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CARBON TAXES AND FISCAL REFORM IN THE UNITED STATES

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In this paper we consider the economic and environmental impacts of taxes on emissions of greenhouse gases. Substituting carbon taxes for other sources of revenue or using the proceeds to reduce deficits or finance expenditures are the keys to integration of carbon taxes with fiscal reform. Recycling carbon tax revenues through reductions of capital income tax rates provides the largest margin of economic benefits over the costs of emissions control. Reducing capital tax rates lowers the cost of capital services and increases the rate of capital formation. This mechanism provides a dramatic illustration of the power of intertemporal general equilibrium modeling in the design of new energy and environmental policies for the United States.

Keywords: carbon taxes, revenue recycling, fiscal reform

JEL Codes: H23, H25

I. INTRODUCTION

Intense debates over measures to reduce the growth of the U.S. public debt have focused attention on fiscal reform to increase tax revenues and reduce government expenditures (National Commission on Fiscal Responsibility and Reform, 2010). Environmental taxes have been mentioned as potential sources of revenues, but few detailed proposals for fiscal reform involving environmental taxes have emerged[1] — despite the support of market-based approaches to environmental policy by many economists.[2] In

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[1] For example, Congressional Budget Office (2012) includes a "price on emissions of greenhouse gases" as a potential revenue source. Dinan (2012) discusses options for reducing the impacts of a carbon tax on low-income households. Marron and Toder (2013) discuss the potential role of carbon taxes in corporate tax reform.

[2] Fullerton and Wolfram (2012) provide a recent collection of papers on the economics of climate policy.

this paper we consider the economic and environmental impacts of taxes on emissions of greenhouse gases, expressed in terms of carbon dioxide equivalents. We refer to these as "carbon taxes."[3]

We have employed the Intertemporal General Equilibrium Model (IGEM) in several studies analyzing alternative climate policies for the U.S. Environmental Protection Agency (EPA). These studies have focused primarily on cap-and-trade policies with complex trading rules, price triggers, safety valves, technology subsidies, sector rebates, and domestic and international offsets. The policies under consideration have stipulated emissions targets, but have not provided consensus estimates of the costs of abatement. Only limited attention has been given to the use of the government revenues generated by auctioning tradable permits (EPA, 2012b).[4]

We analyze the impacts of five levels of carbon tax rates — \$10, \$20, \$30, \$40, and \$50 per metric tonne of carbon dioxide equivalent ($mtCO_2$-e). These rates are expressed in 2005 dollars for the year 2020. The 2020 tax rates are discounted back to 2016 and compounded forward to 2050 at a 5 percent real rate of interest, so that we arrive at five distinct time paths for carbon taxes. After 2050 the carbon tax rates are held at 2050 levels relative to the GDP deflator. Figure 1a displays the five trajectories.[5]

Substituting carbon taxes for other sources of revenue or using the proceeds to reduce deficits or finance expenditures are the keys to integration of carbon taxes with proposals for fiscal reform. We explore the response of the U.S. economy to different carbon tax rates and different uses of carbon tax revenues. These include tax rate reductions, increases in expenditures, and decreases in government deficits. We refer to these options for using carbon tax proceeds as "revenue recycling."[6]

The purpose of imposing a carbon tax is to reduce U.S. emissions of greenhouse gases. This would be the U.S. contribution to an international effort to moderate changes in the climate.

In Section II we consider the impacts of alternative carbon tax policies on emissions of greenhouse gases. We first consider the impact of these policies on emissions expressed in terms of carbon dioxide equivalents for the five distinct time paths for carbon taxes. We then analyze the impact of carbon taxes on greenhouse gas emissions for different uses of the carbon tax revenues.

In Section III we examine three distinct measures of economic performance that allow the ranking of recycling options across all seven fiscal policies. We consider real Gross Domestic Product (GDP), consumption plus government purchases and, finally, the full consumption of goods, services and leisure plus government purchases. None of these

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[3] The impacts of broader environmental taxes are discussed by Jorgenson, Goettle, Ho, and Wilcoxen (2012).

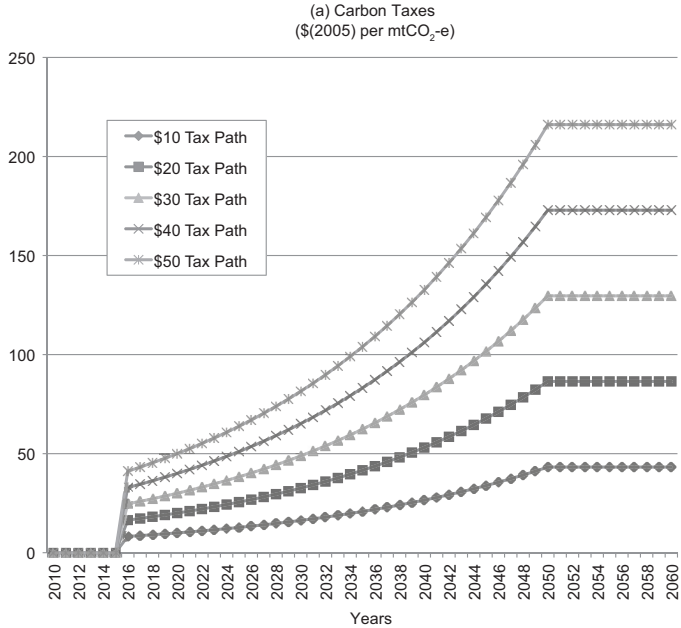
[4] IGEM and the results of these studies are summarized by Jorgenson et al. (2012).

