate that the second-best tax on the dirty good is *less* than the first-best tax. For these reasons, many authors have used the model and extended it to address many related questions.

But the Bovenberg and de Mooij result has no bearing on any of Goulder's three statements of the DDH. The weak form is obvious, and was not contradicted by Bovenberg and de Mooij. The intermediate form cannot be addressed at all: Bovenberg and de Mooij have only one preexisting distorting tax, so they can't find a particular tax that could be replaced beneficially. And the strong form cannot be addressed using their model with only two goods and one tax on labor because results in that model would not say anything about the "*typical* or *representative* distortionary tax" in the U.S. economy.

In addition, to obtain analytical results, Bovenberg and de Mooij simplify the model by assuming various forms of separability in utility. These assumptions are fine for a clear and central benchmark case because we would have no idea whether the dirty good or the clean good was a relative complement to leisure, or whether environmental protection itself increases labor supply. Yet Parry (1995) points out that the second-best tax on the dirty good might optimally exceed the first-best rate if the dirty good happens to be a relative complement to leisure. Similarly, Schwartz and Repetto (1997) get the same result if a cleaner environment increases labor supply. Thus, the DDH *does* hold for certain values of key parameters. The resolution of the debate then awaits empirical estimation of the relevant cross-price elasticities. The matter simply cannot be resolved by further theory.

Finally, the DDH must hold for certain starting points and not others. If tax rates are already set optimally relative to each other, ignoring the environment, then a reform that raises one rate and lowers another will *not* provide any second dividend of reduced tax distortions. On the other hand, the political process is unlikely to achieve such perfect optimality. The current tax on some polluting activity may well be "too low," so that a double dividend is possible, or the *effective* tax may already be "too high" due to existing environmental regulations. This question can be addressed only by measuring the relevant effective existing policy parameters, not by theory.

These Models Cannot Indicate Whether a Double Dividend Is "Likely" or "Unlikely"

As quoted above, Bovenberg and de Mooij find that "the optimal pollution tax *typically* lies below the Pigovian tax" (p. 1085, emphasis added). By the word "typically," they just mean to take a central case by abstracting from possible complementarities or non-separabilities, and from other complications, like many commodities, progressive taxation, other factors of production, imperfect competition, uncertainty, international trade, increasing returns to scale, or labor unionization. They cannot mean that the optimal pollution tax lies below the Pigovian tax in *most* countries or in *most* time periods or in *most* cases in the real world. Yet, that is how the quote has been interpreted.

Others using similar static two-good models have looked at alternative cases and have argued for various reasons that certain cases are more likely than others, and that the more likely cases are those that give rise to a double dividend, somehow defined. For example, one might argue that the dirty good is likely to be a relative complement to leisure. But these papers do not estimate the cross-price elasticity. The models are still based on a simple theory with two goods. Moreover, the models are deterministic. They can be used to assume certain conditions and make definitive statements about the second-best pollution tax rate, but they cannot be used to determine which set of assumptions is more likely. These models do not have random variables, variances, or probabilities. They cannot be used to make statements about probabilities.

The "Number" of Dividends Is Not Relevant

Bovenberg and van der Ploeg (1996) have identified three or four possible dividends. Others identify more. In sum, this literature considers dividends to (1) the environment, (2) employment, (3) public spending, (4) private profits, (5) growth, and (6) distributional objectives. Such categories can be a useful way to analyze and sum the various possible effects of an environmental tax. Often, they just identify different terms in the final expression for the net effect on welfare. But, equally often, the debate focuses on the number of dividends as if that was the objective to be maximized.

The choice among reforms must be based on finding the reform with the highest net social gain, as defined by a social welfare function that might incorporate distributional, environmental, and other objectives. The social welfare function tells us how to make tradeoffs: just as a loss in economic efficiency might be justified for the sake of a large enough gain to distributional equity, a loss in tax efficiency might be justified for the sake of a large enough gain to environmental protection. Policy cannot be limited to options that have only positive effects on *both* separate objectives. Yet that is the focus of the double-dividend debate.

PRACTICAL PROBLEMS WITH MODELS OF THE DOUBLE DIVIDEND HYPOTHESIS

The policy debate, while reflecting in some cases the analysis in the academic literature, differs in that it is usually based on macroeonomic models that produce numerical estimates of the effects of carbon taxes, or of alternatives such as tradeable permits. These models come in many forms. Some are simply aggregated models of the economy that typically predict a contraction in output due to the tax on a factor (energy input) in the economy. Others are disequilibrium models that include short-run unemployment effects from the imposition of a tax or cost and the sectoral disruption that occurs; these models typically find larger output declines in the short and intermediate run, particularly from a large shock. Even in these latter models, however, the use of revenues can make a difference. For example, in simulations done by DRI reported in Repetto and Austin (1997), using revenues to increase an investment tax credit increases output. This outcome reflects the powerful investment response in this model, adding to aggregate demand.

The macroeconomic models that are most closely connected to the "double-dividend" and the revenue recycling issue are large scale general equi-

librium intertemporal models of the economy. Their results are often summarized in policy discussions (e.g., Hamond et al, 1997). When those summaries skip the specific descriptions of the models, however, then readers might not be able to see what is driving the differences in results. Several factors must be kept in mind. First, are the results presented in the form of welfare effects, or in the form of output effects? Second, is the experiment being undertaken a reasonable one for evaluating the "double dividend?" And, third, since the results of any model reflect behavioral responses governed by elasticities, are these behavioral responses consistent with empirical evidence?

Welfare Effects or Output Effects?

