
Carbon Taxes

Equity and Efficiency Trade-Offs

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INTRODUCTION

Recent years have seen increasing use of carbon pricing instruments as a means of mitigating carbon emissions. For example, Stavins (2019) notes that 26 carbon taxes and 25 cap-and-trade policies have either been implemented or are scheduled for implementation worldwide.

In the United States, these include cap-and-trade programs in the states of California and Washington as well as the Regional Greenhouse Gas Initiative (RGGI), a multi-state cap-and-trade system that includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. However, the United States does not have a national carbon pricing mechanism (in particular, one was not included in the Tax Cuts and Jobs Act (TCJA) enacted in 2017), and the prospects for national carbon pricing policies in the immediate future are dim.

Nevertheless, many recent tax policy debates in the United States have included discussions of implementing carbon pricing on a national level. In this paper, we focus on a carbon tax, that is, a tax on fossil fuels proportional to their carbon content as a proxy for the emissions of carbon dioxide that will occur upon combustion.¹ Such taxes are typically coupled

with measures that would “recycle” the resulting revenues, for example, as payroll, personal income, or corporate income tax reductions or as per-household or per-capita lump-sum rebates. These alternative revenue-recycling options would have very different effects on economic efficiency and the distribution of income, and the equity-efficiency trade-offs associated with various alternative carbon tax revenue-recycling mechanisms are the focus of this analysis.

Our paper is organized as follows. In the next section, we provide some background information on carbon taxes and describe our approach to simulating these equity-efficiency trade-offs. Section III provides a brief overview of our model, while Section IV presents our simulation results for the carbon tax policies analyzed in the paper. A concluding section summarizes the results and suggests directions for future research.

¹ See Stavins (2019) and Metcalf (2019) for discussions of the relative merits of carbon taxes and the alternative of a national carbon cap-and-trade system.

SOME BACKGROUND INFORMATION

Carbon taxes have long been recommended by liberal and progressive economists and policymakers as a means of addressing climate change by reducing carbon emissions.² But recent years have also seen interest in carbon taxes from individuals on the other side of the political spectrum. In particular, under the auspices of the Alliance for Market Solutions (AMS), Brill (2017) provides a “conservative dialogue” that examines pro-growth methods of implementing a carbon tax policy that would include revenue recycling focused on reducing capital income taxation and replacing current environmental regulations. Similarly, prior to the passage of the TCJA, Holtz-Eakin et al. (2017) recommended a carbon tax as part of a corporate income tax reform package. Finally, a group of influential policymakers, including former Treasury secretaries James Baker and George Shultz and former Council of Economic Advisers chairmen Martin Feldstein and Greg Mankiw (Baker et al., 2017; Climate Leadership Council, 2018), has formulated a carbon tax that would replace existing and future environmental regulations; the group has offered a

proposal (the “Baker-Shultz Carbon Dividends Plan”) under which revenues from a carbon tax, which would begin at \$40 per ton and increase over time, would be rebated on an equal per-capita basis.³

Recent surveys suggest that support for carbon taxes may be broader than commonly believed, including among conservatives. For example, pollster Kristen Soltis Anderson notes that belief in global warming increased among conservative Republicans by 19 percentage points between 2014 and 2016, observing that conservative icon Ronald Reagan was the first U.S. president to call for research into global warming.⁴ Similarly, a September 2018 poll by the Climate Leadership Council found that 81 percent of the likely voters surveyed, including 65 percent of Republicans, believe that the government should take action to limit carbon emissions, and 56 percent, including 55 percent of Republicans and 58 percent of Democrats, supported the Baker-Shultz Carbon Dividends Plan described above, while 26 percent opposed it and 17 percent were unsure of their position.⁵

² For example, see Larry Summers, “It’s Time the US Placed a Price on Carbon,” *Climate Home News*, www.climatechangenews.com/2015/01/05/larry-summers-its-time-the-us-placed-a-price-on-carbon/, and Joseph Stiglitz, “Summary of Carbon Tax Views,” *Carbon-Price.com*, <http://carbon-price.com/joseph-stiglitz/>.

³ In addition, several observers have argued that the need to finance the large deficits associated with the TCJA — estimated to be on the order of \$1.0–\$1.5 trillion over the 10 years from 2017–2026 (Joint Committee on Taxation, 2017) — may strengthen the case for eventual enactment of a carbon tax (Gleckman, 2017; Mathur and Morris, 2017).

⁴ See Brill (2017, pp. 8–13).

⁵ Climate Leadership Council, *National Survey Results on the Baker-Shultz Carbon Dividends Plan*, <https://www.clcouncil.org/media/Baker-Shultz-Carbon-Dividends-Plan-Survey-Results.pdf>. The survey also found that 71 percent of millennials supported the plan, and that using carbon tax revenues to finance rebates or “carbon tax dividends” was much preferred — by a factor of at least three — to any of eight alternative revenue-recycling options.

SOME BACKGROUND INFORMATION CONTINUED

A carbon tax is an example of a “Pigouvian tax,” as it is designed to offset the negative externalities of carbon dioxide emissions associated with climate change. The primary advantage of the carbon tax approach is that it results in consumer prices that reflect the total social costs of production, including the external costs associated with climate change, so that consumers and producers take such costs into account in their private decision-making. As a result, assuming that the carbon tax is set accurately to reflect these negative externalities, which is typically referred to as the marginal “social cost of carbon,” the market equilibrium with carbon taxes retains the efficiency properties associated with private markets, including efficient allocations of goods across consumers and efficient use of production inputs, as well as equalization of marginal abatement costs across firms, assuming that the other conditions for the efficiency of private markets are satisfied. Additional “command and control” regulations on carbon emissions, such as limits on individual emission sources or mandated emission-reducing technologies, which are often administratively cumbersome, distortionary, and unnecessarily costly, are generally not required.⁶ Lowering the costs of reducing carbon emissions has the added benefit of mitigating political opposition. Equally important, under a carbon pricing system, businesses face the correct price incentives to find new and innovative ways to reduce the carbon intensity of their production processes.

The calculation of the social cost of carbon (SCC) emissions, the marginal social damages that result from

greenhouse gas emissions along an “optimal” global emissions path, is both difficult and controversial — including the contentious issues of the appropriate discount rate and whether the measure of costs should include worldwide costs or simply domestic costs — and estimates vary widely. For example, Marron, Toder, and Austin (2015) report that in one set of estimates, the SCC, measured in dollars per metric ton of CO₂ equivalents, ranges from slightly below zero⁷ to more than \$100, with a central tendency of roughly \$42 per ton, while the EPA (2015) cites a range for the SCC of \$14 to \$138 per ton. In addition, most estimates suggest that the SCC increases over time, as the damages associated with marginal emissions increase as the total stock of greenhouse gases in the atmosphere increases. Marron et al. note that it is difficult to measure the SCC because (among other reasons) (1) costs must be measured over many years because greenhouse gases in the atmosphere are long-lived; (2) costs depend on the highly uncertain stock of greenhouse gases at each point in time; (3) cost estimates depend on a wide variety of controversial assumptions, including the choice of the discount rate,⁸ the costs of adapting to climate change, and the valuation of low probability but extremely costly catastrophic events, especially in the presence of significant risk aversion on the part of policymakers; and (4) estimates of the SCC in the United States vary tremendously depending on whether global or only domestic costs are considered — greenhouse gases emitted in the United States impose worldwide costs,⁹ but the United States bears only 7–10 percent of global SCC.¹⁰

⁶ For further discussion, see Brill (2017, pp. 27–38).

⁷ Negative estimates for the SCC are unusual but can arise if the benefits of climate change, such as increased agricultural production due to greater concentrations of carbon dioxide, are sufficiently large. The FUND (Climate Framework for Uncertainty, Negotiation, and Distribution) integrated assessment model in particular captures such carbon dioxide fertilization effects (Anthoff and Tol, 2013).

⁸ The range of discount rates used is large. For example, the central estimate in the Stern (2007) Review is 1.4 percent while, in a review of that report, Nordhaus (2007) recommends a 4.5 percent rate. The Trump administration has recently proposed using discount rates of 3 and 7 percent (and considering only domestic costs in estimating the SCC). See Drupp et al. (2018) for a recent discussion of the issues raised by the choice of the discount rate.

⁹ For example, Auffhammer (2018, p. 35) stresses that because “the externality is global ... from an economic point of view, the global number is the correct estimate of the externality.” However, Viard, in Brill (2017, p. 45), argues that using a global SCC is appropriate only if the U.S. tax is part of a “comprehensive international climate change agreement” under which all countries “impose taxes equal to the global social cost of carbon.”