[5] The \$20 and \$30 carbon tax trajectories correspond to tax rates in the range of the prices of tradable permits that we have determined in analyzing cap-and-trade policies for the U.S. Environmental Protection Agency (EPA, 2012a).

[6] Jorgenson and Wilcoxen (1993) have shown that substitution of a carbon tax for a capital income tax in the United States could stabilize emissions while increasing GDP. Goulder (2002) provides a collection of papers on substitutions between environmental taxes and other taxes.

Figure 1

Carbon Taxes and Greenhouse Gas Emissions



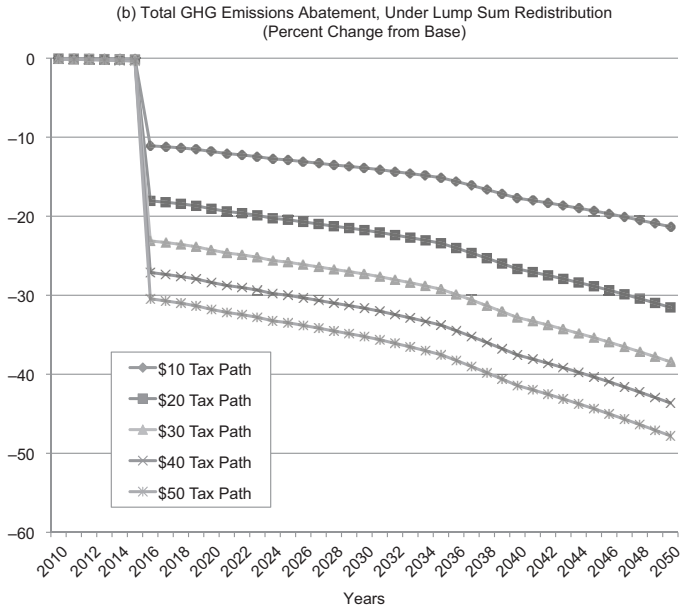
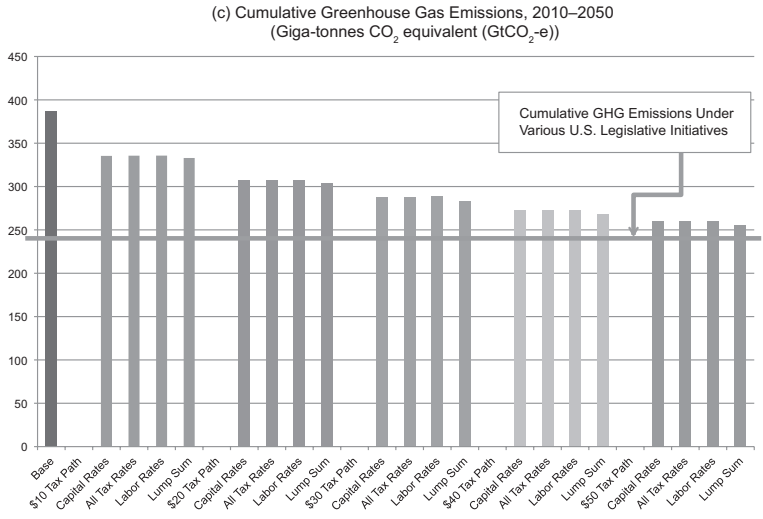


Figure 1, Continued

Carbon Taxes and Greenhouse Gas Emissions



is a measure of economic welfare and we show that the ranking of fiscal alternatives varies with the metric chosen for policy evaluation.[7]

In Section IV we present household and social welfare measures for the five carbon tax scenarios and four options for recycling the revenues — capital tax rate recycling, combined capital and labor tax rate recycling, labor tax rate recycling, and lump sum redistributions to households. Government purchases are held at their base case levels in all of these policy options. We do not provide welfare measures for the remaining options for recycling government revenues, since our model of consumer behavior and the supporting data do not incorporate public consumption.

Section V concludes the paper. We find that levels of emissions control for a given carbon tax level are very similar for different revenue recycling policies. Recycling carbon tax revenues through reductions of capital income tax rates provides the largest margins of economic benefits over the costs of emissions control. Recycling revenues by reducing capital tax rates mitigates the costs of greenhouse gas mitigation by lowering the cost of capital services and increasing the rate of capital formation. This mechanism provides a dramatic illustration of the power of intertemporal general equilibrium modeling in the design of new energy and environmental policies for the United States.

[7] Rausch and Reilly (2012) have analyzed the impacts of a similar menu of carbon tax recycling policies using USREP, a static general equilibrium model of the United States with individual household data from the Consumer Expenditure Survey for 2006. Details on the model are provided by Rausch, et al. (2010).

II. EMISSIONS IMPACTS OF A CARBON TAX

Figure 1b illustrates the potential for emissions abatement associated with carbon taxes. We simplify this representation by giving results only for lump sum redistributions of the tax revenues. We note two features in these annual emissions results. First, there is a large emissions reduction in response to the introduction of a carbon tax in 2016. Much smaller non-price reductions occur earlier, due to the shift away from emissions generating activities that begins immediately in anticipation of the tax.

