The Carbon Tax: Analysis of Six Potential Scenarios

Capital Alpha Partners, LLC
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Capital Alpha Partners, LLC (Capital Alpha) is a non-partisan policy research firm providing independent research and analysis. Capital Alpha was engaged by the Institute for Energy Research to examine the economics of proposed carbon tax models and how those models fit into current and evolving U.S. policy on energy, the environment and taxation, with a particular emphasis on corporate taxation. Capital Alpha used government data only in its review and employed standard macroeconomic analytical tools and its own independent expertise. The results reflect the findings of the economic models and the professional opinions of the authors, not the institutional views of Capital Alpha or any other party. Compensation paid to Capital Alpha for its services was not contingent upon any particular outcome or finding. Capital Alpha does not engage in lobbying nor any other effort to influence public policy or legislation on any entity's behalf. This analysis is for private circulation and distribution in its entirety; it is provided for information purposes only. Capital Alpha makes every effort to use reliable, comprehensive information, but we do not represent or warrant that it is accurate or complete. Capital Alpha has no obligation to update its opinions or the information in this publication. James Lucier, Kathryn May, Alan McCormick, and other Capital Alpha team members contributed to this report. Econometric modeling was performed by the DC Group, Inc.

Some tables have been updated to correct production errors.

Executive Summary

We present a macroeconomic analysis of current representative carbon tax proposals considered as if they were actual legislative proposals before Congress and scored using scoring conventions similar to those used by the Joint Committee on Taxation (JCT), the Congressional Budget Office (CBO) and the U.S. Treasury Department Office of Tax Analysis (Treasury).

We model six carbon tax scenarios. Two are carbon taxes that begin at a set rate and increase annually. These taxes begin at $40 and $49 dollars per metric ton of CO_2 and increase annually by 2%. Four are carbon taxes that phase in over time to a terminal value. These are taxes with terminal values of $36, $72, $108, and $144 per ton. All are in constant 2015 dollars.

A special focus of our study is the role of a carbon tax as a revenue raiser in pro-growth tax reform. There have been many suggestions that a “tax swap” of growth-oriented tax cuts financed by a carbon tax could produce incremental economic growth. We find that this premise would be difficult to achieve using standard scoring conventions. We also examine the possibility of a tax-for-regulatory swap in which a carbon tax would replace all existing regulation and still allow the United States to meet its obligations under the Paris Agreement. We find this premise difficult to achieve as well. A carbon tax would reduce emissions but could still only achieve Paris Agreement obligations as a part of a comprehensive carbon mitigation plan. This is in agreement with World Bank and International Energy Agency (IEA) conclusions and is consistent with the Treasury’s own modeling.

In particular, we find that:

- **A carbon tax is not an efficient revenue raiser for tax reform**. Using standard scoring conventions and assuming that Congress would protect tax payers in the lowest two income quintiles from a tax increase, a carbon tax produces net revenue available for tax reform of only 32 cents on the dollar. Net revenue decreases still further when considerations such as federalism and revenue sharing come into play.

- **A carbon tax pushes static costs and revenue burdens on to the states and local government.** Based on JCT and CBO estimates, we find that static costs and revenue burdens equal to 11% of federal gross revenues from a carbon tax would flow through to the states and local government. In the scenarios we study, the average annual burden on the states and local government during the first 10 years of the tax would range from $18.9 to $30.6 billion in constant 2015 dollars. Dynamic revenue losses to the states and local government could make the total costs higher.

- **No carbon tax we model is consistent with meeting long-term U.S. obligations under the Paris Agreement as a standalone policy.** Two scenarios, phased-in taxes of $72 and $108 per ton, are capable of meeting the U.S. minimum Intended Nationally Determined Contribution (INDC) for 2025. Other scenarios achieve meaningful reductions, but all are far off the trajectory Paris requires by 2040, a finding which is also consistent with World Bank and IEA estimates.

- **Vertical tax competition impedes infrastructure development.** Historically, all excise taxes collected on motor fuel at the federal and state level have gone to the states to finance transportation infrastructure. A federal carbon tax would raise 38% of its revenues from motor fuels. Without revenue sharing, none of this would go to the states. The federal government would collect the majority of excise tax revenues from motor fuel. All incremental revenue would go to the federal government, and states would likely be pre-empted from raising their own motor fuel taxes to finance highway construction for a period of years.

- **Carbon tax-financed tax reform is unlikely to be pro-growth.** Most tax reform and tax swap scenarios modeled lead to reduced GDP relative to the reference case for the entirety of our 22-year forecast period. Better than break-even economic performance with revenue-neutral tax reform may not be possible under standard scoring conventions unless distributional concerns are completely ignored, and low-income taxpayers bear the cost of corporate tax relief.

- **Depressed GDP leads to long-term fiscal challenges.** Small but persistent reductions in GDP relative to the no-tax reference case over a period of many years lead to trillions of dollars in lost production, with challenging implications for federal, state, and local government finances. Sensitivity analyses of the *Budget of the United States Government* conducted by the Office of Management and Budget (OMB) underscore the cost of even temporary, cyclical losses.

We consider five simple revenue-recycling strategies and three mixed revenue-recycling strategies. The simple revenue-recycling strategies direct all net revenue to a single tax reform or tax swap proposal. The mixed revenue-recycling strategies simulate a Congressional exercise in tax reform in which available net revenue is directed to more than one policy option. We find that break-even or slightly better performance relative to the no-tax reference case requires the majority of, if not all, net revenue from the carbon tax to be directed to corporate tax reform, regardless of the regressive impact this would have on lower-income taxpayers. Such tax reform may also require larger corporate tax cuts than are truly revenue-neutral given scoring constraints.

A review of studies from the World Bank and IEA put the carbon taxes we model into a global context. The carbon taxes we examine, if enacted, would be the highest economy-wide carbon taxes in the world. They would raise average annual revenues of up to nine times the total amount of carbon-related revenues collected worldwide in 2017 during their first 10 years.

In our study, we rely on standard data and projections from government sources only. These sources include the IEA, World Bank, Organization for Economic Cooperation and Development (OECD), JCT, CBO, Office of Management and Budget (OMB), Energy Information Administration (EIA), Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), and Census Bureau. We perform our economic modeling with a commercial macroeconomic model that has been widely used for public-sector forecasting at the state and local level for decades. We estimate carbon tax revenues raised and carbon emissions reduced using an open-source model developed by a state government to assist in the implementation of a carbon tax.

1. Introduction

In this study, we present a macroeconomic analysis of current carbon tax proposals considered as if they were actual legislative proposals before Congress and scored using conventions similar to those used by the Joint Committee on Taxation (JCT), the Congressional Budget Office (CBO) and the U.S. Treasury Department Office of Tax Analysis (Treasury).