¹⁰ For additional discussion, see Newbold et al. (2010), Nordhaus (2014a, b), Pizer et al. (2014), Gillingham and Stock (2018), and Auffhammer (2018); and, for a critical view, see Pindyck (2017).

SOME BACKGROUND INFORMATION CONTINUED

This uncertainty naturally complicates the choosing of an efficient level of carbon tax. Nevertheless, Baker et al. (2017) reasonably argue that “mounting evidence of climate change is growing too strong to ignore,” so that such a plan is desirable because “the risks associated with future warming are too big and should be hedged. At least we need an insurance policy.” We do not attempt to estimate the SCC in this paper or address the issues that make such estimates controversial.¹¹ Instead, in our simulations, we analyze the macroeconomic and distributional effects of a federal carbon tax and the associated equity-efficiency trade-offs for a representative carbon tax under a variety of revenue-recycling options.

Although opponents of carbon taxes raise many objections, two of the most commonly expressed concerns, both of which are addressed in this paper, are that (1) the implementation of a carbon tax would reduce economic efficiency and thus reduce domestic output and slow economic growth, especially to the extent that it would act as a tax on energy-intensive production inputs, increasing relative consumer prices for energy-intensive goods and lowering real wages; and (2) the burden of a carbon tax would be regressive, as it would be borne disproportionately by lower-income households who spend a relatively large fraction of their income on carbon-intensive goods, especially gasoline, electricity, natural gas, and fuel oil.¹² Moreover, choosing among alternative carbon tax revenue-recycling options involves difficult equity-efficiency trade-offs. In particular, using such revenues to reduce distortionary taxes on capital income, such as the corporate income tax or personal income taxes on capital income, tends to be most effective in mitigating the inefficiencies associated with carbon taxation. But it also exacerbates the distributional concerns noted above. By comparison, using carbon taxes to finance per-household or per-capita rebates

effectively addresses distributional concerns but provides no benefits in terms of reducing existing distortionary taxes.¹³ These equity-efficiency trade-offs in the design of carbon tax policies are the focus of our analysis.

More specifically, in this paper we use the Diamond-Zodrow dynamic CGE model (described in Section III), calibrated to the tax rates in effect since the 2017 enactment of the Tax Cuts and Jobs Act, to examine these equity-efficiency trade-offs, as we analyze the effects of the implementation of a carbon tax coupled with various revenue-recycling options on (1) GDP and other macroeconomic variables, and (2) intragenerational and intergenerational lifetime income distributions. In particular, we assume a “representative” carbon tax of roughly \$50 (in 2016 dollars) per metric ton of CO₂ equivalent that is introduced in 2020, which increases for 30 years at a rate of roughly 2 percent (the precise time path is specified in Interagency Working Group on Social Cost of Greenhouse Gases, 2016), and is then held constant in real terms beginning in 2050.

We consider several revenue-recycling options in our analysis. Our “maximum rebate” case assumes that all of the revenues from the carbon tax are used to finance an equal lump-sum per-household rebate, a policy similar in spirit to the Baker-Shultz Carbon Dividends Plan.¹⁴ Equal rebates imply that this plan is highly progressive, as a uniform rebate will be a smaller fraction of income as income increases. However, because none of the recycled carbon tax revenues are used to reduce existing distortionary taxes, this plan is the most inefficient of the revenue-recycling options.

By comparison, our “minimum business tax” case assumes that all of the revenues from the carbon tax are used first to reduce or eliminate the corporate income tax and individual-level taxation of pass-through business income. Because taxes on capital income are the most distortionary taxes in

¹¹ For recent surveys, see Auffhammer (2018) and Rose et al. (2017).

¹² For example, see U.S. Senate, H.Con.Res.119, <https://www.congress.gov/bills/115/congress/house-concurrent-resolution/119/text>.

¹³ As will be discussed further below, intermediate policies, such as reducing payroll taxes or personal income taxes on labor and capital income, tend to have results that fall between these two extremes.

¹⁴ Note, however, that we model an equal per-household rebate while the Baker-Shultz plan calls for an equal per-capita rebate.

SOME BACKGROUND INFORMATION CONTINUED

our model (in particular, they are more distortionary than either taxes on labor income or taxes on consumption), such a policy is relatively efficient. However, because capital income is highly concentrated among the higher income groups, this policy is simultaneously highly regressive (from a static, short-run perspective).

We then consider two plans that mix varying amounts of household rebates and business tax cuts. Under the first plan, we assume that 75 percent of carbon tax revenues are used to finance equal per-household rebates, with the remaining revenues used to finance reductions in business taxes. Under the second plan, we assume that 25 percent of carbon tax revenues are used to finance equal per-household rebates, with the remaining revenues used to reduce business taxes.

Our final simulation takes an entirely different approach, as we assume that all of the carbon tax revenues are used to finance a reduction in payroll taxes. We then examine how this policy compares to the plans above that trade off household rebates and business tax cuts.

Before proceeding further, we note several features of our analysis. First, our calculations require estimates of the effects of the carbon tax on the prices of producer and consumer goods, which is a function of their carbon intensity.

Because our model is relatively highly aggregated and does not consider differences in carbon intensity, we cannot perform such an analysis. Accordingly, we rely on estimates prepared by the Rhodium Group (RHG) (Larsen et al., 2018) as part of an earlier research project in which we participated (Diamond and Zodrow, 2018), which was conducted under the auspices of the Carbon Tax Research Initiative of Columbia University's SIPA Center for Global

Energy Policy.¹⁵ As part of their analysis, RHG analyzed the price effects of the representative carbon tax described above using a highly disaggregated model of the U.S. economy, which includes considerable detail on energy production and usage. In particular, RHG used the National Energy Modeling System (NEMS) constructed by the U.S. Energy Information Administration, which provides a detailed representation of the energy and carbon intensity of production in the United States across a wide variety of business sectors. The RHG version of this model, RHG-NEMS, was utilized to estimate (among many other outputs) the effects of the representative carbon tax on the prices of a group of 15 major consumer goods (based on National Income and Product Accounts (NIPA) classifications of personal consumption expenditures, with "Gasoline and Other Goods" and "Housing and Utilities" disaggregated into two and four subcategories, respectively, resulting in a total of 19 consumer goods). As described in Diamond and Zodrow (2018), we use the carbon tax-induced consumer price effects calculated by RHG and convert them into the analogous price increases for the four consumer/producer goods in our model (described further below).¹⁶ We then simulate the short-run and long-run macroeconomic and distributional effects of the representative carbon tax policy under the various revenue-recycling options noted above.

Second, our study, like most of the literature examining the growth effects of carbon taxes, takes a rather narrow perspective by simply ignoring their environmental benefits — a perspective that greatly simplifies the analysis but also increases the likelihood that carbon taxes will result in reductions in economic welfare. This assumption, however, by no means implies that these environmental benefits are not substantial. For example, Goulder and Hafstead

¹⁵ "Carbon Tax Research Initiative," SIPA Center for Global Energy Policy, <https://energypolicy.columbia.edu/our-work/topics/climate-change-environment/carbon-tax-research-initiative>.

¹⁶ The Rhodium Group study estimates that the representative carbon tax would reduce carbon emissions by 35-36 percent below 2005 levels by the year 2025, and by 37-49 percent by 2050, with most of the reductions occurring due to reduced use of coal in the electric power generation sector, with coal production falling by between 28-84 percent by 2030. The average price of gasoline would initially increase by 44 cents a gallon, or roughly 20 percent, while the average price of electricity would increase by 12.5 cents per kwh, or 19 percent. The projected reductions in emissions would be more than sufficient to meet the U.S. goal under the Paris Agreement of a 26 percent reduction in emissions by 2025, but clearly would fall considerably short of the goal of an 80 percent reduction in emissions by 2050.