Second, when pairing the nearly linear patterns of emissions reductions in Figure 1b with the non-linear tax paths of Figure 1a, we see evidence of increasing marginal abatement costs within each tax scenario. We also note the narrowing spread in emissions reductions as the carbon tax regimes become more aggressive. As emissions abatement increases with rising taxes at a decreasing rate, we observe increasing marginal abatement costs across tax scenarios as well.

For comparisons of emissions abatement among the seven options for recycling carbon tax revenues, we focus on cumulative emissions of greenhouse gases over the period 2010–2050 in Figure 1c. We again observe the steepening marginal abatement cost schedules across all carbon tax regimes and all recycling alternatives. More importantly, there is remarkable uniformity in the levels of emissions abatement within each tax regime, despite the important differences in the economic impacts of carbon taxes under the differing policies for recycling the revenues.

The cumulative emissions in our tax cases lie above the quantities achieved in IGEM analyses of various legislative proposals over the past decade (EPA, 2012a). These cap-and-trade quantities are depicted by a representative horizontal line in Figure 1c. Moreover, this represents abatement that was achievable at low carbon price paths in the $10–$20 range. Why do our current emission reductions seem to be so much smaller for the same or higher prices? The answer lies in the absence of lower cost abatement opportunities external to IGEM that were included in our previous analyses. We consider pollution abatement exclusively through adjustments within IGEM — input and output substitution, induced technical change, and altered output levels. Abatement opportunities such as carbon capture and storage, agricultural sequestration, and international trading of emissions permits are not included.

III. PRESENT VALUE METRICS AND FISCAL REFORM

We next consider the evaluation of alternative carbon tax policies. To compare the seven revenue recycling alternatives, we calculate three present-value measures of economic performance. The present value of changes in real GDP is a summary measure of the impact of carbon tax policies on production. The present value of changes in private and public consumption is a summary measure of the impact of carbon tax policies on market consumption. The present value of changes in private full consumption, including goods and leisure, and public consumption, also includes non-market consumption and is closest to a welfare measure of the impact of carbon tax policies.

We provide present-value metrics for each of the policies for recycling tax revenues. For each metric we calculate the present value of the annual differences between the policy case and the base case against cumulative emissions abatement. In calculating the present values we use IGEM's estimated social rate of time preference of 2.63 percent as the discount rate. We present the summary measures for changes in real GDP in Figure 2a. We first observe that the spread across the revenue recycling options is quite large. The best case, capital tax recycling, yields positive measures for all carbon tax levels. These reach as high as $2.6 trillion in 2005 dollars for the $40 carbon tax. The worst case incurs a present-value loss of $24.0 trillion under the $50 carbon tax and lump sum redistribution.

Given the magnitudes of changes in the components of final demand, we find large differences in the impacts on real GDP among the alternative carbon tax trajectories. We also find substantial differences among policy options for recycling the tax revenues. However, since abatement increases under higher tax regimes and is relatively insensitive to the choice of recycling option, we find recycling policies to be more important than the carbon tax rates.

Ranking fiscal alternatives from most to least favorable in terms of impacts on production begins with capital tax rate reductions, followed by combined capital and labor tax rate reductions, and next by labor tax rate reductions. The ranking continues with increasing government purchases, next with decreases in the deficit, then debt reduction and, finally, lump sum redistribution. Only recycling through capital tax rate reductions produces increases in both production and emissions abatement. All of the other recycling options incur present-value losses in real GDP.

Ranking by impact on production separates tax rate reductions from non-tax recycling, with tax reductions clearly outranking non-tax recycling. Capital tax reductions are the preferred mechanism for recycling among the tax options and government purchases incur significantly smaller present-value losses than the other non-tax options. Deficit and debt reduction are only slightly preferred to lump sum distributions.

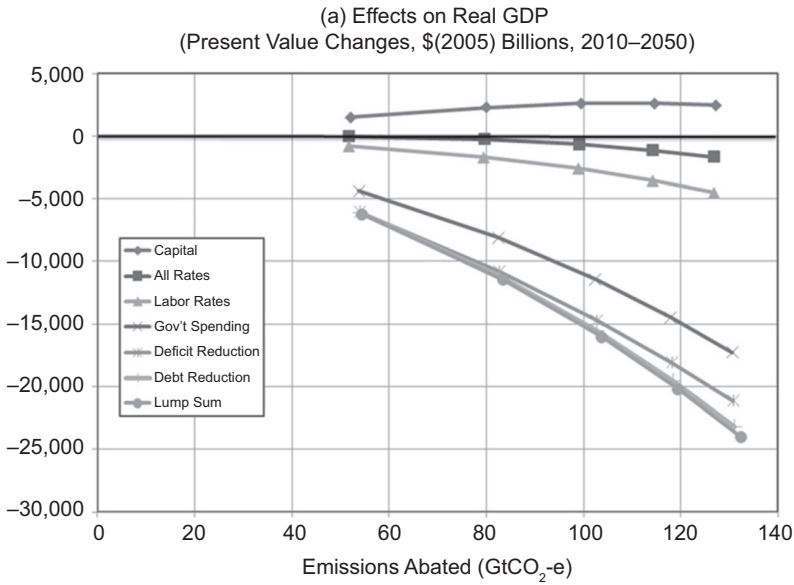
Finally, we note that the benefits are smaller and the costs are larger as the carbon tax regimes increase in severity on the basis of tonnes of pollution abatement. For example, progressing from the $10 to the $50 tax trajectory under capital tax recycling, the gains in real GDP fall from $29 in 2005 dollars per tonne abated to $19 per tonne abated. The corresponding changes when all tax rates are reduced involve losses of $16 to $13. With labor tax recycling the decline ranges from $36 to $15.

