Double Dividend: Environmental Taxes and Fiscal Reform in the United States is the culmination of a remarkable research program, carried out over a half century by Dale Jorgenson and his colleagues. These include Jorgenson’s co-authors on this book, as well as many others. The book includes references to more than 50 publications by Jorgenson and various co-authors, dating back to 1963.

Over the years, Jorgenson and his colleagues have contributed to the literatures on producer behavior, consumer behavior, investment, productivity, economic growth, general-equilibrium modeling, and welfare measurement. They have studied a wide variety of policy issues, but no other policy area has received more attention than energy and the environment. In this book, they investigate the possibility of a “double dividend,” under which an environmentally-motivated tax can lead to non-environmental benefits. The idea is that the revenues from an efficiency-enhancing carbon tax could be “recycled” to reduce reliance on other, distortionary taxes. If this tax switch were to enhance welfare, quite apart from the benefits associated with a cleaner environment, then society would reap a double dividend.

Since the early 1990s, economists have written extensively about the possibility of a double dividend. It is fair to say that the results of this literature are quite mixed. In an early paper, Bovenberg and de Mooij (1994) are very skeptical regarding the possibility of double dividends. However, their strong results arise because they assume an initial tax system that is optimal in the absence of environmental considerations, so that a double dividend is effectively ruled out by assumption. If a double dividend is to

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occur, the initial tax system must not be optimal (apart from its effects on the environment). For example, Parry and Bento (2000) assume that the initial tax system contains inefficient tax preferences for housing, and they find that revenue-neutral emissions taxes can generate non-environmental benefits. But the mere existence of a pre-existing distortion does not guarantee that a double dividend will occur. Bovenberg and Goulder (1997) assume an initial tax system that is inefficient in its treatment of capital and labor, but they only find non-environmental benefits from environmental taxes for unusual combinations of policies and parameters. Many other researchers have weighed in on the question of whether environmental taxes can produce a double dividend. Double dividends have been found by some modelers in some circumstances, but a double dividend is far from a foregone conclusion.

The results of Jorgenson, Goettle, Ho, and Wilcoxen are consistent with the earlier literature, in that they find modest double dividends for some policies and parameters, but not in every case. They simulate carbon taxes of various sizes, along with a variety of methods of achieving revenue neutrality. When the revenue collected by the carbon tax is rebated to consumers as a lump-sum distribution, the overall non-environmental effect is a welfare loss (i.e., a double dividend does not occur). The point of recycling the revenues from a carbon tax is to reduce the distortions from the rest of the tax system. Since a lump-sum rebate does not directly reduce any distortions at the margin, it is not surprising that the combination of a carbon tax and a lump-sum rebate does not generate a double dividend.

The authors also report on simulations in which the carbon-tax revenue is offset by reductions in capital taxes, labor taxes, or a combination of the two. The most favorable results come from simulations with capital-tax reductions. The system of capital taxes in the United States distorts a large number of economic decisions in significant ways. Decades of research studies, going back to Harberger (1966), have found welfare gains from reforms of capital taxation, including both more uniform capital taxation and reductions in the level of capital taxation. Consistent with that literature, the authors of *Double Dividend* find that when carbon taxes are combined with capital-tax reductions, the benefits from revenue recycling typically outweigh the costs of higher energy prices for all types of consumers. As a result, consumers experience a welfare gain, over and above the environmental benefits, and thus there is a double dividend. However, for labor-tax reductions, the simulations yield a welfare loss in most cases. When combinations of labor-tax and capital-tax reductions are used, the authors find welfare gains in some cases and welfare losses in others, but the magnitudes of these gains and losses are very small.

Many of the methods used in this book will be familiar to those who have followed Jorgenson’s writings over the years. Production and consumption are specified using translog functions, which were pioneered by Christensen, Jorgenson, and Lau (1973). The authors use a long time series to estimate the parameters of production functions for 35 sectors, and of consumption functions for 35 categories of consumption expenditure, plus leisure. They provide sector-specific estimates of the rate of technical change, which are decomposed into rates of price-induced and autonomous technical change.
The tax treatment of capital income is specified using the cost-of-capital approach, pioneered by Hall and Jorgenson (1967). The estimated parameters are then combined in an intertemporal general-equilibrium model, in which agents have perfect foresight regarding future prices.