SOME BACKGROUND INFORMATION CONTINUED

(2018) use a dynamic, perfect foresight, infinite-horizon CGE model with 35 production sectors and two regions (the United States and the “rest of the world”) to estimate the direct benefits of reducing carbon emissions. They use what they describe as the “most widely cited” IWG estimate of the worldwide social costs of carbon, which reflects a cost in 2017 of \$42.69 per metric ton of CO₂ in 2013 dollars, increasing at roughly 1-2 percent per year to an SCC of \$77.52 in 2050 (again in 2013 dollars), as well as estimates of the health benefits of the reductions in pollution associated with reduced carbon emissions and (relatively small) estimates of the energy security benefits of reduced reliance on imported oil. Their analysis suggests that the ratio of total benefits to total welfare costs of their carbon tax with the revenues used to finance per-household rebates is 4.24. This ratio increases if the revenues are used to finance reductions in distortionary taxes. Indeed,

for reductions in the corporate income tax (the most distortionary tax in their model), the ratio of total benefits to total welfare costs associated with the carbon tax policy is 11.78. For the carbon tax with payroll tax cuts and personal income tax cuts, these benefit-cost ratios are 4.91 and 5.57, respectively. Although such estimates are necessarily subject to considerable uncertainty, their magnitudes suggest that the environmental benefits of reducing carbon emissions are quite substantial.

Third, our results, of course, build on a large number of important existing studies that also examine the macroeconomic and distributional effects of carbon taxes.

Because we discuss many of these studies, including those presented in the recent comprehensive Stanford Energy Modeling Forum 32 study,¹⁷ at considerable length in earlier research (Diamond and Zodrow, 2018 and forthcoming), we do not present a literature review in this study.

¹⁷ For an overview of the study, see McFarland et al. (2018).

THE DIAMOND-ZODROW MODEL

Recent years have seen increasing use of carbon pricing instruments as a means of mitigating carbon emissions. For example, Stavins (2019) notes that 26 carbon taxes and 25 cap-and-trade policies have either been implemented or are scheduled for implementation worldwide.

This section provides a brief description of the model used in this analysis; for more details, see Zodrow and Diamond (2013) and Diamond and Zodrow (2015). The Diamond-Zodrow (DZ) model is a dynamic, overlapping generations, computable general equilibrium (CGE) model of the U.S. economy that focuses on the macroeconomic, distributional, and transitional effects of tax reforms. Using the carbon tax-induced price increases from the RHG-NEMS model as described above, the model is well suited to simulating in considerable detail the dynamic short-run and long-run macroeconomic effects and intergenerational and intragenerational distributional effects of the implementation of a carbon tax.¹⁸

The DZ model is a micro-based general equilibrium model in which households act to maximize utility over their

lifetimes, and firms act to maximize profits or firm value, with behavioral responses dictated by parameter values taken from the literature; these responses include changes in consumption, labor supply, and bequest behavior by households, as well as changes in the time path of investment by firms that take into account the costs of adjusting their capital stocks. Households and firms are characterized by perfect foresight and therefore do not overreact to the short-run price effects of policy changes as they typically do in models with myopic agents. By construction, the model tracks the responses to a tax policy change every year after its enactment and converges to a steady-state long-run equilibrium characterized by a constant growth rate. As a result, we can track both the short-run and long-run responses to a tax policy change.

¹⁸ For a recent comparison of various models used to simulate the effects of tax reforms, including macroeconomic forecasting models broadly similar to the MAM/NEMS model underlying the Rhodium modeling effort and our dynamic, overlapping generations, general equilibrium model, see Auerbach and Grinberg (2017).

THE DIAMOND-ZODROW MODEL CONTINUED

The overlapping generations structure of the DZ model enables us to track the effects of policy reforms across generations and across income groups within each generation, rather than simply tracking the effects of reforms in terms of broad aggregate variables. Specifically, each generation includes 12 income groups, which reflect lifetime income deciles in each generation, with the first decile (the lowest lifetime income decile) split into the bottom 2 percent (group 1) and the remaining 8 percent (group 2), and the tenth decile split into the top 2 percent (group 12) and the remaining 8 percent (group 11).

The model includes considerable detail on business taxation, including separate tax treatment of corporate and pass-through entities, separate tax treatment of owner-occupied and rental housing, and separate tax treatment of new and old capital (including explicit calculation of asset values before and after the enactment of a reform). We also model the progressive taxation of labor income for households at different income levels, capture differential taxation of different types of capital income (although we do not model differential capital income taxes across income groups), and model government expenditures, including government transfers and a pay-as-you-go Social Security system.

The model includes four consumer/producer sectors, characterized by profit-maximizing firms and competitive markets. The goods produced by these four sectors are: (1) a composite good C produced by the “corporate” sector, which includes all business subject to the corporate income tax; (2) a second composite good N produced by the “noncorporate” sector that encompasses all pass-through entities including

S corporations, partnerships, LLCs, LLPs, and sole proprietorships; (3) an owner-occupied housing good H ; and (4) a rental housing good R .

The model includes a simplified treatment of international capital flows and international trade. The allocation of mobile capital is determined by relative interest rates at home and abroad. Trade is assumed to satisfy a standard balance-of-payments constraint.

On the consumption side, each household has an “economic life” of 55 years, with 45 post-education working years and a fixed 10-year retirement, and makes its consumption and labor supply choices to maximize lifetime welfare subject to a lifetime budget constraint that includes personal income and other taxes as well as a fixed “target” bequest. There are therefore 55 overlapping generations at each point in time in the model, and each generation includes the 12 lifetime income groups described above.

The government purchases fixed amounts of the composite goods at market prices including the carbon tax, makes transfer payments, and pays interest on the national debt. It finances these expenditures with revenues from the corporate income tax, a progressive labor income tax, and flat-rate taxes on capital income.

All markets are assumed to be in equilibrium in all periods. The economy must begin and end in a steady-state equilibrium, with all of the key macroeconomic variables growing at the exogenous growth rate, which equals the sum of the exogenous population and productivity growth rates.

SIMULATION RESULTS

EXAMINING EQUITY-EFFICIENCY TRADE-OFFS

We examine the macroeconomic and distributional effects of the enactment of a carbon tax under the various scenarios noted above. In each case, we compare the effects of the policy change to the values that would have occurred in the absence of any changes — that is, under a current law long-run scenario, which includes the permanent features of the Tax Cuts and Jobs Act (TCJA) enacted in 2017, including the corporate income tax rate cut to 21 percent, but does not include provisions like expensing and the personal income tax rate cuts that are currently scheduled to be phased out.

As described above, we assume the carbon tax is imposed in 2020 at a rate of \$49.40 (in 2016 dollars) per metric ton of CO₂ equivalent, increases for 30 years at a real annual rate of roughly 2 percent, and then is held constant in real terms beginning in 2050. Mapping the carbon tax-induced price increases calculated by Larsen et al. (2018) into the four goods in our model (as described in Diamond and Zodrow (2018)) yields the following increases in consumer prices: (1) 1.3–1.6 percent in the corporate (C) sector, (2) 1.5–1.7 percent in the noncorporate (N) sector, and (3) 2.7–3.3 percent in the owner-occupied housing (H) and rental housing (R) sectors. Note that the price increases in the model are largest for the two housing sectors and smallest for the corporate sector, with a price increase for the noncorporate sector that is slightly larger than the price increase for the corporate sector. This is broadly consistent with earlier studies (e.g., Grainger and Kolstad (2010) and Rausch, Metcalf, and Reilly (2011)) that found relatively large price increases for utilities, which are included in the housing sector in our model.

This pattern implies that the carbon tax-induced consumer price increases act to offset existing production distortions in the model, as (1) the corporate sector, taking into consideration both the new 21 percent federal corporate income tax rate and individual-level taxes, is slightly more heavily taxed than the noncorporate sector, taking into consideration the 20 percent income deduction allowed under TCJA, and (2) the housing sector — at least the owner-occupied housing sector, which accounts for more than 85 percent of the capital in the housing sector — is the least-heavily taxed sector of all due to the various tax preferences for owner-occupied housing under the income tax, including the exemption of imputed rent, mortgage interest deductibility (which is less important under the TCJA since it roughly doubled the standard deduction, which implies many fewer taxpayers will itemize deductions¹⁹), and very low effective capital gains tax rates.

At the same time, the high level of aggregation in our model (a total of four consumer/producer sectors with only two nonhousing sectors and no intermediate goods) implies that the distortionary effects on consumer choices of many of the price differentials attributable to the carbon tax tend to cancel; the only tax differentials we capture are among the corporate and noncorporate sectors and the owner-occupied and rental housing sectors. This has the effect of muting the distortionary effects of the carbon tax on both consumption and labor supply. In addition, we do not capture the distortionary effects on the decisions of firm managers of carbon tax-induced price differentials on production inputs, including carbon-intensive intermediate goods.