For the $10 carbon tax path the losses for the deficit, debt, and lump sum options are $112, $113, and $115, respectively; with the $50 tax trajectory the losses are $162, $177, and $182, respectively. As carbon tax policies become more aggressive, it becomes more difficult for any recycling option to insulate the economy from adverse effects. Moreover, the less favorable the recycling option, the greater is the loss under higher tax trajectories. For the present-value GDP measure, there is no recycling option that outpaces the costs of higher carbon taxes.

The effects of carbon taxes on the present values of market consumption are shown in Figure 2b. These depart dramatically from the production impacts based on the

Figure 2

Economic Impacts of Carbon Taxes



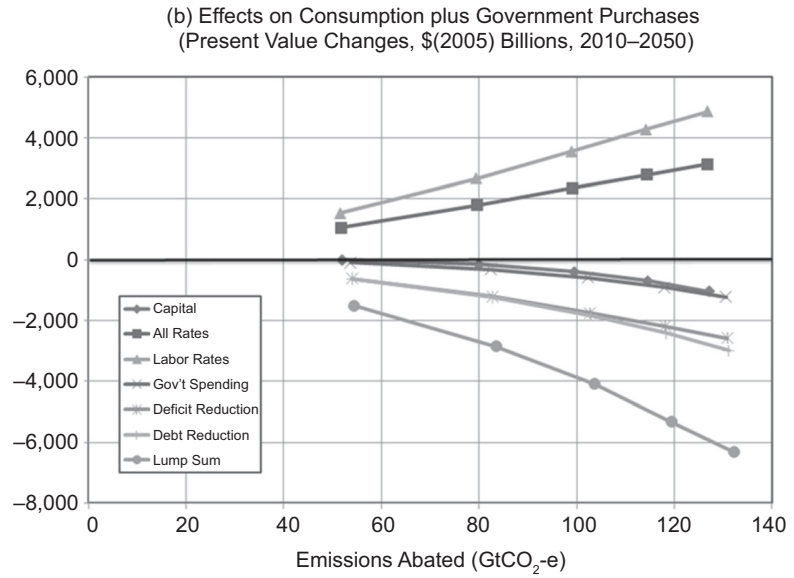
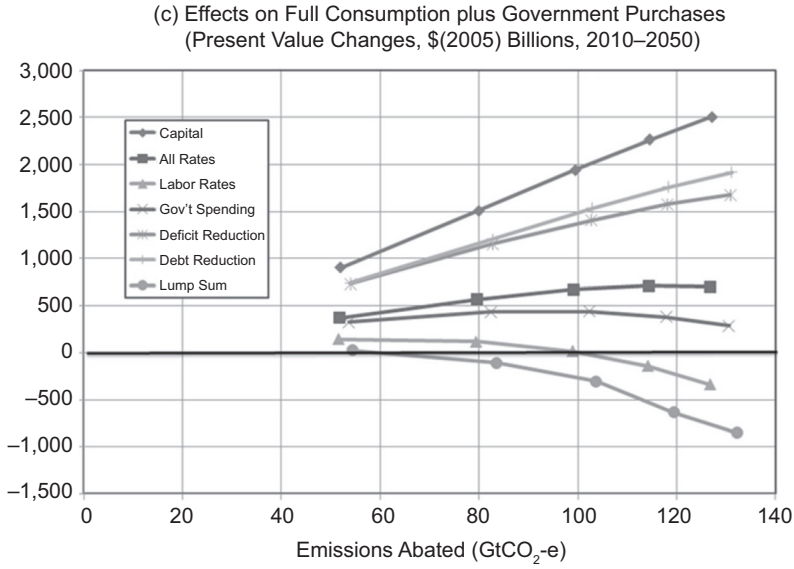


Figure 2, Continued
Economic Impacts of Carbon Taxes



present-value changes in real GDP. For the three tax rate reductions and for lump sum distribution of tax revenues, we assume that there are no changes in government purchases, so that we observe only changes in the present value of private consumption.

Capital tax rate reductions result in small losses in market consumption. However, the labor tax rate reduction and combined tax options increase consumption while reducing greenhouse gas emissions. Under lump sum redistributions we observe losses in market consumption that are proportionally much smaller than the losses in GDP, investment, and exports. Under deficit and debt reduction, the losses in consumption are lessened relative to lump sum redistribution and are partially offset by increases in government purchases. With the government spending option, consumption is crowded out but increased government purchases substantially compensate for the loss.

Comparing alternative tax trajectories, we find that present-value gains in private and public consumption under labor tax rate recycling rise from $1.5 trillion (in 2005 dollars) to $4.9 trillion as we move from the $10 carbon tax trajectory to the $50 trajectory. The corresponding values under combined capital and labor tax recycling are $1.1 and $3.1 trillion, respectively. In these cases, the benefits from the recycling option outweigh the costs of more aggressive tax policies.