The general-equilibrium model is first solved for a base case. Then certain policy parameters are altered, and the model is solved again. The model has 4,000 endogenous variables per period, cast into the future for 120 periods. Solving a model of this magnitude is a remarkable achievement, made possible by the use of enhanced Newton methods, together with a generalization of the algorithm developed by Fair and Taylor (1983). The structure of the model allows the authors to compare prices, quantities, pollution levels, and welfare across various policy scenarios, and it also allows them to provide confidence intervals for their estimates.

Despite its great complexity, the model used in *Double Dividend* is of course not all-encompassing. For example, it is essentially a one-country model. The simulations include imports and exports, but the rest of the world is not modeled explicitly, and the current account is set exogenously. Since increasing concentrations of greenhouse gases are a global problem, the model used here must inevitably set aside a number of important questions. The authors of *Double Dividend* are primarily concerned with what might happen to the U.S. economy, under a variety of U.S. policies that are considered in isolation from policy responses and economic effects in the rest of the world.

*Double Dividend* would benefit from a more balanced assessment of the various approaches to computational general-equilibrium (CGE) analysis found in the literature. This is most evident in the discussion of “calibration.” Researchers employ calibration techniques in an effort to anchor their model economies more firmly to the realities of the economy that is being modeled. Calibration techniques are used in every CGE model, including the one at center stage in this book. CGE models tend to have a very large number of parameters, so that it is not generally possible to estimate all of the parameters econometrically. Some researchers (myself included) use elasticity estimates taken from the existing econometric literature, and then impose utility maximization, cost minimization, and the zero-profit condition to solve for the other parameters of the model. Jorgenson and his co-authors would say that such models use the “calibration approach.” They put great emphasis on the distinction between the calibration method and their own approach, which involves estimating a relatively large number of parameters econometrically, and using calibration more sparingly.

For example, the authors of *Double Dividend* argue that “The obvious disadvantage of the calibration approach is the highly restrictive assumptions on technology and preferences required to make calibration feasible” (p. 15). However, calibration methods can be used in conjunction with flexible functional forms. For example, in some of my own research, Ballard and Goddeeris (1999) use calibration methods to specify the parameters of a translog production function, and Ballard and Medema (1993) construct a calibrated model that allows for flexible input-output coefficients. More generally, a vast number of calibrated models (e.g., Fullerton and Rogers, 1993)
allow for varying degrees of flexibility through the use of complex nested production
functions and utility functions.

Although Jorgenson and his co-authors are highly critical of the “calibration
approach,” they nevertheless make considerable use of calibration methods. Some of
these methods are necessary because the solution of their intertemporal model requires
that the model economy must eventually achieve a steady state, which requires calibrat-
ing productivity growth and the savings rate. They introduce a risk premium to calibrate
the growth rate of the economy to the observed consumption share of gross domestic
product. They calibrate their base case to a set of energy-use projections by the Energy
Information Administration, and their path of emissions to an exogenously specified
series. They calibrate government fiscal policies to the assumption that the budget deficit
and current-account deficit will be zero by 2060. They also assume that, beyond 2020,
the domestic interest rate will remain at 5.47 percent indefinitely. Thus, although the
authors of Double Dividend estimate a large number of parameters econometrically,
they also engage in a significant amount of calibration.

The problem here is more with their rhetoric than with their model. All simulation
modelers face difficult choices. If we are to have any hope of solving our models
numerically, we must make a number of simplifying assumptions, many of which can
be clustered under the rubric of calibration. The econometric techniques and results
reported in Double Dividend are an impressive and useful achievement. The achieve-
ment is not diminished by the fact that the authors, like all other simulation modelers,
have to use some parameters that do not come from their own econometric estimation.
Moreover, the flexible functional forms used in Double Dividend do allow the authors
to address a number of issues that cannot be addressed with the simple functional forms
used by Bovenberg and de Mooij (1994), and others. In particular, Ballard, Goddeeris,
and Kim (2005) show that double dividends are more likely to occur when utility func-
tions are non-homothetic, so the fact that the model of Double Dividend allows for
non-homotheticity is a distinct advantage.

In at least one regard, I would have preferred to see additional attention to calibration
issues. Intertemporal models are capable of producing extremely large responses of sav-
ings and labor supply. This is especially true for models with infinitely-lived consumers,
as assumed in Double Dividend. When model consumers have great flexibility and long
time periods over which to reallocate consumption and labor supply in response to a
change in the economic environment, they can exhibit very elastic responses, unless the
researcher takes great care to control these responses (Gravelle, 2002; Ballard, 1997).
For example, when Jorgenson and Wilcoxen (2002) simulate the effects of adopting a
national retail sales tax in a model broadly similar to the one used in Double Dividend,
they find an instantaneous increase of 30 percent in the number of hours worked, and
a long-run increase of 15 percent.