We consider economy-wide carbon taxes that begin at $40 and $49 per ton of CO_2 and increase annually as well as carbon taxes that phase in to terminal values of $36, $72, $108, and $144 per ton.[1] All quantities expressed are in constant 2015 dollars unless otherwise noted. We model a carbon tax that would take effect in 2019 and extend over the 22-year period through 2040. We estimate the amount of carbon emissions reduced by each tax and the amount of net revenue generated for the federal government. We also compare federal revenues from the carbon tax to state and local government revenues from income, general sales, and excise taxes. In our modeling, we estimate the effects of various tax reform, tax swap, and tax-for-regulatory swap strategies. Our results are as follows:

- A carbon tax is not an efficient revenue raiser for tax reform since the maximum static net revenue available for tax reform is only 32 cents on the dollar if taxpayers in the lowest two income quintiles are to be protected from a tax increase. With no set-aside for low-income taxpayers, the amount of net revenue available for tax reform rises to 59 cents on the dollar.

- A carbon tax would push static costs and revenue losses equivalent to 11% of gross revenues through to the states and local government.[2] Under the scenarios we study, this would amount to between $18.9 and $30.7 billion per year. Dynamic losses to state income and general sales taxes would push these costs higher.

- The carbon tax scenarios we model would reduce carbon dioxide emissions by as much as 563 million tons per year within 10 years of enactment. They would also be the largest economy-wide carbon taxes in the world. However, none of them is capable of meeting long-term U.S. obligations under the Paris Agreement as a standalone policy.

- A federal carbon tax would introduce vertical tax competition to federal and state excise taxes on motor fuel and impede state efforts to finance new transportation infrastructure. Currently, the bulk of all motor fuel revenue is raised by the states, and all of it eventually goes to the states for infrastructure spending. A federal carbon tax in the scenarios we study would divert the bulk of motor fuel revenues to the federal government, effectively doubling taxes on motor fuels with no new revenue allotted to the states. The federal tax increase would likely preclude state options to raise motor fuel taxes for a period of years.

[1] Throughout the paper, we use the term "per ton" tax to reference a tax rate per metric ton of CO_2 or CO_2-equivalent (CO_2-e) as appropriate.
[2] References to "state government" may include "state and local government" as appropriate.

- Tax reform that produces positive economic growth (of between 36 and 92 basis points relative to the reference case over 10 years depending on the amount of tax) in our modeling requires 75% of gross revenues to be recycled as corporate tax relief. This amount of gross revenue is in excess of the actual net revenue likely to be available after standard offsets are taken into account.

- A tax swap that recycles 75% of gross revenue by returning it to taxpayers as a lump-sum rebate results in persistent economic underperformance over the entire 22-year forecast period. GDP is reduced by between as much as 1.07% and 1.67% relative to the reference case at the beginning of the forecast period, depending on the amount of tax, and gradually recovers over time. However, the production lost in the interim is never recovered.

- Revenue recycling by means of a lump-sum rebate results in lost GDP equal to between $1.88 trillion and $2.75 trillion in constant 2015 dollars over a standard 10-year budget period and between $3.76 trillion and $5.92 trillion over the entire 22-year forecast period.

- Recycling 75% of gross revenue through personal tax relief and infrastructure spending produces similar results.

- Measured in net present value terms as a percentage of reference-case 2019 GDP, revenue recycling by means of a lump-sum rebate results in losses of between 6.99% and 11.0% over a 10-year period, and 13.3% and 16.9% over the full 22-year forecast period.

- Persistent economic underperformance over a period of many years would have negative consequences for federal, state, and local government finances. In a sensitivity analysis prepared by the White House Office of Management and Budget (OMB) for the Fiscal Year 2018 Budget of the United States, OMB estimates the cost of losing one percentage point of anticipated GDP at the beginning of its 10-year forecast period to be $809 billion in increased debt that results from a combination of decreased revenues and increased outlays over that time.[3]

1.1 Methodology

In this study we attempt to use data, tools, and methodology similar to those used by a government scorekeeping agency.

[3] White House Office of Management and Budget, "Budget of the United States Government, Fiscal Year 2018", distributed by U.S. Government Publishing Office, May 23, 2017. See "Analytical Perspectives," pp. 15-16, Table 2-4, "Sensitivity of the Budget to Economic Assumptions."

- We follow the practice of the JCT, CBO, and Treasury in using a 25% offset to estimate the difference between gross and net receipts from an excise tax.[4]

- We follow scoring determinations made by CBO in its analysis of the Waxman-Markey bill and related legislation in 2009.[5] These provide an estimate of the increased direct and indirect energy costs resulting from a carbon tax to federal state and local government (13% of gross revenues) and the amount of revenue needed to protect taxpayers in the lowest two income quintiles from a tax increase (27% of gross revenues).

- We present results in a 10-year budget window to reflect Congressional scoring requirements as well as in a long-term forecast.

- We consider intergovernmental effects and transfers such as the impact of a carbon tax on state and local government.

The study relies on standard data and projections from government sources including the IEA, World Bank, Organization for Economic Cooperation and Development (OECD), JCT, CBO, OMB, Energy Information Administration (EIA), Bureau of Labor Statistics (BLS), and Census Bureau. Data come from government or intergovernmental sources only.

We perform our macroeconomic modeling with the PI+ model from Regional Economic Models, Inc, (REMI), a commercial macroeconomic model that has been widely used for forecasting at the state and local level for decades.[6] The REMI PI+ model has been used with different inputs and assumptions in studies that find positive growth effects from fee-and-dividend or lump-sum rebate revenue recycling.[7] Our modeling was done before the tax reform of 2017, and we discuss how the tax changes of 2017 might affect our specific results in Section 4. Our broad policy conclusions are not affected. There is no impact on portions of the study which do not draw on macroeconomic analysis, such as static offsets, cost burdens passed through to the states, tax-for-regulatory swaps, and vertical tax competition. We model carbon dioxide emission reductions and tax revenues using the Carbon Tax Assessment Model (CTAM), a model developed by the State of Washington to support its own efforts to implement a carbon tax and made available to the public on an open-source basis. We cross-check our results and estimates where possible against results and estimates from JCT, CBO, and Treasury.

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[4] See Congressional Budget Office, "The Role of the 25% Revenue Offset in Estimating the Budgetary Effects of Legislation, January 13, 2009. See also discussion in Appendix C.

[5] See Congressional Budget Office, "Cost Estimate H.R. 2454 American Clean Energy and Security Act of 2009," June 5, 2009; Congressional Budget Office, "The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454," June 19, 2009; and Congressional Budget Office, "The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions," September 2009.

[6] See *infra,* notes 45 and 46.

[7] See, for instance, Nystrom, Scott and Patrick Luckow, "The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax," Regional Economic Models, Inc. and Synapse Energy Economics, Inc. for Citizen's Climate Lobby, June 9, 2014.

1.2 Carbon Tax Scenarios

The study considers six carbon tax scenarios. Two are based on recent, highly visible proposals. Four are generic proposals linked to a proxy for the social cost of carbon.