¹⁹ The Tax Policy Center estimates that the fraction of taxpayers who itemize will fall from 26.9 percent to 10.9 percent under the TCJA (“Impact on the Number of Itemizers of H.R.1, The Tax Cuts and Jobs Act (TCJA) by Expanded Cash Income Level, 2018”), <https://www.taxpolicycenter.org/model-estimates/impact-itemized-deductions-tax-cuts-and-jobs-act-jan-2018/t18-0001-impact-number>.

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

Finally, note that, given the overlapping generations nature of our model, we identify gains and losses by generation and by lifetime income group rather than summing the discounted values of all of the future gains and losses caused by a carbon tax reform into a single aggregate measure of reform-induced welfare changes. In particular, the long-run gains in GDP we report are not offset by short-run losses (as they would be in a calculation of the present value of all future changes in GDP). Note also that the implementation of the carbon tax tends to impose windfall losses on the elderly at the time of enactment due to the reform-induced increases in consumer prices, which are only partially offset by the indexation of transfer payments including Social Security benefits; depending on the reform analyzed, these losses may be offset by lump sum rebates for lower-income households, and by lower taxes on dividends and capital gains for higher-income households. Analogous but smaller losses are imposed on those who are near retirement at the time of enactment of the carbon tax. These losses cannot be shifted to future generations because our model assumes a fixed target bequest. As a result, these windfall losses give rise to a one-time revenue increase for

the government which, if utilized for reductions in future taxes, may stimulate additional labor supply and saving and increases in production in the medium and long terms.²⁰

1 | CARBON TAX REVENUES FINANCE UNIFORM PER-HOUSEHOLD REBATES

We first consider the macroeconomic effects of the carbon tax detailed above when the revenues are used to finance uniform per-household rebates. The carbon tax raises revenue equal to 1.20 percent of GDP in 2020 (\$270 billion²¹) and 1.45 percent of GDP in the long run.²² These revenues finance rebates that are initially \$1,874 per household and increase to \$2,196 per household by 2029, to \$3,057 per household by 2039, and to \$6,132 per household by 2069. The simulation results are shown in Table 1. In contrast to the alternative of revenue recycling in the form of reductions in other distortionary taxes, uniform lump sum rebates have no incentive effects on labor supply or saving. In particular, this policy creates carbon tax-induced increases in consumer prices that lead to reductions in real wages that are not

TABLE 1

Macroeconomic effects of carbon tax with uniform per-household rebates

(Percentage changes in variables, relative to steady state with no carbon tax)

VARIABLE % CHANGE IN YEAR	2020	2024	2029	2039	2069	LR
GDP	-0.56	-0.51	-0.60	-0.68	-0.73	-0.74
Total Consumption	-0.40	-0.48	-0.58	-0.75	-0.84	-0.85
Corporate Good	0.11	0.02	-0.13	-0.33	-0.45	-0.46
Noncorporate Good	-0.68	-0.69	-0.81	-0.85	-0.86	-0.87
Rental Housing	-0.74	-0.56	-0.50	-0.69	-0.51	-0.43
Owner-Occupied Housing	-1.67	-1.89	-1.88	-2.15	-2.29	-2.32
Total Investment	-1.39	-0.75	-0.76	-0.49	-0.40	-0.42
Total Capital Stock (K)	0.00	-0.26	-0.46	-0.61	-0.54	-0.55
Total Employment (hours worked)	-0.58	-0.54	-0.56	-0.60	-0.68	-0.69

²⁰ See Zodrow (2002) for a discussion of such reform-induced losses.

²¹ These revenues are similar but not identical to those estimated by Larsen et al. (2018), as we duplicate their carbon tax rates exactly but can then only approximate their revenue levels within the context of our model specification.

²² This figure represents the total revenue raised by the carbon tax. Note that static estimates of the effects of carbon taxes, such as those prepared by Rosenberg, Toder, and Lu (RTL) (2018), typically include a “revenue offset” of roughly 25 percent (the specific offset RTL estimate is 26 percent), which reflects the estimated reduction in income and payroll tax revenues due to the decline in labor and capital income attributable to the imposition of the carbon tax. By comparison, such income and payroll tax revenue effects are calculated endogenously in our general equilibrium model so that no revenue offset is needed. A rough “partial equilibrium” or static calculation suggests that our model parameterization is consistent with a revenue offset of approximately the same magnitude as that estimated by RTL and others.

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

offset by any positive effects on labor supply attributable to the recycling of carbon tax revenues.

As a result, the macroeconomic effects of this policy are uniformly negative. In particular, declining real wages imply that aggregate labor supply declines by 0.58 percent initially, by 0.60 percent after 20 years, and by 0.69 percent in the long run. The reduction in labor supply is accompanied by a reduction in total investment, which decreases initially by 1.39 percent, by 0.49 percent after 20 years, and by 0.42 percent in the long run. This leads to a reduction in the total capital stock of 0.26 percent five years after enactment of the reform and 0.55 percent in the long run. GDP declines initially by 0.56 percent and by 0.74 percent in the long run. Similarly, aggregate consumption declines by 0.4 percent initially and by 0.85 percent in the long run.

The changes in the composition of consumption reflect the price increases in owner-occupied and rental housing relative to nonhousing goods and in the price of the noncorporate good relative to the corporate good. Upon enactment, the consumption of owner-occupied housing declines by 1.67 percent, the consumption of rental housing declines by 0.74

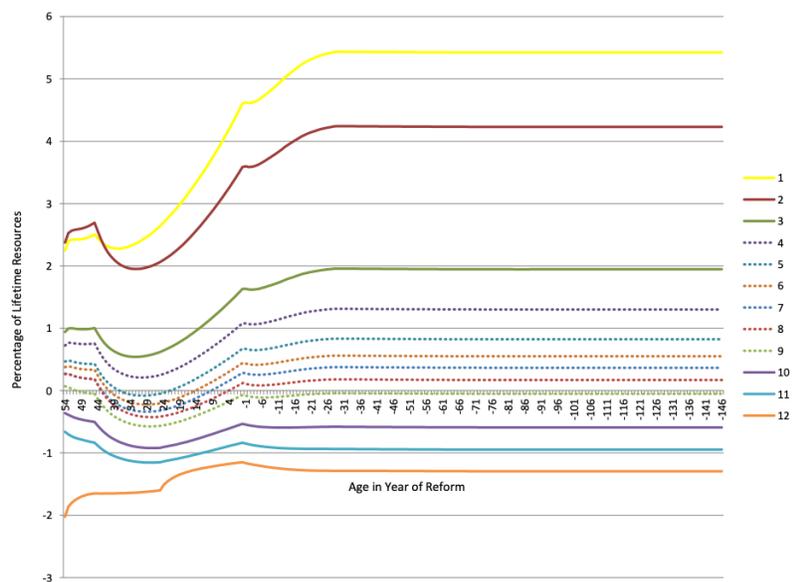
percent, the consumption of the noncorporate good declines by 0.68 percent, and the consumption of the corporate good increases by 0.11 percent. In the long run, with total consumption declining by 0.85 percent, consumption of each of the individual goods declines, with the largest decline by far occurring for owner-occupied housing, which falls by 2.3 percent. The decline in rental housing consumption is much less pronounced, as the rental housing sector benefits from the reduction in the taxation of noncorporate entities, while the tax treatment of owner-occupied housing is basically unchanged.

The distributional effects of this reform are shown in Figure 1. We utilize an equivalent variation measure, defined as the percentage change in remaining lifetime resources,²³ including the value of leisure but excluding the value of the inheritance/bequest (which is simply transmitted across generations and grows at the exogenous growth rate), which is required in the initial equilibrium for a household to achieve the same level of lifetime utility as under the newly enacted carbon tax plan. Uniform per-household rebates disproportionately benefit households with relatively low lifetime incomes, so this carbon tax plan is highly progressive. For example, at the

FIGURE 1

Distributional Effects of Carbon Tax with Uniform Per-Household Rebates

(Present value of all future equivalent variations, relative to present value of all remaining lifetime resources)



²³ The second-lowest lifetime income group experiences larger welfare gains than the lowest group primarily because the price of rental housing increases more due to general equilibrium effects than the price of owner-occupied housing, and the lowest lifetime income group consumes significantly more rental housing than the second group.