Under the remaining revenue recycling options economic losses increase with carbon tax rates and pollution abatement levels. The losses in present value are small with capital tax rate cycling — $6 billion to $1.0 trillion. Allowing additional government

spending yields present-value losses from $97 billion to $1.2 trillion. Losses for deficit and debt reductions range from $625 billion–$630 billion to $2.6 trillion–$3.0 trillion, respectively. The losses from lump sum redistribution are consistently the largest. For the $10 tax trajectory, the present-value of the loss in consumption is $1.5 trillion. This falls to $6.3 trillion under the $50 tax trajectory.

For the present value of full private consumption plus public consumption, the range of gains and losses significantly narrows and the ranking of recycling options changes dramatically. Figure 2c displays these results. While the present value of real GDP changes captures the impacts on production and the present value of changes in public and private consumption captures the impacts on consumption, the inclusion of leisure in private consumption generates a measure that is closer to the gains and losses in welfare discussed in the following section.

In the recycling policy options that increase private consumption — labor tax rate reductions and reductions in the combined capital and labor tax rates — leisure demand decreases. Under some recycling options, losses in consumption are offset by gains in leisure. Under capital tax recycling, there are ultimately gains in both consumption and leisure. Combining changes in private full consumption with changes in government purchases, where permitted by recycling policy, leads to the following ranking of the policy options: capital rate reduction, debt reduction, deficit reduction, combined capital and labor tax rate reductions, government purchases, labor tax rate reductions and, finally, lump sum redistributions.

Gains in the present value of changes in full private consumption and public consumption are common outcomes in these simulations of IGEM. Lump sum recycling of revenues exhibits a modest gain for the $10 carbon tax trajectory. Labor tax rate recycling produces gains for the $10, $20, and $30 carbon tax trajectories, generating losses under the $40 and $50 schedules. For all other combinations of carbon tax policies and recycling arrangements, this full private plus public consumption measure is positive and often rising with increasing emissions abatement.

The gains for private full consumption plus government purchases are bracketed by the capital rate reduction and lump sum redistribution policy options. From the $10 to $50 carbon tax trajectories under capital tax rate recycling, the gains for full consumption plus government purchases rise from $902 billion in 2005 dollars to $2.5 trillion. The debt and deficit options yield gains that are lower but still substantial — $730 billion to $740 billion and $1.7 trillion to $1.9 trillion, respectively. Under lump sum recycling, this measure falls from a gain of $27 billion to a loss of $854 billion.

In this section we have demonstrated that the rankings of recycling alternatives under the present-value metrics of changes in production and consumption do not coincide. Neither ranking matches the ranking by present value of full private consumption plus government purchases, which is closest to our preferred measure of welfare. These differences indicate that rankings by the present-value metrics should be used only with caution in assessments of alternative energy and environmental policies.

IV. WELFARE IMPACTS OF A CARBON TAX

The household model in IGEM enables us to establish a link between consumer behavior and the measurement of individual welfare.[8] We derive an expenditure function for each household type that depends on prices and the level of individual welfare. Individual welfare is a function of the entire time trajectory of full consumption of the household. The expenditure function expresses full wealth, defined as tangible assets plus the household time endowments, as a function of prices and the level of individual welfare.

We express the impact of a change in energy and environmental policy on individual welfare as the equivalent variation in full wealth. This answers the question, how much is the increase of full wealth at base case prices required to generate the same gain in individual welfare as the proposed change in policy? This is the monetary equivalent of the change in individual welfare from the base case to the alternative case involving a change in policy. The equivalent variation can be applied to any number of alternative policies and preserves the ordering of these policies in terms of their impacts on individual welfare.

In this section we evaluate four of the alternative recycling options in terms of their impacts on individual household and social welfare. Measures of individual welfare depend on the demographic characteristics of households. These are defined by size (numbers of children — 0, 1, 2, or 3 or more — and adults — 1, 2, or 3 or more), region of residence (Northeast, Midwest, South, or West), race and gender of head (white, nonwhite, male, or female), and location (urban or rural). These combinations yield 384 possible household types of which only 244 are represented in the most recent Consumer Expenditure Survey (CEX) sample used in estimating the unknown parameters of our model of household behavior.

To summarize the distributions of changes in household welfare, we form population-weighted averages for each combination of the household characteristics. These are shown in Figure 3 for the $20 carbon tax trajectory and the four revenue recycling options — capital rate recycling only, combined capital and labor rate recycling, labor rate recycling, and lump sum redistributions. The findings are robust to changes in the carbon tax rates. However, it is important not to misinterpret these summary measures as indicators of social welfare.

Under capital tax rate reductions, combined tax rate reductions and labor tax reductions, we find that households with fewer adults improve in average individual welfare. For lump sum recycling this relationship reverses and we find that households with more adults improve in welfare. For a given number of adults those with fewer children generally fare better across all four recycling options.

For capital rate reductions, combined tax rate reductions, and lump sum recycling, the regional ranking, most to least favorable, is West, Northeast, Midwest, and South.

[8] The household model in IGEM is presented by Jorgenson, Jin, Slesnick, and Wilcoxen (2012). Measures of the distributional impact of climate policy are presented by Jorgenson, et al. (2010).