The study considers carbon taxes that start at $40 and $49 per ton of CO_2 and increase annually by 2% in real terms. These are similar but not identical in their particulars to proposals made by the Climate Leadership Council and Treasury.

- The Climate Leadership Council (CLC) has proposed a carbon tax of $40 per ton of CO_2, increasing at 2% per year in real terms.[8] The proceeds would be rebated back to the public in a tax swap. The tax would include a border adjustment mechanism, so that exports would be free of tax while imports would be taxed. Upon implementation, the tax would replace all existing greenhouse gas regulations in a tax-for-regulatory swap.[9] We model a tax of $40 per ton with a lump-sum rebate revenue-recycling strategy that resembles the CLC plan.

- The U.S. Treasury Department has presented a working blueprint for a carbon tax of $49 per ton of CO_2, also increasing at 2% per year in real terms.[10] The Treasury study presents a static revenue analysis, a distributional analysis, and estimates of reductions in greenhouse gas emissions. We model a $49 per ton tax similar to the one presented by Treasury.

The four generic proposals reflect taxes that are phased in to a terminal value over time. The phase-in reflects a policy option for Congress to introduce new taxes gradually rather than all at once. The generic proposals are set at multiples of a proxy for the social cost of carbon set at $36 per ton of CO_2 in 2015 dollars.[11] The carbon price is deliberately chosen to be conservative rather than aggressive. The taxes are phased in to reach terminal values of $36, $72, $108, and

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[8] Made available by the Washington State Department of Commerce at https://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/.

[9] See Martin S. Feldstein, Ted Halstead, and N. Gregory Mankiw, "A Conservative Case for Climate Action, The New York Times, February 8, 2017; George P Schultz, and James A. Baker, III, "A Conservative Answer to Climate Change," The Wall Street Journal, February 7, 2017; and Climate Leadership Council website, clcouncil.org.

[10] John Horowitz, Julie-Anne Cronin, Hannah Hawkins, Laura Konda, and Alex Yuskavage. *Working Paper 115: Methodology for Analyzing a Carbon Tax*. U.S. Department of Treasury Office of Tax Analysis. Treasury.gov. Originally published January 2017. (Accessed August 17, 2018.)

[11] We set a proxy for the social cost of carbon or the social cost of greenhouse gases that is lower than the levels recommended by the U.S. Government's Interagency Working Group on the Social Cost of Greenhouse Gases in August 2016. These recommendations are now under review by the Trump administration. Some analysts may prefer that higher numbers be used. We chose a proxy at a lower level that is fixed in time in order to simplify analysis, make the effect of taxes that phase in over time more visible, ease comparisons between taxes set at a multiple of our proxy, and generally choose conservative over aggressive estimates, with an emphasis on moderate proposals that Congress might be more willing to consider than others. For reference see, Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, August 2016. https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf

$144 per ton of CO_2. The phase-in periods are roughly proportional to the size of the tax. The terminal value of the carbon price stays constant once fully phased in. The six carbon tax scenarios modeled in this study are summarized in Table 1.2-1.

Table 1.2-1: Carbon Tax Scenarios

Tax	Type	Step
$40/ton	Annual Increase	2% real
$49/ton	Annual Increase	2% real
$36/ton, roughly 1x SCC	Phase-in, terminal value	two-year phase-in
$72/ton, roughly 2x SCC	Phase-in, terminal value	five-year phase-in
$108/ton, roughly 3x SCC	Phase-in, terminal value	10-year phase-in
$144/ton, roughly 4x SCC	Phase-in, terminal value	20-year phase-in

We model two carbon tax scenarios with an annual step of 2% in real terms and four tax scenarios that phase in to a terminal value. Values in 2015$.

1.3 Modeling

The study considers options for tax reform, tax swaps, and tax-for-regulatory swaps.

We begin by creating an emissions baseline that is consistent with withdrawal from the Clean Power Plan (CPP) and a tax-for-regulatory swap in which carbon emission regulations are replaced by a carbon tax. We use fossil fuel consumption projections from the No CPP case of the EIA Annual Energy Outlook 2016 to generate a fuel-related emissions baseline with the Carbon Tax Assessment Model (CTAM). We then use CTAM to model carbon emission reductions and gross revenues raised by each carbon tax scenario over the period 2019 to 2040. This allows us to evaluate whether a tax-for-regulatory swap could meet U.S. obligations under the Paris Agreement, and to estimate static cost burdens that are passed through to state and local government.

We next model simple revenue-recycling strategies in which the entirety of available net revenue is recycled in a single way. We use CTAM data on tax revenues raised and process them through the PI+ model. The study provides macroeconomic results for revenue recycling through corporate tax relief, debt reduction, infrastructure spending, a taxpayer rebate, and individual tax relief. This provides a preliminary basis for evaluating tax swaps and tax reform.

The third step is to consider mixed revenue-recycling strategies that would more closely approximate an actual Congressional exercise in tax reform. The mixed recycling strategies are 50/50 taxpayer rebate and corporate tax relief; low-income tax relief, infrastructure spending, and corporate tax relief; and finally, low-income tax relief, infrastructure spending, and additional tax relief split equally between corporate and middle-class tax relief. The mixed strategies offer more granular insight into tax swaps and tax reform.

We also consider the burden on government finances that results from long-term economic underperformance. For Fiscal Years 2010 through 2018, OMB prepared annual sensitivity analyses showing the possible 10-year impact of reduced economic growth on government outlays and receipts. The OMB analyses suggest that sustained, below-trend growth could have severe consequences, possibly adding trillions of dollars to the public debt over time.[12]

1.3.1 Net Revenue Available for Revenue Recycling

Revenue recycling occurs when tax reform or a tax swap is paid for by using receipts from a carbon tax. In order to present the strongest possible results for tax reform or a tax swap paid for by a carbon tax, this study recycles 75% of gross revenues. The only discount applied is the standard 25% JCT offset used to estimate static net revenue from an excise tax. In practice, much less than 75% of gross revenues would be available for revenue-neutral pro-growth tax reform. An important finding of this study is that static revenue offsets present a significant obstacle to tax reform financed by a carbon tax even if the dynamic effects of a carbon tax are not considered.

In general, offsets reduce the amount of gross revenue that is available on a net basis for tax reform. Tax reform that spends more than the available revenue is not revenue-neutral. The difference would need to be made up with higher taxes elsewhere, which can occur on either the federal or state level in this this study. Otherwise, the federal government will run a deficit, or state governments may run afoul of balanced budget requirements and find their credit ratings in jeopardy unless they raise taxes of their own.

In this study, we identify JCT's 25% offset as the absolute minimum offset that can be applied in theory. We also identify several other offsets that Congress is likely to observe in practice.