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

time of enactment, the oldest households in the two poorest lifetime income groups (which together make up the poorest decile) experience a welfare gain of more than 2 percent of remaining lifetime resources, while the most elderly in the richest lifetime income group experience a loss slightly greater than 2 percent, with the magnitudes of the gains declining uniformly for all households between these two lifetime income groups. In the long run, the uniform rebate plan is uniformly progressive. All lifetime income groups in the bottom seven deciles (groups 1–8) experience gains from reform, while the higher-income households in the top three lifetime income deciles (groups 9–12) are net losers from reform. For example, in the long run, the poorest lifetime income group experiences a welfare gain of 5.4 percent of remaining lifetime resources, while the richest lifetime income group experiences a loss of roughly 1.3 percent.

The U-shaped patterns in Figure 1 during the transition period for generations that are not retired at the time of enactment reflect the effects of the initial decline in after-tax real wages. In addition, they reflect the effects of the target bequest and slightly lower interest rates, which cause welfare to decline for those above the economic age of 25 at the time of enactment who have already received their inheritance and must augment it each year after reform in order to achieve their target bequest. This effect is diminished for those who are younger than 25 economic years, since the latter effect is not relevant until they receive their inheritance — they have more years to adjust to the need for reduced consumption to finance the target bequest in the presence of lower post-enactment interest rates. Note that the bequest is far more important for the top lifetime income group (the top 2 percent) than for any other group, since these households account for 65 percent of all bequests (group 11 accounts for 13 percent, group 10 for 8 percent, and the aggregate share of all of the other groups combined is below 3 percent). Thus, small changes in interest rates in the years after enactment of reform have a disproportionately large impact on the highest income group.

2 | TAX REVENUES FINANCE CUTS IN BUSINESS INCOME TAXES

In this simulation, we use carbon tax revenues to cut the corporate tax rate to roughly zero in the long run and to reduce noncorporate tax rates, including those in the rental housing sector, such that the combined business and individual-level taxes are approximately equal across the two business sectors.²⁴ Specifically, we reduce the non-corporate and rental housing tax rates by 60 percent in every period after reform and then use the remaining carbon tax revenues (and also additional revenues created by economic growth) to cut the corporate tax rate as much as possible. The corporate tax rate is cut from 21 percent in the initial steady state to 12.5 percent after 2 years, 10.6 percent after 10 years, 4.4 percent after 20 years, and 0.8 percent after 30 years and in the long run. As discussed above, reductions in taxes on business and capital income tend to be relatively efficient, as they reduce tax disincentives for saving and investment and thus increase the capital stock, labor productivity, and wages. However, they also tend to favor higher-income households that receive a disproportionately large share of business and capital income.

The results of this simulation are shown in Table 2. The net effect on GDP of the policy is initially negative (by -0.28 percent) but quickly turns positive as increased investment results in a larger capital stock, yielding a gain of 1.71 percent after 20 years and in the long run. Aggregate consumption follows roughly the same pattern as GDP, declining initially (by 1.13 percent), but then increasing by 0.71 percent after 20 years and by 0.86 percent in the long run. The pattern of changes in the components of consumption again reflects the changes in relative prices and relative demands, as (1) the demand for owner-occupied housing declines by 2.36 percent initially and by

²⁴ For purposes of illustration, we make that individual-level taxes on business income can be reduced without simultaneously reducing individual-level taxes on all other forms of income, including labor income and noncorporate dividends and capital gains. Implementing such a policy would of course be exceedingly difficult from an administrative standpoint — as would eliminating the extent to which the corporate income tax serves as a “backstop” to the personal income tax.

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

TABLE 2

Macroeconomic Effects of Carbon Tax with Cuts in Business Income Taxes

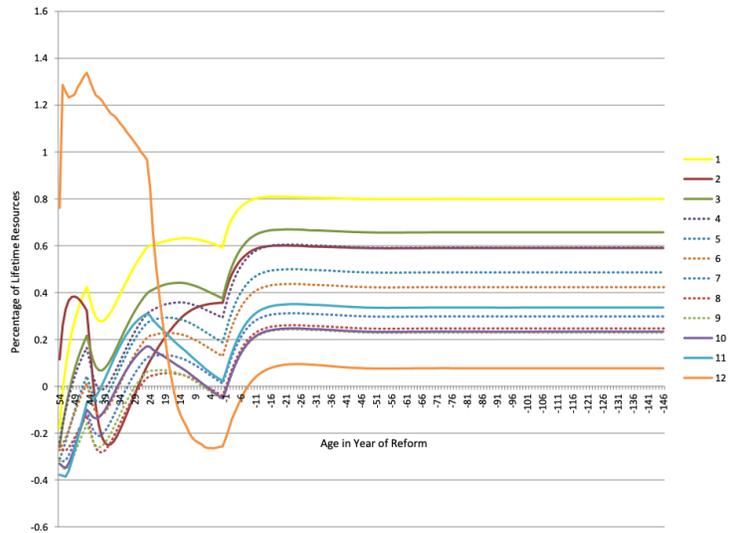
(Percentage changes in variables, relative to steady state with no carbon tax)

VARIABLE % CHANGE IN YEAR	2020	2024	2029	2039	2069	LR
GDP	-0.28	0.88	1.43	1.71	1.71	1.71
Total Consumption	-1.13	-0.29	0.25	0.71	0.87	0.86
Corporate Good	-0.61	0.13	0.66	1.12	1.25	1.24
Noncorporate Good	-1.38	-0.57	-0.03	0.59	0.84	0.82
Rental Housing	-2.44	0.47	1.18	1.39	1.54	1.53
Owner-Occupied Housing	-2.36	-1.46	-0.88	-0.70	-0.63	-0.64
Total Investment	3.04	6.04	6.62	6.07	5.31	5.34
Total Capital Stock (K)	0.00	1.16	2.53	4.03	4.42	4.40
Total Employment (hours worked)	0.01	0.07	0.01	-0.11	-0.17	-0.17

FIGURE 2

Distributional Effects of Carbon Tax with Cuts in Business Income Taxes

(Present value of all future equivalent variations, relative to present value of all remaining lifetime resources)



0.64 percent in the long run, while rental housing declines initially by 2.44 percent but increases in the long run by 1.53 percent; (2) the effects on the demand for the noncorporate good are initially more muted (a decline of 1.38 percent) and eventually turn positive, with an increase of 0.82 percent in the long run; and (3) the demand for the corporate good declines initially by 0.61 percent but eventually increases by 1.24 percent in the long run.

Total investment increases due to the reduction of business income taxes, by 3.04 percent initially and by 5.34 percent in the long run. The capital stock increases as a result, by 1.16 percent after five years and by 4.40 percent in the long run.

The decline in the real wage rate due to carbon tax-induced price increases, as well as the increase in leisure demand due to the reform-induced increase in income, is sufficient to cause total employment to decline by 0.17 percent in the long run.

The distributional effects of the carbon tax, coupled with a reduction in business income taxes, are shown in Figure 2. For retired households, the largest gain goes to the highest lifetime income households, which gain between 0.7 and 1.3 percent of lifetime resources because they benefit the most from reduced business income taxes, both because of an increase in after-tax returns to their capital income and because they are able to achieve their target bequest more easily. Retired households in

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

the two lowest lifetime income groups (mostly) gain, between 0 and 0.4 percent of remaining lifetime resources, as the carbon tax-induced increase in consumption prices is offset by an increase in transfer payments. The reform has relatively small and roughly progressive effects on lifetime income groups 3–11, most of which lose between 0 and 0.4 percent of remaining lifetime resources.

The capital accumulation, wage increases, and growth in GDP due to the reduction in business income tax rates, coupled with indexed transfers to lower-income households, implies that, in the long run, all lifetime income groups benefit from reform, with gains that range from 0 to 0.8 percent. Interestingly, the policy is progressive in the long run; several factors contribute to this outcome. Note first that cutting business tax rates, as in the minimum business tax case, and then offsetting the revenue loss with a decrease in uniform per-household rebates would be a highly regressive policy; under this scenario (not shown in the tables), the three highest income groups would experience significant welfare gains (0.8 to 1.4 percent), the middle income groups (groups 4–9) would experience small welfare gains or losses (0.2 to -0.8 percent), and the lowest three income groups would experience significant welfare losses (-1.4 to -5 percent). However, replacing the per-household rebate fiscal offset to the business tax cut in this simulation with the carbon tax examined in this paper (but without any transfers to offset the impact of the carbon tax on low-income households) yields a much different pattern of welfare gains and losses. In this case (also not shown in the tables), it is difficult to assess the progressivity of the reform, as the smallest gains would accrue to the highest income group, followed by group 2 (less than 0.1 percent); groups 4, 3, 5, 6, and 11 (in that specific order) would experience the largest gains of 0.3 to 0.4 percent, and all other groups would fall in between. This occurs because the carbon tax financing mechanism is relatively (and significantly) less regressive than raising revenues with uniform per-household taxes (or reductions in rebates). Finally, adding in the indexation of transfers for the carbon

tax-induced price increases significantly benefits the lowest three income groups. In this case, the lowest three income groups experience the largest welfare gains (roughly 0.6 to 0.8 percent) relative to any other income group. All middle-income groups also gain from the indexation of transfer payments, but much less than the top three groups. This yields the welfare gains that are depicted in Figure 2, which are almost uniformly progressive except for group 11.