Figure 3

Household Welfare Impacts of Carbon Taxes

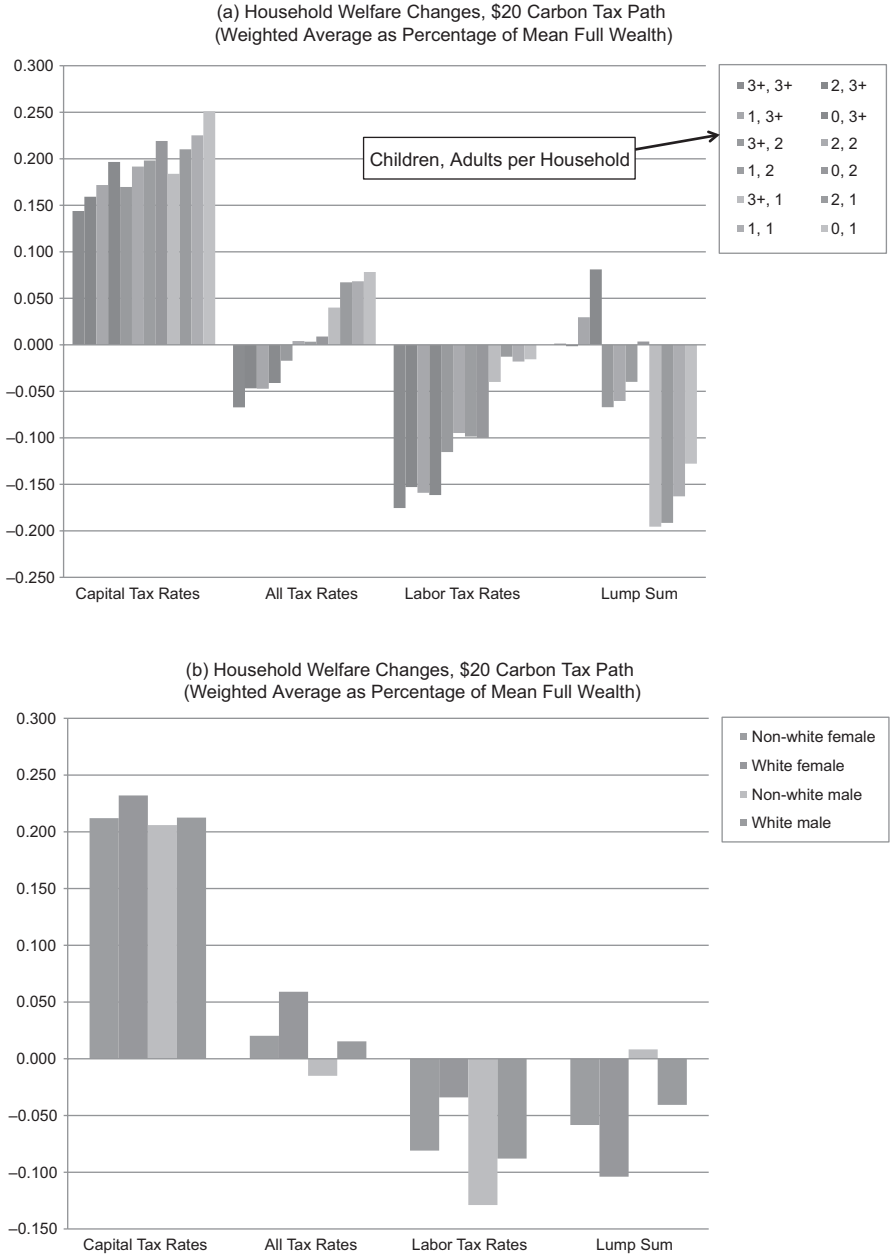
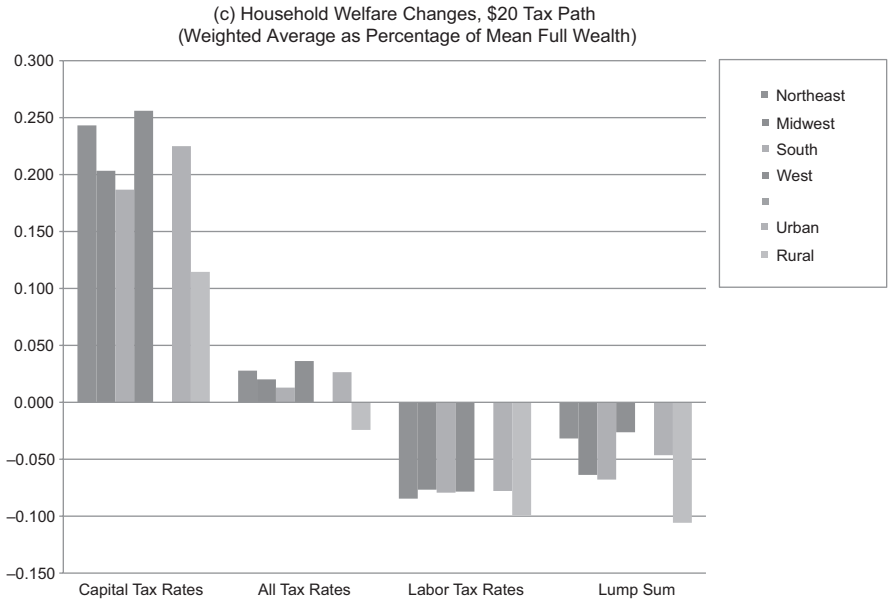


Figure 3, Continued
Household Welfare Impacts of Carbon Taxes



With labor tax reductions, this ranking appears as Midwest, West, South, and Northeast. With capital, combined capital and labor tax policies, households headed by females or whites fare better than those headed by males or non-whites; under the lump sum arrangement, this reverses. In all cases, households located in urban areas are better off under a carbon tax than those located in rural areas.