- CBO estimated in 2009 that a carbon tax would increase direct and indirect energy costs to federal state and local government by 13 to 14%.[13] In order for tax reform to be revenue-neutral, that increased cost would need to be offset by higher taxes or reduced spending elsewhere. As we will see, the states in particular are likely to be forced into a tax increase if Congress does not offset the increased energy costs in its own budget.

- Congress is not likely to pass a tax with regressive impact on the poor and working families without taking some measure to protect low-income taxpayers from a tax

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[12] White House Office of Management and Budget, "Budget of the United States Government" annual editions for Fiscal Years 2010-2018, "Analytical Perspectives" section.

[13] See, for instance, Congressional Budget Office, "Cost Estimate H.R. 2454 American Clean Energy and Security Act of 2009," June 5, 2009; and Congressional Budget Office, "The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454," p. 5; Congressional Budget Office, "The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions," p. 21. Note, CBO also states direct and indirect costs to all levels of government would be 14%, "Estimated Costs," p. 12. In order to adopt the more conservative estimate, this study uses the 13% figure.

increase. CBO has estimated that in order to hold taxpayers in the lowest two income quintiles harmless, Congress would need to set aside 27% of gross revenues.[14]

- An excise tax reduces income tax revenue. JCT applies a 25% offset to calculate net revenues from an excise tax to account for the reduction in income and payroll taxes due to the excise tax. The same applies at the state level. The state income tax base is closely aligned with the federal income tax base. A federal excise tax will also reduce state income tax revenue. We estimate the static offset against state income taxes to be 3%.[15] Note that beyond the static offsets, a carbon tax that reduces economic growth could have dynamic effects that also reduce income tax revenue at the federal and state levels.

The offsets that are likely to be the minimum offsets applied in practice are therefore JCT's 25% static offset against federal income and payroll taxes; CBO's 13% offset for increased direct and indirect energy costs to federal, state, and local government; CBO's 27% set-aside for low-income taxpayers; and a 3% offset against reduced state and local income taxes. These offsets totaling 68% reflect budgetary impacts on federal, state, and local government. The impact on states has implications for federalism. To balance their budgets, states will either raise taxes, cut spending, or most likely of all, demand revenue sharing from the federal government. In the sidebar discussion below, we demonstrate that 68 cents on the dollar in static offsets leaves only 32 cents on the dollar available for pro-growth tax reform.

The minimum static offsets that we list here are also not the only static offsets that are possible or likely. A federal carbon tax which is functionally a new federal excise tax on motor fuels introduces vertical tax competition between the federal government and the states, who have hitherto had excise tax revenues from motor fuel collected on both the federal and state level reserved for their own use. A substantial federal excise tax increase could make it difficult for many if not all states to raise their own fuel taxes for years to come—and the increased revenue would go to the federal government for its purposes, not to pay for highways and infrastructure at the state and local level. The static offsets affecting state revenue compounded by vertical tax competition for future motor fuel excise tax revenues make it all the more likely that a federal carbon tax would create demand from the states for a federal-state revenue-sharing program that would further reduce the amount of net revenue available for tax reform. In Section 3, we present revenue-sharing options based on giving states a share of motor fuel excise tax revenues in addition to reimbursing them for their other costs. These could easily reduce the amount of revenue available for tax reform to as little as 25 cents or 13 cents on the dollar before any dynamic offset is applied.

In short, we model our tax reform scenarios with only a 25% static offset to provide the strongest possible results for revenue recycling with carbon tax revenues, even though a 25% revenue offset would not represent revenue-neutral tax reform, nor is it likely to represent a viable bill in Congress. To support this practice, we assume that any revenue shortfall can be deficit-financed at the federal level with negligible impact on economic growth during our forecast period, and

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[14] Terry Dinan, "Offsetting a Carbon Tax's Costs on Low-Income Households," CBO Working Paper Series, Working Paper 2012-16," November 2012.

[15] See discussion in Sec 3.3.2, p. 31.

that federal revenue sharing can preempt the need for state tax increases. Other studies have estimated a dynamic revenue offset effect that results from decreased government revenues due to the overall macroeconomic effect of a carbon tax. These studies have produced offset estimates or allow the inference of offset estimates that are greater than 25% and range from 35% to 66% in various cases. The 25% offset we use is modest by comparison.[16]

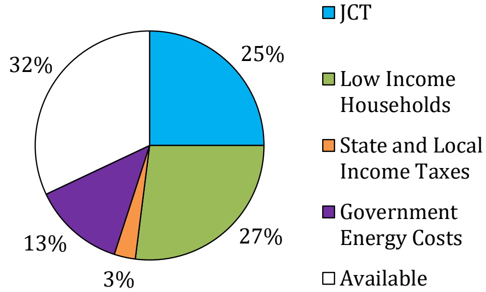
1.4 The 10-Year Budget Window

JCT and CBO commonly score legislation within a 10-year forecast window to meet the statutory requirements of the Budget Act. We follow this convention and provide results within a 10-year budget window as well as a long-run 22-year forecast. This emphasis on short-term transitional impacts distinguishes work by JCT and CBO from academic studies which consider a long-term steady state rather than the immediate cash flow requirements of the federal government. Critics of the short-term approach argue that the 10-year forecast does not adequately demonstrate the advantage of policies that have significant near-term or transitional costs before reaching their equilibrium state. Nonetheless, proposals which lose revenue over the 10-year period are subject to statutory or procedural points of order, and realistic assessment of legislation before Congress requires the 10-year view. We bridge the gap between the Congressional and academic perspectives by providing both short-term and long-term views.

[16] In contrast to our essentially static approach, another way to estimate the difference between gross revenue and net revenue is to compare modeling results for revenue with and without the tax. For instance, Smith, Harrison, et al. calculate and compare reduction in federal tax revenues due to two different carbon tax scenarios. In the first scenario, a tax of $20 per ton that increases by 2% annually and has revenues allocated 50/50 to deficit reduction and a personal income tax reduction, they find the deadweight loss ranges from 41% of gross revenues in 2013 to 35% in 2043 and 37% in 2053. In the second scenario, a carbon tax that begins at $20 but increases as necessary up to a maximum value of $1000 per ton to achieve an 80% reduction in carbon emissions by 2053, the deadweight cost is 40% of gross revenues in 2013 and increases to 52% of gross revenues in 2053 (See Anne E. Smith, David Harrison, et al. *Economic Outcomes of a US Carbon Tax*. February 26, 2013. NERA Economic Consulting. Prepared for National Association of Manufacturers. p. 26, figures 16-17.). Goulder and Hafstead model a $10 carbon tax beginning in 2013 which increases annually by 5% until 2040, when it reaches a maximum value of $37.37 in 2012 dollars. They find gross revenues of approximately $375 billion in 2050 and net revenues of approximately $125 billion in the same year, which would imply a leakage of 66% (See Lawrence H. Goulder and Marc A.C. Hafstead, "Tax Reform and Environmental Policy: Options for Recycling Revenue from a Tax on Carbon Dioxide," Resources for the Future, October 2013. p. 17, figure 4b.). Neither of these studies considers costs passed on to state and local governments.