This leaves two interesting issues to discuss. First, why are the welfare gains for group 11 and group 12 so different?

This is the result of the combination of several factors: a target bequest model, a target bequest for the highest income group that is roughly five times as large as the target bequest for next-highest income group, a relatively steep wage profile for the highest income group, and the carbon tax-induced price increase. The large target bequest and steep wage profile for the highest income group lead young, rich households to consume most of their income rather than save it (recognizing that they will receive their inheritance at economic age 25 – or actual age 46), with the exception being the saving required to reach the target bequest at the end of life. In this case, the carbon tax-induced price increase requires a larger reduction in consumption and leisure relative to other income groups, as consumption is high relative to income and saving is forced by the presence of a large target bequest.

The second issue is the impact that housing price changes have on the welfare impacts across the income distribution.

Housing is a significant fraction of total consumption for both high- and low-income households, with high-income households consuming relatively larger quantities of owner-occupied housing services and smaller quantities of rental housing services relative to lower-income households. As business tax rate reductions that apply to rental housing are financed with carbon tax revenues, the relative tax advantage to owner-occupied housing (e.g., the non-taxation of imputed rent and deductions for interest and property taxes) is reduced significantly, so that investment in owner-occupied housing declines significantly in the long

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

run while investment in all other sectors increases. Net demand and supply effects result in an increase in the price of owner-occupied housing of 0.4 percent and a decrease in the price of rental housing services of 4.1 percent. This reduces the welfare gains of high income groups (especially the top 4–5 income groups) relative to lower income groups, and exacerbates the reduction in consumption and leisure facing the highest income group because of the carbon tax-induced price increases, noting in particular that carbon tax rates are almost twice as high on rental and owner-occupied housing services relative to corporate and non-corporate consumption goods.

Given these factors, the two lowest lifetime income deciles gain between 0.6 and 0.8 percent of lifetime income, while most of the higher lifetime income groups experience gains between 0.2 percent and 0.4 percent of lifetime income, and the highest income group has a gain of just under 0.1 percent from the reform.

3 | POLICY MIXES: PER-HOUSEHOLD REBATES COUPLED WITH CUTS IN BUSINESS INCOME TAXATION

In these simulations, we use carbon tax revenues both to reduce business income taxes and to finance uniform per-household rebates. We compare the effects of two mixed policies. The first reduces business income tax rates by 75 percent of the decrease in tax rates in the minimum business tax simulation, which is still enough of a reduction to result in a long-run increase in GDP. The second “GDP-neutral” policy reduces business income tax rates by 25 percent of the decrease in business income tax rates in the minimum business tax simulation, and results in virtually no effect on GDP in the long run. In each case, all remaining carbon tax revenues are used to finance uniform per-household rebates (the long-run increase in rebates is 0.3 percent of GDP if business taxes are cut by 75 percent and 1 percent of GDP if business taxes are cut by 25 percent). As discussed above,

reductions in taxes on business and capital income tend to be relatively efficient, as they reduce tax disincentives for saving and investment and thereby increase investment, the capital stock, labor productivity, and wages — but they tend to be regressive, favoring higher-income households who receive a disproportionately large share of capital income. By comparison, per-capita household rebates are distributed in a lump sum fashion that is independent of household income and are therefore highly progressive, but they do not generate any efficiency gains because they do not reduce any distortionary taxes.

Table 3 shows the results when roughly 75 percent of carbon tax revenues are used to cut business income taxes, with the remaining revenues used to finance uniform per-household rebates. The results in this case are naturally between those in the “maximum rebate” and “minimum business tax” cases, but closer to the latter. The net effect on GDP of this mixed policy is initially negative (by -0.34 percent) but quickly turns positive as increased investment results in a larger capital stock and higher wages, yielding a gain of 1.17 percent after 20 years and 1.15 percent in the long run. By comparison, the long-run increase in GDP in the maximum rebate case is -0.74 percent and 1.71 percent in the minimum business tax case.

Aggregate consumption in this case follows roughly the same pattern as GDP, declining initially (by 0.96 percent), but then increasing by 0.38 percent after 20 years and by 0.47 percent in the long run. The pattern of changes in the components of consumption again reflects the changes in relative prices and relative demands. In the housing sector, the demand for owner-occupied declines by 2.20 percent initially and by 1.02 percent in the long run, while the demand for rental housing declines initially (by 2.04 percent), but increases in the long run by 1.09 percent. This pattern reflects the fact that lower-income households are disproportionately renters and initially burdened by the carbon tax-induced price increases, which are not offset by relatively small rebates. Total investment increases due to the reduction in business income taxes, by 2.01 percent

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

TABLE 3

**Macroeconomic Effects
of Carbon Tax with
Per-Household
Rebates Coupled with a
75 Percent Cut in Business
Income Taxation**

(Percentage changes in
variables, relative to steady
state with no carbon tax)

VARIABLE % CHANGE IN YEAR	2020	2024	2029	2039	2069	LR
GDP	-0.34	0.57	0.97	1.17	1.16	1.15
Total Consumption	-0.96	-0.33	0.06	0.38	0.48	0.47
Corporate Good	-0.44	0.11	0.48	0.79	0.87	0.85
Noncorporate Good	-1.22	-0.59	-0.20	0.26	0.45	0.44
Rental Housing	-2.04	0.23	0.79	0.92	1.08	1.09
Owner-Occupied Housing	-2.20	-1.55	-1.11	-1.03	-1.01	-1.02
Total Investment	2.01	4.48	4.93	4.57	4.02	4.04
Total Capital Stock (K)	0.00	0.83	1.84	2.96	3.31	3.29
Total Employment (hours worked)	-0.13	-0.07	-0.12	-0.23	-0.29	-0.29

TABLE 4

**Macroeconomic Effects
of Carbon Tax with
Per-Household Rebates
Coupled with a 25
Percent Cut in Capital
Income Taxation**

(Percentage changes in
variables, relative to steady
state with no carbon tax)

VARIABLE % CHANGE IN YEAR	2020	2024	2029	2039	2069	LR
GDP	-0.49	-0.13	-0.05	-0.02	-0.05	-0.06
Total Consumption	-0.59	-0.42	-0.35	-0.35	-0.37	-0.38
Corporate Good	-0.08	0.05	0.09	0.07	0.02	0.01
Noncorporate Good	-0.86	-0.65	-0.59	-0.45	-0.39	-0.40
Rental Housing	-1.19	-0.28	-0.05	-0.12	0.06	0.12
Owner-Occupied Housing	-1.85	-1.76	-1.60	-1.75	-1.83	-1.86
Total Investment	-0.20	1.09	1.24	1.31	1.18	1.17
Total Capital Stock (K)	0.00	0.13	0.35	0.65	0.83	0.82
Total Employment (hours worked)	-0.42	-0.38	-0.40	-0.47	-0.55	-0.55

initially and by 4.04 percent in the long run, resulting in increases in the capital stock of 0.83 percent after five years and by 3.29 percent in the long run. Total employment initially falls by 0.13 percent and continues to decline in the medium and long run, by 0.23 percent after 20 years and by 0.29 percent in the long run.