Our model of household behavior defines a measure of individual welfare as a function of the trajectory of full consumption for the household. In order to evaluate alternative energy and environmental policies, we combine measures of individual welfare for all households by means of a social welfare function. Social welfare increases with an increase in individual welfare for each household. Transfers from richer to poorer households also increase social welfare. We consider social welfare functions for two extreme assumptions about society's aversion in inequality. The egalitarian view gives the greatest weight to inequality while the utilitarian view gives the least weight to inequality.[9]

We translate social welfare comparisons among policies into monetary equivalents by means of a social expenditure function that expresses full wealth for society as a whole in terms of prices and the level of social welfare. Full wealth is defined as tangible assets for society as a whole, plus time endowments for all households. We

[9] More detail is provided in chapters and 3 and 8 of Jorgenson et al. (2013).

express the impact of a change in energy and environmental policy on social welfare as the equivalent variation in full wealth. This shows how much full wealth would have to increase at base case prices in order to generate the same increase in social welfare as the change in policy.

The egalitarian and utilitarian measures for social welfare are presented graphically in Figure 4. We divide the equivalent variation in social welfare into components due to a change in equity and a change in efficiency. We define the change in efficiency as the change in social welfare under a perfectly egalitarian distribution of full wealth. Equivalently, this is the maximum social welfare achievable through a reallocation of full wealth. This equalizes individual welfare for all households and is independent of the actual distribution of full wealth among households as well as society's aversion to inequality. The change due to equity is the difference between the efficiency change and the actual change in social welfare. Changes in social welfare and in equity depend on the social welfare function.

Capital tax recycling is welfare improving under both views of aversion to inequality. Moreover, the improvements in welfare increase with increasingly aggressive carbon tax structures — $2.2 trillion to $5.4 trillion in the egalitarian case, and $2.6 trillion to $6.5 trillion in the utilitarian case, expressed in 2005 dollars. These are large in absolute terms but, like their household counterparts, are small proportions of economy-wide full wealth — in the range of 0.2 to 0.4 percent. As before, the benefits from this recycling option more than compensate for the economic costs of the carbon taxes. The gains occur in terms of both the total and efficiency measures of welfare change. The gains in social welfare are not as large under the egalitarian view as society's aversion to inequality weights the adverse equity effects more heavily.

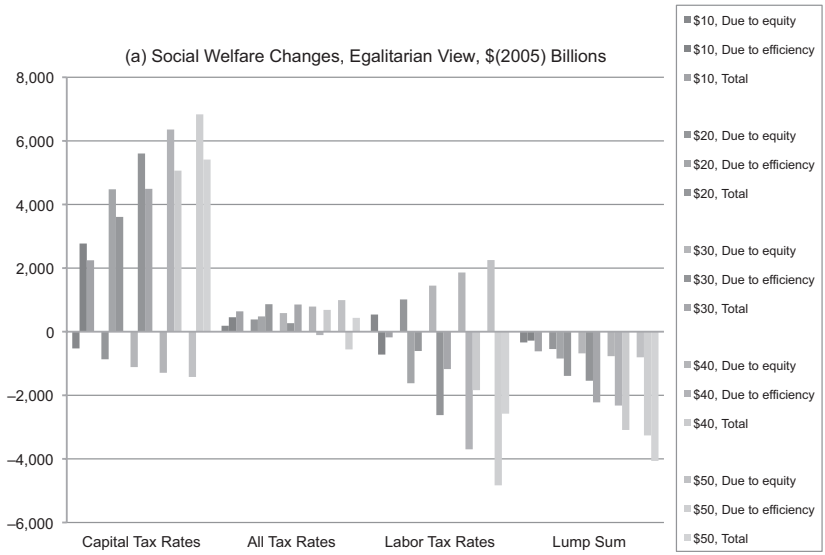
Combining capital and labor tax reductions is welfare improving under both views of equality. There are rising efficiency gains for the lower two carbon tax paths but these begin to erode under the $30 schedule and become efficiency losses for the two higher tax paths. The equity change has a higher value in the egalitarian case, leading to larger offsets to efficiency. In this case, the welfare changes are higher when society values equity more, for example, $436 billion versus $6 billion under the $50 rates.