32 Cents on the Dollar

Carbon Tax Revenue Offsets



	Offset
JCT Offset Against Federal Income Tax	25%
Set-Aside Low-income Households	27%
Direct and Indirect Energy Costs – All Levels of Government	13%
Offset Against State and Local Income Tax	3%
Total Offset	68%
Net Revenue Available for Tax Reform	**32%**

Data: JCT, CBO, Capital Alpha Estimate

The carbon tax is not an efficient revenue raiser for tax reform, because the net static proceeds available for tax reform after accounting for static offsets are only 32 cents on the dollar. Assuming that Congress wishes to protect taxpayers in the lowest two income quintiles from a tax increase, the static offsets amount to 68 cents on the dollar. The 32-cent figure is the remainder after these offsets are applied. Offsets include the standard JCT excise tax offset against federal income tax revenues, a CBO estimate of the percentage share of gross revenue needed to hold taxpayers in the lowest two income quintiles harmless, and a CBO estimate of direct and indirect energy costs for all levels of government. We estimate the federal excise tax offset against state and local income taxes to be 3%. Revenue sharing with the states to address vertical tax competition could reduce the available net revenue for tax reform to 25 cents on the dollar or less, as we discuss in Section 1.

2. Carbon Emissions and the Paris Agreement

Our first step is to provide context and metrics for each of the carbon tax scenarios we study.

- We consider how each carbon tax would compare with other, existing carbon taxes in the world.
- We measure the ability of each carbon tax to reduce carbon emissions.
- We determine whether any carbon tax, considered by itself, could meet U.S. obligations under the Paris Agreement.

Our findings in brief are that the carbon taxes we study, if implemented, would be the highest economy-wide carbon taxes in the world. The carbon taxes would effectively reduce U.S. fuel-based emissions by hundreds of millions of tons of CO_2 annually within a few years of being enacted, and some eventually by billions of tons per year. Over 22 years, the carbon taxes we study would achieve cumulative reductions in fuel-based emissions of between 10 and 27 billion tons of CO_2. Yet no carbon tax we model is consistent with meeting long-term U.S. obligations under the Paris Agreement as a standalone policy. Two scenarios, phased-in taxes of \$72 and \$108 per ton, are capable of meeting the U.S. minimum INDC for 2025. Other scenarios achieve meaningful reductions but by 2040 are far off the trajectory needed for compliance with the Paris 2050 goal of an 80% reduction in emissions from the 2005 baseline.[17] Thus, none of the carbon taxes we study could possibly replace all other policies needed to reach the Paris targets in a tax-for-regulatory swap. Our findings are consistent with IEA's determination that even a carbon tax of $190 per ton of CO_2 would fall short of meeting the 2050 Paris goal without a full range of appropriate complementary policies.[18]

2.1 Comparison with Existing Carbon Taxes Worldwide

To compare our carbon tax scenarios with carbon taxes worldwide, we go to the World Bank's *State and Trends of Carbon Pricing 2017* and *State and Trends of Carbon Pricing 2018* and OECD's *Effective Carbon Rates: Pricing CO_2 through Taxes and Emissions Trading Systems (2016)*.

There exist some carbon taxes with rates higher than those we model, but none of them are economy-wide. Instead, the carbon taxes are applied more narrowly on a sector-by-sector basis. The World Bank reports per-ton tax rates that are comparable to or higher than the ones we model in Sweden ($139), Switzerland ($101), Finland ($77), Norway ($4 to $64), and Iceland ($36). France, a standout for its reliance on nuclear power, has a carbon tax of $55 as of 2018. It is scheduled to increase annually to reach $107 in 2022.[19] However, in these European countries the carbon tax is not applicable to industries covered by the Emissions Trading System (ETS), in which the average carbon price was $6.91 (€5.76) per ton in 2017.[20] [21]

The World Bank estimates that Sweden, Switzerland, and Finland apply their carbon tax to only 40% of emissions or less. Norway, by contrast, is a standout performer, applying its carbon tax to 60% of emissions but at a weighted average rate that is approximately $20 per ton.[22]

Additional data from the World Bank show that, globally, most carbon emissions are not taxed or are taxed only at a low level, resulting in comparatively little revenue raised.

- Implemented and scheduled carbon pricing currently covers about 20% of global GHG emissions.[23]

[17] According to the U.S. INDC for 2025, "This target is consistent with a straight line emission reduction pathway from 2020 to deep, economy-wide emission reductions of 80% or more by 2050." See http://www4.unfccc.int/Submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf

[18] International Energy Agency and International Renewable Energy Agency, *Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System*, March 2017.

[19] World Bank and Ecofys, *State and Trends of Carbon Pricing 2018*, May 2018. p. 11.

[20] Markets Insider, "CO2 EUROPEAN EMISSION ALLOWANCES IN EUR-HISTORICAL PRICES," Business Insider, n.d. (Accessed 2018).

[21] Note that carbon prices are trending higher in 2018 as European governments eliminate excess carbon emission permits. See Rachel Morison and Jeremy Hodges, "Carbon Reaches 10-Year High, Pushing Up European Power Prices," *Bloomberg*, August 23, 2018.

[22] World Bank, Ecofys and Vivid Economics, *State and Trends of Carbon Pricing 2017*, November 2017. p. 30.

- About half of emissions covered by a pricing regime are priced at less than $10 per ton.[24]

- Total global carbon revenues raised in 2017 were $33 billion.[25]

The OECD offers similar information from a survey of 41 OECD and G20 countries which together account for 80% of global emissions from energy use.

- 60% of emissions are not priced at all.

- Only 10% of emissions are priced at or above $36 (approximately €30). These result mostly from road-transportation use.

- Non-road transport emissions represent 85% of total emissions. Of these, 70% face no carbon price at all, and only 4% face a price that is higher than $36. [26]

The World Bank's finding that total global carbon revenues in 2017 were $33 billion is notable in light of the revenue that we find that an economy-wide carbon tax would raise from the United States alone. Figure 2.1-1 shows our estimates of the average annual gross revenue that each of our carbon tax scenarios would raise during the 10-year period from 2019 to 2028, the scoring period normally used in Congressional budgeting and forecasting. A carbon tax of $40 per ton of CO_2 would raise average annual gross revenues equal to $232 billion during its first 10 years. A carbon tax of $49 per ton of CO_2 would raise average gross revenues equal to $279 billion during the same period. These are respectively 7 times and 9 times total global carbon revenue in 2017. The chart shows that each of our carbon tax scenarios would raise average annual gross revenues in their first 10 years that are significant multiples of current total global annual carbon revenue.