For models of the economy that allow intertemporal allocation of consumption over time and that include both leisure and consumption goods, output effects are a poor proxy for welfare gains. The welfare effects with a reduction in leisure will be less, and perhaps considerably less, than the increase in output. The welfare effects from a reduction in consumption today in exchange for an increase in consumption in the future will be proportionally less, and perhaps considerably less, than the gain in long run output.

Is the Experiment Appropriate?

When a carbon or energy tax is substituted for a proportional consumption tax or, in a static model, a labor tax, the experiment is a clean one. However, in many of the revenue recycling experiments, the tax substitution involves a reduction in the progressivity of tax rates (a flat energy tax is substituted for a progressive income tax), or the energy tax is substituted for capital income taxes or the corporate income tax. Yet, most of the gains from such a tax substitution are not dependent on adopting a carbon tax.

These effects are numerically important. Hamond et al (1997) report three simulations of tax substitution in the Jorgenson and Wilcoxen (1994) intertemporal model. When a carbon tax is imposed and returned as a lump-sum rebate, the loss in output by 2020 is 1.7 percent. When it substitutes for a labor tax, the loss in output is 2/3 of a percent. When it substitutes for capital taxes, the result is a *gain* in output of 1.1 percent. Even the substitution for labor tax is not a clean experiment because, in an intertemporal model, an energy tax is a type of consumption tax and therefore includes a lump-sum tax on old capital (and on current older generations). It lowers the marginal effective tax on labor income because the consumption base is larger than the wage base. A substitution of consumption for labor taxes would yield an increase in output even in the absence of an energy tax, and it has intergenerational redistribution effects that are important policy considerations.

This point about the appropriate experiment is summarized succinctly by Goulder (1995b), who suggests that recycling experiments should be based on substitution for a "representative" tax:

> If a particular existing tax generates especially large distortionary costs, then there is an independent efficiency rationale for reducing (or eliminating) this tax. The extraordinary costs of this tax are not a legitimate basis for endorsing a carbon tax. At the same time, we suggest that one would understate the case for a carbon tax if one required that the cost assessment be performed only in the case where revenues are returned in a lump-sum fashion. (p. 272)

There is no denying the importance of illustrating that lump-sum rebates can be an inferior way of returning revenues, a point that is quite relevant to policy options such as the handout of tradeable permits. At the same time, it is less appropriate to model the substitution for a particularly burdensome tax that could simply be altered by an independent tax revision.

Some of these inappropriate experiments go to the extreme. For example, simulations using the Jorgenson and Wilcoxen model by the Alliance for Energy (Norland and Ninassi, 1998) combine energy and fundamental tax reform by simulating the growth effects with a full replacement of the current income tax with a consumption tax. This simulation goes beyond the recycling of carbon tax revenues to a much larger tax revision, one that could be accomplished in the absence of carbon taxes and that involves many other economic considerations, such as distributional and administrative effects.

Are the Behavioral Responses Reasonable?

Intertemporal models such as those of Goulder and Jorgenson-Wilcoxen are driven by many forces. They are infinite horizon models that use a representative, infinitely-lived agent who allocates consumption of goods and leisure over time. Be-

cause the horizon is infinite, the savings elasticity is infinite in the long run: the after-tax rate of return must eventually return to its previous level. Moreover, models that include the allocations of both leisure and goods over time can produce very large labor supply responses in the short run from enacting a tax change that reduces or eliminates the tax on the rate of return. An important phenomenon in these models is the reallocation of leisure over time, which requires an increase in labor supply in the short run. That is, the representative agent responds to an increase in the rate of return by increasing labor supply in the short run in order to reduce it (and increase leisure) in the long run. Hence, growth in the short run is not limited to the modest accumulation of capital from savings increases that would occur in a model with a less responsive labor supply. In addition to the effect of elasticities, an important force driving this short-run effect is how many additional hours are available for work. Since some minimum time is occupied in sleeping and other daily living, this amount of additional hours is not a precise measure and is not based on empirical estimates.

Many economists find the results that are produced from these intertemporal models questionable, not only because the underlying premise of the infinitely-lived representative agent is unrealistic, but also because the results are at odds with empirical evidence on the responsiveness of both labor supply and savings to changes in wage and interest rates. These effects are influenced by various assumptions, particularly, in the short run, the endowment of hours available for labor and the intertemporal substitution elasticity. Engen, Gravelle, and Smetters (1997) explore the workings of these models and find that lowering the intertemporal substitution elasticity or constraining the available hours of work to reflect empirical estimates of labor supply response dramatically reduce these effects in the shorter and intermediate run. The Jorgenson and Wilcoxen model, for example, has a very high intertemporal substitution elasticity of 1, which is much larger than in virtually all other intertemporal models (whether life-cycle or infinite-horizon) and which cannot be easily justified on empirical grounds. Moreover, it is reasonable to expect significant adjustment costs in labor supply responses as well as in production technology.

These multi-sector models are affected also by the reallocation of capital into different sectors, particularly out of owner-occupied housing (which is favored by the current tax law). This reallocation also produces an increase in output in models that incorporate depreciation, due to the lower durability of business capital. This increase in gross national product, however, would be consistent with only a negligible increase in net national product, another reason to be cautious about the measures of gain used to report results. Even these increases (whether in output or welfare) would be slowed by adjustment costs, a point stressed by Goulder (1995b).

In the longer run, introducing uncertainty into a life-cycle model or lowering the factor substitution elasticity would significantly reduce these effects. Until a more realistic model of intertemporal choice that is more consistent with empirical evidence can be applied to the carbon tax recycling studies, these results should be considered with skepticism. Indeed, until a proper experiment, expressed in welfare terms, and reflecting realistic behavioral responses can be prepared, these results should also be considered irrelevant to the environmental tax debate.

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