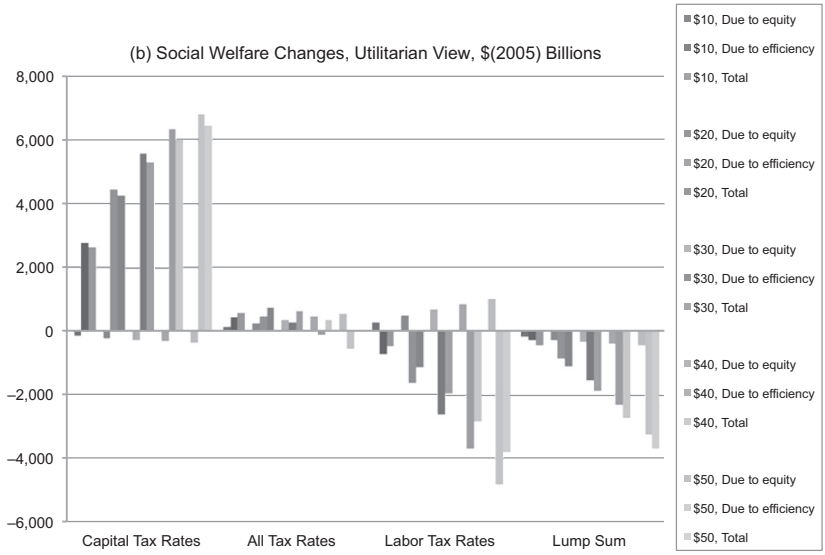
Labor tax recycling unambiguously involves welfare losses — $0.2 trillion to $2.6 trillion and $0.5 trillion to $3.8 trillion under the two societal views. The fiscal policy rankings under the egalitarian view are consistent with those in Figure 2c — capital followed by combined, labor, and then lump sum. There is a large equity increase in welfare under the egalitarian view, offsetting the large efficiency losses, but only a small equity change under the utilitarian view. As a result, the labor tax appears slightly inferior to lump sum redistribution as a utilitarian recycling mechanism.

Under lump sum redistribution, the efficiency losses in welfare are smaller than those in the labor tax case. Losses in consumption are partially compensated by gains in leisure. The efficiency losses are reinforced by equity changes, more so under egalitarianism and less so under utilitarianism. In the end, the overall losses in welfare compared to those of labor tax recycling are much larger under the egalitarian rule, by 3.5 to 1.5 times as tax schedules rise.

Figure 4

Social Welfare Impacts of Carbon Taxes





V. SUMMARY AND CONCLUSION

In this paper we have analyzed five trajectories for carbon tax rates — $10, $20, $30, $40, and $50 in 2005 dollars per metric tonne of carbon dioxide equivalent. We have considered seven options for the use of this tax revenue: (1) reducing capital tax rates; (2) proportionally reducing capital and labor tax rates; (3) reducing labor tax rates; (4) increasing federal, state, and local government purchases; (5) deficit reduction; (6) debt reduction; and (7) lump sum redistribution to households. As the carbon tax rates increase, we find cumulative abatement increasing at a decreasing rate.

We focus on the market consequences of the carbon tax and recycling policies. We do not consider the avoided damages and climate benefits that would accompany such policies. We use three present value metrics to summarize the economic impacts of carbon tax trajectories and revenue recycling options. We have compared all seven carbon tax recycling options in terms of present-value metrics reflecting production, market consumption, and real full consumption plus government purchases. None of these measures corresponds to changes in social welfare.

For the production measure we obtain the following ranking of recycling options from most to least favorable: capital tax rate reduction, capital and labor rate reductions, labor rate reduction, government purchases, deficit and debt reductions, and lump sum distributions. The consumption measure produces the following ranking: labor tax rate reduction, capital and labor tax rate reductions, capital rate reduction, government purchases, deficit and debt reductions, and lump sum distribution. For the full consumption measure, the ranking is capital rate reduction, debt and deficit reductions, capital and labor rate reductions, government purchases, labor tax rate reduction, and lump sum distributions.

In order to evaluate alternative carbon tax policies we provide measures of individual and social welfare for capital and labor tax rate reductions and lump sum distributions. For alternative tax rate trajectories and recycling options, we find both welfare improvements and welfare losses among households. At low carbon tax rates all household types gain in welfare under capital tax rate recycling, while at higher tax rates there are only losers under labor rate tax recycling. Lump sum distributions are not unambiguously the worst recycling option for carbon tax revenues, contrary to much conventional wisdom.

Reductions in capital tax rates provide the greatest improvements in social welfare of all carbon tax rate trajectories. For both egalitarian and utilitarian social welfare functions, gains in efficiency from capital tax rate reductions greatly exceed the relatively modest costs in lost equity. Substantial emissions reduction is accompanied by welfare gains from capital tax rate reductions, providing a "double dividend" from carbon tax policies. Cuts in capital income tax rates reduce the cost of capital and increase the rate of capital formation, mitigating the costs of climate control.

On a proportionate scale the gains and losses from carbon taxes are small. For households, the gains or losses are in the tens of thousands of dollars relative to millions in full wealth. Urban households fare better than rural ones. Under capital, combined,

and lump sum recycling, the regional ranking from best to worst is West, Northeast, Midwest, and South; under pure labor recycling, it is Midwest, West, South, and Northeast. For a given number of adults in a household, having fewer children is generally welfare improving. Under lump sum recycling, households with more adults, headed by non-whites or headed by males, fare better whereas we find the opposite under the three tax rate alternatives.

We have provided measures of the impacts of carbon taxes on individual and social welfare, production, market consumption, and the sum of private full consumption and public consumption. These can serve as a guide to the trade-offs between carbon taxes and other changes in government revenues and expenditures associated with fiscal reform. The results demonstrate the substantial margin of benefits over costs made feasible by appropriate policy design, even without incorporating the benefits of emissions abatement.

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DISCLOSURES

The authors have no financial arrangements that might give rise to conflicts of interest with respect to the research reported in this paper.

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