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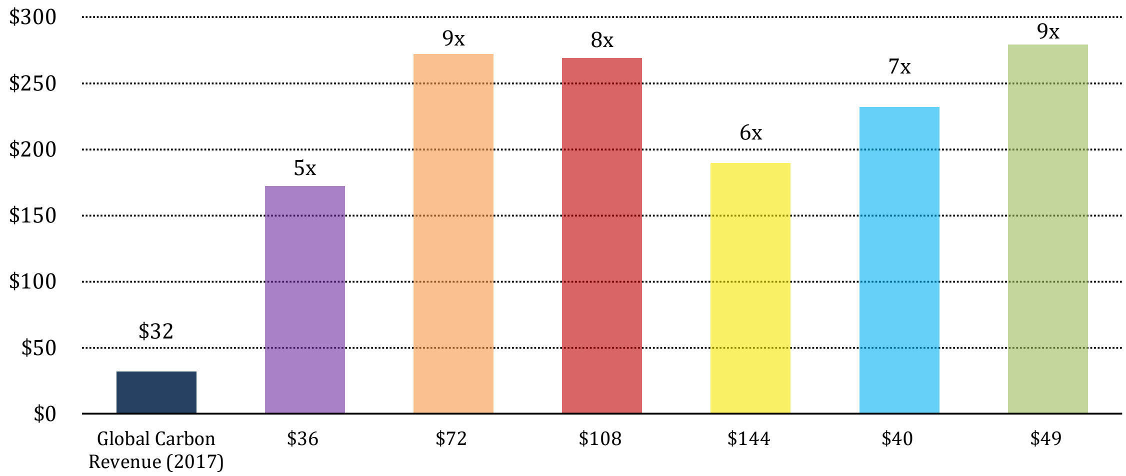
[23] World Bank, *State and Trends of Carbon Pricing 2018*, p. 8.

[24] *Ibid*, p. 27.

[25] *Ibid*, p. 17.

[26] OECD, *Effective Carbon Rates: Pricing CO2 through Taxes and Emissions Trading Systems*, OECD Publishing, 2016.

Figure 2.1-1: Tax Scenarios Raise Multiples of 2017 Global Carbon Revenue (Billions 2015$)



Source: World Bank State and Trends of Carbon Pricing 2018, deflated to 2015 dollars; and model estimate using EIA Annual Energy Outlook 2016

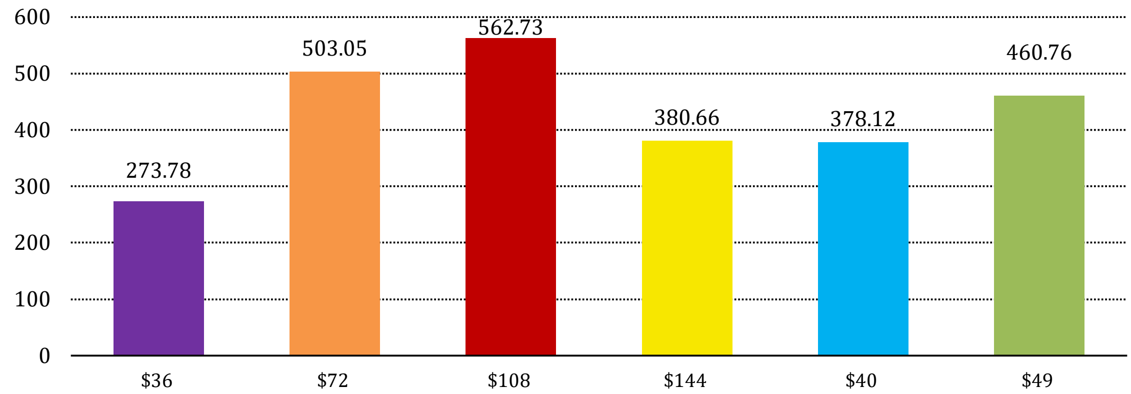
Total global carbon revenues in 2017 were $31.69 billion (2015$). Carbon Tax scenarios raise from 5 times to 9 times as much every year from U.S. only. Tax revenues are average annual revenues for $2019-2028 in billions 2015$.

2.2 Carbon Emission Reductions Achieved

The carbon tax scenarios we model achieve meaningful reductions in CO_2 emissions.

Figure 2.2-1 shows emission reductions in a simple way by presenting average annual carbon emissions reductions for each scenario during the 10 years from 2019 to 2028. On average, a carbon tax of $40 per ton of CO_2 similar to the CLC plan would reduce emissions relative to the no-tax baseline by about 378 million tons per year during the first 10 years. A carbon tax of $49 per ton would reduce emissions by 461 million tons per year on average during that period.

Figure 2.2-1: Average Annual Emission Reduction (MMT CO_2)

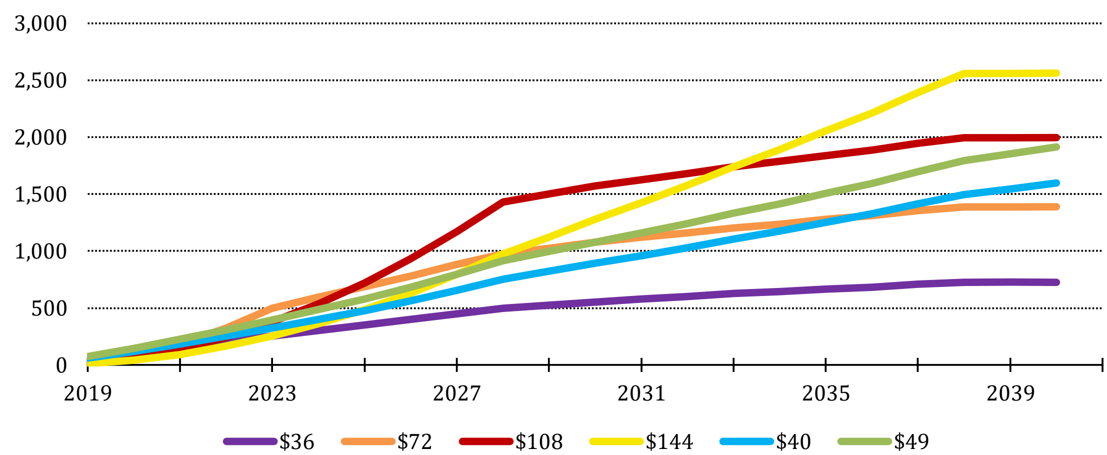


Source: Model estimate using EIA Annual Energy Outlook 2016.

Figure 2.2-1 shows average annual reduction in CO_2 emissions relative to baseline for each tax scenario for years 2019-2028 in Million Metric Tons CO_2.

Figure 2.2-2 shows carbon emission reductions in more detail over the entire forecast period. Carbon emissions are reduced by hundreds of millions of tons per year relative to our current policy baseline in the early years, and by billions of tons per year in five of our six scenarios by the end of the forecast period.