These excessive intertemporal responses can be reduced in a variety of ways. For
example, adjustment costs in the investment process will dampen the swings in invest-
ment, as will uncertainty regarding future prices and incomes. In addition, Ballard (2000)
shows that the labor-supply response can be made consistent with empirical estimates
by adjusting the size of the assumed time endowment. Because the authors of *Double Dividend* do not adjust their model along any of these lines, the model is vulnerable to producing excessively large responses. However, it appears that the behavioral responses in *Double Dividend* are not especially excessive. This could be because the carbon-tax simulations do not affect wages or the net rate of return as dramatically as the switch to a national retail sales tax.

As noted above, the authors of *Double Dividend* tend to find more favorable welfare outcomes when carbon taxes are accompanied by capital-tax reductions, but the results are much less positive when carbon taxes are accompanied by reductions in labor taxes. This difference between capital-tax reductions and labor-tax reductions may be due in part to the specification of labor taxes. The tax on labor income used by the authors includes federal, state, and local income taxes, but it does not include contributions for social insurance. Instead, Social Security contributions and benefits are regarded as transfers within the household sector. This specification is likely to understate the true extent of the labor-market distortions caused by payroll taxes. Since the Social Security program links the taxes paid during one’s working years to the benefits received during retirement, some workers may not consider all of the payroll tax to be truly a tax. However, the link between payroll taxes and benefits is made through an extraordinarily complicated formula, which gives substantially higher implicit rates of return to some groups than to others (e.g., Karamcheva, Wu, and Munnell, 2014). Thus it seems extreme to assume that payroll taxes have no distortionary effects whatsoever. By comparison, Altig et al. (2001) assume that individuals only perceive that 25 percent of contributions are linked to benefits at the margin, so that 75 percent of the Social Security payroll tax does indeed distort labor-supply decisions.

If the authors of *Double Dividend* understate the true extent of labor-tax distortions, then the benefits of achieving revenue neutrality through reductions in the labor tax will also be understated. We have seen that when the carbon tax is replaced by a lump-sum rebate, the authors find welfare losses. By assuming that a substantial portion of the labor tax is very much like a lump-sum tax, they probably make the policy of labor-tax reductions look worse than it really is.

Computational general-equilibrium models tend to be very complicated, and they tend to have a large number of parameters. The model described in *Double Dividend* is certainly complicated, and it has thousands of parameters. As one who is both a producer and a consumer of the results of CGE models, I consider the complexity of these models to be both a strength and a weakness. The strength is that a detailed CGE model, such as the one used in *Double Dividend*, grapples explicitly with many issues that are ignored in smaller, simpler models. The weakness is that the model results are influenced through a huge number of channels, which makes it impossible to interpret the results in a fully transparent way. My conclusion is that the results of *Double Dividend*, or of any CGE study (including my own) should be taken with one or two grains of salt.

At the end of the day, if we institute a carbon tax, will we get a double dividend? The answer to this question was unclear before the publication of *Double Dividend*, and it is still unclear. In this book, we see welfare improvements in some cases, but
not in all. Regardless of whether the welfare changes are positive or negative, they tend to be relatively modest in size. Most of the reported welfare changes are less than three-tenths of one percent of full wealth in absolute value, and none is as large as one percent of full wealth. For reasons stated above, I am somewhat more optimistic that we could achieve a double dividend by combining a carbon tax with reductions in labor taxes. However, even if labor-tax replacement were to provide welfare benefits, they are very unlikely to be large. In any event, it remains very difficult to make a general case for a double dividend.

The authors of *Double Dividend* report the entire path of greenhouse-gas emissions under several of their policy scenarios. Relative to the base case, they find some very substantial emissions reductions. Depending on the size of the carbon tax, these results suggest that emissions could be reduced by something in the range of 20 to 50 percent by 2050. If emissions reductions of this magnitude can be achieved, the global climate in 2100 might turn out to be much more tolerable than it would otherwise be. If a double dividend can be found, on top of the environmental improvement, it would be a pleasant bonus. The simulation results presented in *Double Dividend* suggest that modest double dividends may occur in some cases. However, the main reason to enact environmentally-motivated taxes has always been to improve the environment.

**REFERENCES**