Table 4 shows the results for our second “mixed policy” case, when 75 percent of revenues are used to finance per-household uniform rebates with the remainder used to finance a reduction in business tax rates. The results in this

case are again between those in the “maximum rebate” and “minimum business tax” cases, but in this case closer to the former. With most of net revenues used to finance rebates, the net effect on GDP of the policy is negative both initially (by -0.49 percent) and in the long run (by -0.06 percent). Similarly, consumption declines initially by 0.59 percent and by 0.38 percent in the long run, and the pattern of changes in the components of consumption is similar to that in the “maximum rebate” case. The effects on investment of this mixed policy are muted relative to the “minimum business

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

FIGURE 3

Distributional Effects of Carbon Tax with Per-Household Rebates Coupled with a 75 Percent Cut in Business Income Taxation

(Present value of all future equivalent variations, relative to present value of all remaining lifetime resources)

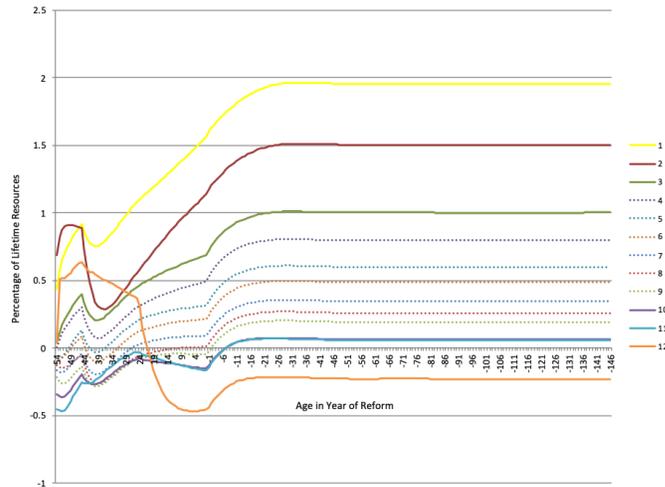
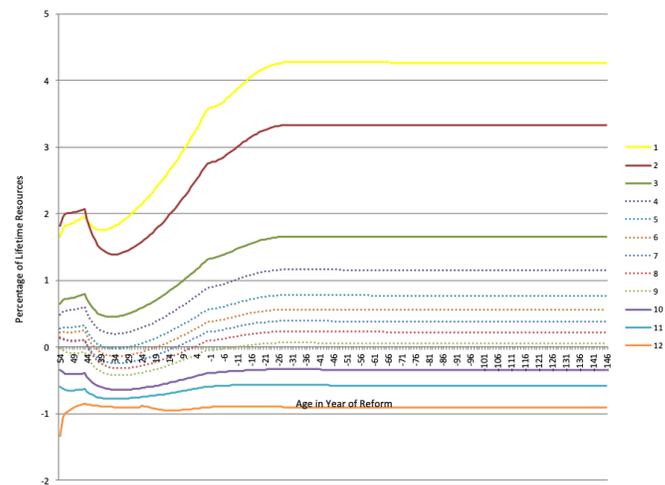


FIGURE 4

Distributional Effects of Carbon Tax with Per-Household Rebates Coupled with a 25 Percent Cut in Capital Income Taxation

(Present value of all future equivalent variations, relative to present value of all remaining lifetime resources)



tax” case but still eventually positive, as investment declines by 0.2 percent initially but increases by 1.17 percent in the long run, resulting in an increase in the capital stock of 0.13 percent five years after reform and 0.82 percent in the long run. Total employment declines initially by 0.42 percent and by 0.55 percent in the long run.

The distributional effects of the carbon tax, with roughly 75 percent of carbon tax revenues used to reduce business income tax rates and 25 percent used for uniform per-household rebates, are shown in Figure 3. These results indicate that a relatively modest amount of per-household rebates is sufficient to narrow the losses to households that are retired at the time of reform to, at most, 0.5 percent of lifetime resources with all gains less than 1 percent of

resources. However, these effects are roughly progressive, except at the very top of the income distribution (group 12). At the same time, the capital accumulation due to the reduction in business income taxes implies that younger and future generations in all but the highest income group experience welfare gains that range from 0 to 2 percent. For the reasons discussed above, these gains are progressive, with the lowest lifetime income group experiencing a gain of nearly 2 percent and the highest lifetime income group suffering a small loss of roughly 0.25 percent in the long run.

By comparison, Figure 4 shows that the distributional effects of the carbon tax, with roughly 25 percent of revenues used to reduce business income tax rates and 75 percent used for uniform per-household rebates, reflect a wider range of

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

outcomes that favor lower-income households, similar to the results when all revenues are used to finance per-household rebates. This policy is more progressive than the previous mixed policy, as more carbon tax revenue is used to finance uniform per-household rebates, but it has virtually no long-run negative effect on GDP because it does include some reductions in business taxes. Lower-income retired households all gain from the reform by as much as 2 percent of lifetime resources, while higher-income retired households are net losers, with net welfare changes ranging from -0.5 percent to 1.5 percent of lifetime resources. In the long run, the bottom quintile gains roughly 1-4 percent of lifetime resources, but the gains to higher income groups are smaller or become negative; in particular, the top three deciles lose as much as 1 percent of lifetime income from the reform when 75 percent of revenue is used to finance uniform per-household rebates.

4 | CARBON TAX REVENUES FINANCE PAYROLL TAX REDUCTIONS

Finally, the macroeconomic results for the case in which carbon tax revenues are used to finance proportionate reductions in payroll taxes are shown in Table 5. In this case, carbon tax revenue enables a reduction in Social Security payroll tax rates of 2.35 percentage points in 2020, 2.32

percentage points in 2029, 2.74 percentage points in 2039, and 2.98 percentage points in the long run.²⁵ These figures include the effects of indexing Social Security benefits in the short run for the price increases associated with the carbon tax; this indexing is phased out over a 30-year period to reflect the fact that, in the long run, Social Security benefits are indexed to wages rather than to consumer prices.

The simulation results indicate that the net effect on GDP of the carbon tax coupled with a payroll tax reduction is initially slightly negative (-0.08 percent) but increases to 0.15 percent after 20 years and 0.24 percent in the long run. Aggregate consumption falls initially (by 0.21 percent) but eventually increases slightly with a long-run gain of 0.05 percent. The pattern of changes in the components of consumption follows the pattern implied by the carbon tax-induced price changes described above. Specifically, the demand for rental and especially owner-occupied housing declines the most dramatically (by 1.00 and 1.35 percent initially and by 0.67 and 1.29 percent in the long run), the demand for the noncorporate good initially declines by 0.50 percent while increasing by 0.05 percent in the long run, and the demand for the corporate good increases (by 0.29 percent initially and by 0.46 percent in the long run).

Total employment increases gradually over time, with increases of 0.15–0.21 percent.²⁶ This reflects that all carbon

TABLE 5

Macroeconomic Effects of Carbon Tax with Payroll Tax Reductions

(Percentage changes in variables, relative to steady state with no carbon tax)

VARIABLE % CHANGE IN YEAR	2020	2024	2029	2039	2069	LR
GDP	-0.08	0.12	0.11	0.15	0.24	0.24
Total Consumption	-0.21	-0.09	-0.05	-0.01	0.05	0.05
Corporate Good	0.29	0.40	0.42	0.42	0.45	0.46
Noncorporate Good	-0.50	-0.31	-0.26	-0.10	0.04	0.05
Rental Housing	-1.00	-0.86	-0.71	-0.77	-0.69	-0.67
Owner-Occupied Housing	-1.35	-1.36	-1.24	-1.32	-1.29	-1.29
Total Investment	0.46	1.07	0.78	0.86	1.03	1.00
Total Capital Stock (K)	0.00	0.24	0.39	0.49	0.78	0.81
Total Employment (hours worked)	0.15	0.16	0.14	0.18	0.22	0.21

²⁵ Medicare payroll taxes are not reduced, and the 0.9 percent tax on high-income taxpayers enacted under the Affordable Care Act is also unchanged.

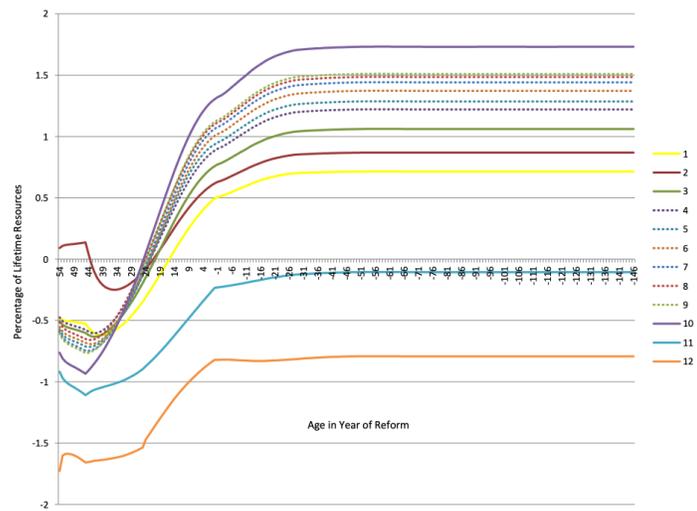
²⁶ Recall that our model assumes full employment, so the increase in employment or hours worked reflects additional hours worked by a fixed number of employees rather than new jobs.