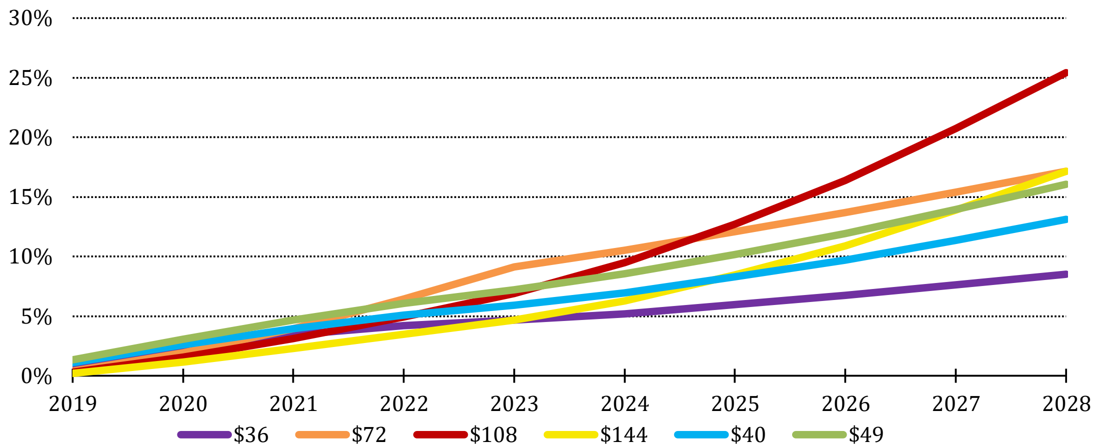
Figure 2.2-2: Annual Emissions Reductions, Yearly (MMT CO_2)



Source: Model estimate using EIA Annual Energy Outlook 2016

Figure 2.2-2 shows annual reductions in CO_2 emissions relative to no-tax baseline, yearly, for each scenario, in Million Metric Tons CO_2.

Figure 2.2-3: Annual Emission Reductions as a Percentage of No-Tax Baseline



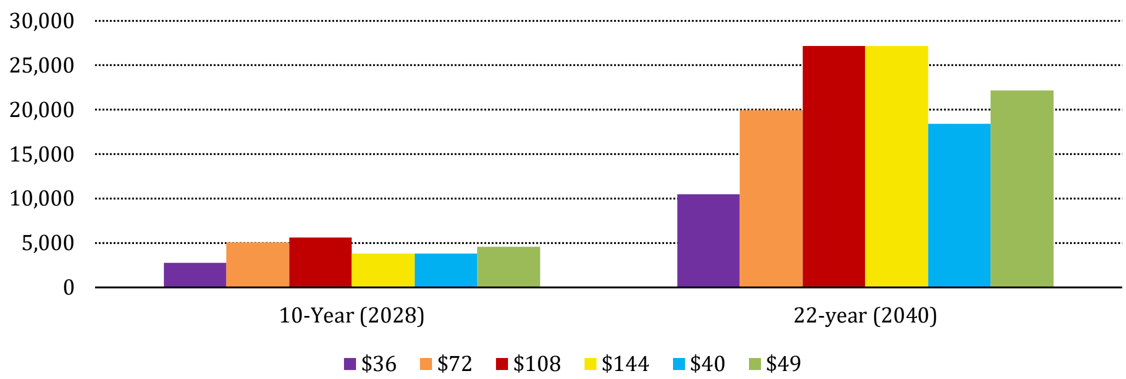
Source: Model estimate using EIA Annual Energy Outlook 2016

Figure 2.2-3 shows annual emission reductions, yearly, as a percentage of the no-tax emissions baseline.

Figure 2.2-3 shows annual reductions in each scenario as a percentage of reductions from the no-tax baseline scenario over the entire forecast period. The various scenarios reduce emissions by 5% to 9% after five years. By the end of the forecast period, in 2040, all but the two lowest tax rates reduce emissions by more than 15%.

Figure 2.2-4 shows cumulative CO_2 emissions for each scenario for 10 years and over the entire forecast period. In the first 10 years, cumulative emission reductions range from 2.73 to 5.63 trillion tons. Over the entire forecast period, cumulative emission reductions range from 10.05 trillion to 27.19 trillion tons.

Figure 2.2-4: Cumulative Emissions Reductions (MMT CO_2)



Source: Model estimate using EIA Annual Energy Outlook 2016

Figure 2.2-1 shows cumulative emissions relative to the no-tax baseline over 10-year and 22-year periods in Million Metric Tons CO_2.

2.3 A Tax and Regulatory Swap for the Paris Agreement

In this section, our study considers whether a tax-for-regulatory swap could meet U.S. obligations under the Paris Agreement. In theory, a carbon tax could replace all existing greenhouse gas regulations with a single pricing mechanism that could obviate the need for environmental regulations such as the Clean Power Plan (withdrawn by the Trump administration), efficiency standards, clean energy subsidies, electric vehicle standards, and regulatory policies to address methane and greenhouse gas emissions.

Our first step is to review results from authoritative governmental or international agency studies that pertain to meeting the Paris goals with such a tax-for-regulatory swap. The World Bank and IEA determine that a pure tax-for-regulatory swap is not likely to reach the Paris targets, even with carbon taxes that are higher than those considered in this study. The Treasury Department results indicate that a carbon tax of $49 per ton would not lower emissions sufficiently to meet the Paris targets even when combined with all the climate policies then in force in 2016, at the end of the Obama administration.

The study then considers each of our tax scenarios as if it were a tax-for-regulatory swap. In order to establish a baseline that would be consistent with the elimination of the Clean Power Plan as a precondition for the swap, we use CTAM to generate a fuel-only emissions baseline using EIA's projection of fossil fuel consumption in the No CPP alternative to the reference case presented by the 2016 Annual Energy Outlook. By not accounting explicitly for fugitive methane and non-GHG emissions, our baseline runs the risk of being overly lenient for purposes of measuring possible compliance with an aggregate emissions limit.[27] But even so, we find that only the carbon taxes set at $49 per ton or higher come close to the minimum near-term

[27] We compare our emissions baseline with estimates from EIA and Rhodium Group in Appendix B.

threshold for compliance with the Paris Agreement, and none of the taxes reaches the best-efforts goal. None but the tax of $144 per ton comes close to meeting an interim target for 2040 that is consistent with the Paris long-term goals, and none of them is on a trajectory to meet the Paris goals for 2050 and beyond.