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

FIGURE 5

Distributional Effects of Carbon Tax with Payroll Tax Reductions

(Present value of all future equivalent variations, relative to present value of all remaining lifetime resources)



tax revenues reduce payroll taxes and thereby increase after-tax real wages, offsetting the effects of carbon tax-induced price increases (which apply to both working and retired households). These wage changes vary considerably across income groups. Specifically, after-tax real wages increase for the bottom nine income groups and decrease for the top three income groups (who do not benefit from the cut in payroll taxes, as such taxes are capped), with the net effect being an increase in hours worked.

Total investment (including replacement investment) increases by 0.46 percent initially and by 1.00 percent in the long run, which reflects modest growth as well as the reallocation of production from structures-intensive owner-occupied housing to the more equipment-intensive corporate and noncorporate sectors, mainly due to the carbon tax-induced increase in the price of housing. The capital stock increases gradually as a result, by 0.24 percent after five years and by 0.81 percent in the long run.

The distributional effects of the carbon tax proposal across generations and across the 12 income groups are shown in Figure 5. These results indicate that the carbon tax with revenue recycling in the form of payroll tax reductions (1) redistributes from the old to the young and future generations

within each lifetime income group, (2) initially has roughly proportional impacts across the income distribution — except for a relatively low burden or small gain for households in the lowest lifetime income decile and a disproportionately large burden on households in the top lifetime income decile, and (3) in the long run is a moderately regressive policy across much of the income distribution (income groups 1-10), but eventually become progressive in the sense that the largest percentage burden is borne by households in the top lifetime income decile (lifetime income groups 11 and 12).

Initially, almost all elderly retired households lose from reform, as they face carbon tax-induced higher prices for consumer goods (which are only partially offset by indexation of transfers including Social Security benefits) but do not benefit from higher after-tax wages attributable to the reduction in payroll taxes. In addition, because interest rates decline slightly with the enactment of the carbon tax reform,²⁷ elderly households, especially relative wealthy households that have disproportionately large bequests, have to save more to finance their target bequests, which are fixed in nominal terms; they therefore have less income to finance consumption during retirement. As a result, the highest three lifetime income groups (groups 10-12) experience the largest reductions in welfare among elderly

²⁷ Interest rates decline slightly — by 13-20 basis points — after enactment of this carbon tax reform.

SIMULATION RESULTS EXAMINING EQUITY-EFFICIENCY TRADE-OFFS CONTINUED

households at the time of enactment. For example, the oldest retired households in the highest lifetime income group (the 12th group, or the top 2 percent of the lifetime income distribution) suffer a loss equal to roughly 1.7 percent of remaining lifetime resources, groups 10 and 11 suffer losses of roughly 0.7 to 0.9 percent of remaining lifetime resources, and the elderly households in the bottom and middle lifetime income groups lose roughly 0.5–0.7 percent of remaining lifetime resources.

These losses tend to diminish with reductions in age at the time of enactment for generations that are in the labor force (those with an economic age of 44 or less, or roughly 65–67 years old or younger) when the carbon tax is enacted. These declining losses reflect four factors. First, households that are not retired at the time of enactment have some time to benefit from the payroll tax reduction, and this effect increases as the age at the time of enactment declines. Second, younger households benefit most from the modest increase in economic growth, including the increases in real after-tax wages noted above, an effect that also increases with time and indeed continues, albeit at a modest rate, for roughly 100 years after the time of enactment. Third, as noted above, the reform causes interest rates to decline slightly, which implies that households alive at the time of enactment have to increase their savings to finance their target bequests, which are fixed in nominal terms. Younger generations have more time to make this adjustment, so the negative impact on their welfare is smaller. Finally, the decline in interest rates implies that the return to existing assets declines, and the importance of this effect also decreases with declines in age at the time of enactment.

In the long run, this version of the carbon tax is moderately regressive except at the top of the income distribution. For example, the lowest lifetime income group experiences a gain of only 0.7 percent of lifetime resources. Welfare

gains increase monotonically from 0.9 percent for the second lifetime income group to 1.7 percent for the tenth lifetime income group. This regressivity reflects the fact that at the margin, the payroll tax reduction results in a disproportionately large increase in after-tax wages for higher income groups relative to lower income groups, because the reductions in the payroll tax are equal across the bottom 10 income groups, but marginal income tax rates increase with income. Thus, higher and lower income groups suffer a proportional loss in income due to the carbon tax-induced price increases, but the higher income groups have a larger increase in after-tax income due to the payroll tax reduction. Households in the top decile of the income distribution do not fare as well from the reform, as the loss for the 11th lifetime income group is 0.1 percent of lifetime resources, while the 12th lifetime income group experiences a loss equal to 0.8 percent of lifetime resources. This occurs for three reasons. First, the top lifetime income group benefits less than proportionately from the reduction in the payroll tax because much of their earnings are above the Social Security earnings cap while all of their expenditures are subject to carbon tax-induced price increases. Second, these groups finance virtually all of their consumption with funds that are not subject to indexing for carbon tax-induced price increases. Third, because we assume that the target bequest is fixed in nominal terms, these households receive an inheritance that is smaller in real terms than it would be in the absence of the tax; this effect is disproportionately more important in the top income decile (lifetime income groups 11 and 12). The net result is that all households except the top decile benefit from the reform, with the middle and upper income groups (through the ninth decile of the lifetime income distribution) benefiting the most.

CONCLUSION

Although numerous discussions of tax policy options in the United States have considered the possibility of implementing a carbon tax, concerns have often been raised about its potential negative effects on output and economic growth and on income distribution. In this paper, we examine the macroeconomic and distributional effects of the implementation of a representative carbon tax under a variety of assumptions regarding recycling of the resulting tax revenues, focusing on evaluating the equity-efficiency trade-offs associated with various policies. We simulate these effects using the Diamond-Zodrow (DZ) dynamic overlapping generations computable general equilibrium (CGE) model with 12 lifetime income groups, a model that is designed to estimate the short-run and long-run macroeconomic effects and the intergenerational and intragenerational distributional effects of tax reforms in the United States.

Our results can be summarized as follows. The macroeconomic effects of the various carbon tax reforms reflect the expected equity-efficiency trade-offs. Using all carbon tax revenues for equal per-household rebates has a negative effect on the macroeconomy, with a long-run decline in GDP of 0.74 percent. By comparison, using all carbon tax revenues to cut business taxes results in an increase in GDP of 1.71 percent. Our two mixed policies have intermediate effects, but even a policy that cuts business taxes modestly (by 25 percent of the maximum amount used in the model) generates enough investment and capital growth to result in effectively no effect on GDP in the long run. Similarly, using the revenues to finance a payroll tax cut has an intermediate effect on long-run GDP — an increase of 0.24 percent.

The distributional effects of the various reforms are quite varied. Using all the revenues for per-household rebates is

a highly progressive policy, with respect to both households alive at the time of enactment and future generations. In the long run, the poorest households gain nearly 5.5 percent of lifetime resources, while the richest households lose nearly 1.5 percent. Using all carbon tax revenues for business tax cuts initially favors the wealthiest elderly households (a gain of roughly 1.3 percent), although the range of losses and gains for all other elderly households is relatively small (-1.4 percent to 0.4 percent). Interestingly, this policy results in gains for all income groups and is progressive in the long run, with gains of 0.8 percent for the poorest households and gains of 0.1 percent for the richest households, as the gains attributable to wage increases due to capital accumulation and indexed transfers are relatively more important at the bottom of the income distribution.

Intermediate results are obtained for the two mixed-policy cases, but the results indicate that a relatively modest amount of per-household rebates (with business tax reductions equal to 75 percent of those in the “maximum business tax cut” case) is sufficient to narrow the losses for households that are retired at the time of reform to, at most, 0.5 percent of lifetime resources, with all gains less than 1 percent of resources, while resulting in long-run gains for all households (of up to 2 percent of resources) except the wealthiest (who lose roughly 0.25 percent of lifetime resources). Finally, using carbon tax revenues for payroll tax cuts has a roughly proportional effect across the income distribution for those who are retired at enactment, except for a relatively low burden or small gain for the poorest households and a disproportionately large burden on the richest households, and in the long run is a moderately regressive policy across almost all of the income distribution, but eventually becomes progressive for the top lifetime income decile.

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