2.3.1 Background on the Paris Agreement

The Paris Agreement entered into force on November 4, 2016. Parties to the Paris Agreement seek to stabilize global temperatures as closely as possible to pre-industrial levels. Following commonly recognized benchmarks from the U.N. Framework Convention on Climate Change, parties seek to limit warming to less than 2 degrees Centigrade, the level associated with severe harm. A limit of 1.5 degrees Centigrade is seen as desirable. The target stabilization period is generally seen as the years from 2050 to 2100. Parties to the accord generally agree to follow policies consistent with reducing emissions by 80% from 2005 levels in a straight-line trajectory by the year 2050.[28]

The United States recognizes the two-degree goal and the 80% emissions reduction target. However, under the Obama administration, the United States committed specifically only to policies that would reduce emissions by at least 26% from the 2005 baseline by 2025 and by as much as 28% with "best efforts." These policies are partly described in the U.S. INDC, which President Obama transmitted to the U.N. in September 2016 with the indication that additional steps to meet the goals would still be needed. The Rhodium Group estimates that the U.S. is not on pace to meet the 2025 goals and will likely reduce emissions by only 12%-20% under Trump administration policies.[29]

On June 1, 2017, President Trump announced his intent to withdraw from the Paris Agreement, and on August 4, 2017, the U.S. State Department sent the U.N. a notice of the President's intention to withdraw. However, parties may not formally begin the process of withdrawal until the agreement has been in force for three full years, which will not occur until November 4, 2019. Parties may not actually withdraw until the treaty has reached its fourth year in force on November 4, 2020. Thus, despite the President's announcement, the United States is still formally a party to the agreement, and the United States cannot cease being a party to the agreement until one day after the Presidential election of 2020. Further, Trump and the State Department have made clear that the United States would reconsider its decision to withdraw from the agreement if the terms can be renegotiated. Assuming that Trump remains firm in his decision to withdraw, a Democratic candidate for President might pledge to rejoin if elected, so that the United States might never formally leave the agreement for more than a few months.[30]

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[28] U.S. INDC; UN INDC Portal https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/ndc-registry#eq-4 (accessed August 2018).

[29] John Larsen, Kate Larsen, Whitney Herndon, Peter Marsters, Hannah Pitt, and Shashank Mohan. *Taking Stock 2018*. June 28, 2018. Rhodium Group.

[30] See, for instance, Hardy, Chelsea, "Withdrawing from the Paris deal takes four years. Our next president could join again in 30 days," *Washington Post*, June 5, 2017." https://www.washingtonpost.com/news/energy-environment/wp/2017/06/05/withdrawing-from-the-paris-deal-takes-four-years-our-next-president-could-join-again-in-30-days/?utm_term=.f18b29f5f75c

There is a further complication to analysis in that Trump has withdrawn the Clean Power Plan, which was the centerpiece of the Obama administration's INDC pledge. Trump has proposed to replace the Clean Power Plan with a more limited plan that regulates only the thermal efficiency of coal-fired power plants and does not offer the mass-based compliance option which would have opened the way to a national greenhouse gas emissions trading system based at the state level. [31] Should the United States rejoin the Paris Agreement, a future President could likely direct the EPA to develop a national emissions trading system under Section 115 of the Clean Air Act, which grants the EPA broad powers to regulate emissions under a treaty with reciprocal obligations to reduce emissions.[32] In short, the future of U.S. participation in the Paris Agreement and the pathway to a national emissions trading system is very much an open question. A carbon tax in a tax-for-regulatory swap would represent a potential alternative policy to an emissions trading system if it could actually meet the Paris goals, as we seek to determine here.

2.3.2 Findings from the World Bank and IEA

The World Bank and IEA have both concluded in official reports that a carbon tax at levels consistent with meeting the goals of the Paris Agreement would have to start higher or phase in faster than any of the scenarios we consider. Even so, a carbon tax could not achieve the required reductions in emissions as a standalone policy. Instead, the carbon tax would need to be one element of a comprehensive policy solution.

According to the High-Level Commission on Carbon Prices, in a report co-authored by Nobel Prize Laureate Joseph Stiglitz and World Bank Chief Economist Nicholas Stern, carbon prices that are consistent with reaching the Paris goals would need to be "at least" $40-$80 per ton by 2020 and $50-$100 per ton by 2030, but even with taxes at these levels, additional policy measures would be needed.

> The Commission believes that the carbon-price ranges suggested above would be able to deliver on the temperature objective of the Paris Agreement, provided the pricing policy is complemented with targeted actions and a supportive investment climate—in the absence of these elements, the carbon- price range required is likely to be higher. The temperature objective of the Paris Agreement is also achievable with lower near-term carbon prices than indicated above, but doing so would require stronger action through other policies and instruments and/or higher carbon prices later, and may increase the aggregate cost of the transition.[33]

[31] Still more complexity arises in that although the Trump administration has withdrawn the CPP, certain states and localities have announced their intent to observe the goals of the CPP as if it were still in force. See Larsen, et al., *Taking Stock 2018*.

[32] See Bob Sussman, "The essential role of Section 115 of the Clean Air Act in meeting the COP-21 targets," *Brookings Institution PlanetPolicy Blog*, April 29, 2016. https://www.brookings.edu/blog/planetpolicy/2016/04/29/the-essential-role-of-section-115-of-the-clean-air-act-in-meeting-the-cop-21-targets/ See also Michael Burger, et al, "Legal Pathways to Reducing Greenhouse Gas Emissions Under Section 115 of the Clean Air Act," Sabin Center for Climate Change Law, Columbia Law School, January 2016.

[33] Carbon Pricing Leadership Coalition, *Report of the High-Level Commission on Carbon Prices*, May 29, 2017, pp. 50-51.

The International Energy Agency calculates that in order to reach the two-degree goal of the Paris Agreement, carbon prices in the OECD would need to rise from $20 in 2020 to $120 in 2030, $170 in 2040, and $190 in 2050 – and once again, further policy measures will be necessary.

> Yet even at these unprecedented levels, CO_2 prices alone would be insufficient to stimulate the required pace and extent of energy sector transformation and would need to be accompanied by the phase out of fossil fuel subsidies and additional fuel taxation. In addition, the co-ordinated enforcement of mandates, standards, energy market reforms, research, development and deployment (RD&D) and other emissions reduction policies would also be required. These additional measures would be essential across all sectors, and, as with CO_2 prices, go well beyond those enacted to date.[34]

2.3.3 Findings from the U.S. Treasury Department

In its January 2017 working paper, the Treasury Department Office of Tax Analysis presents the working outline of an economy-wide carbon tax set at $49 per ton. The Treasury Department assumes that all climate policies in place at the end of the Obama administration, including the Clean Power Plan – "current policy" – remain in force. In its main scenario, Treasury estimates that annual aggregate greenhouse gas emissions will be 5.01 billion tons of CO_2 equivalent (CO_2-e).[35]

Treasury does not compare these numbers with the Paris goals, but this is possible by checking the EPA's 2005 estimate of greenhouse gas emissions – 6.58 billion tons of CO_2-e – and calculating that a 26% reduction would mean 4.87 billion tons.[36] Aggregate emissions that are higher than this level, such as the 5.01 billion tons that the Treasury estimates would result from implementation of its $49 per ton tax do not meet the goal. Notably too, the Treasury is not considering a tax-for-regulatory swap in which the tax replaces all carbon emission-related regulations. The tax fails to meet the goal even when supported by the full range of polices that were in place as of 2016. [37][38]

2.3.4 Regulatory Swap Results Through 2025

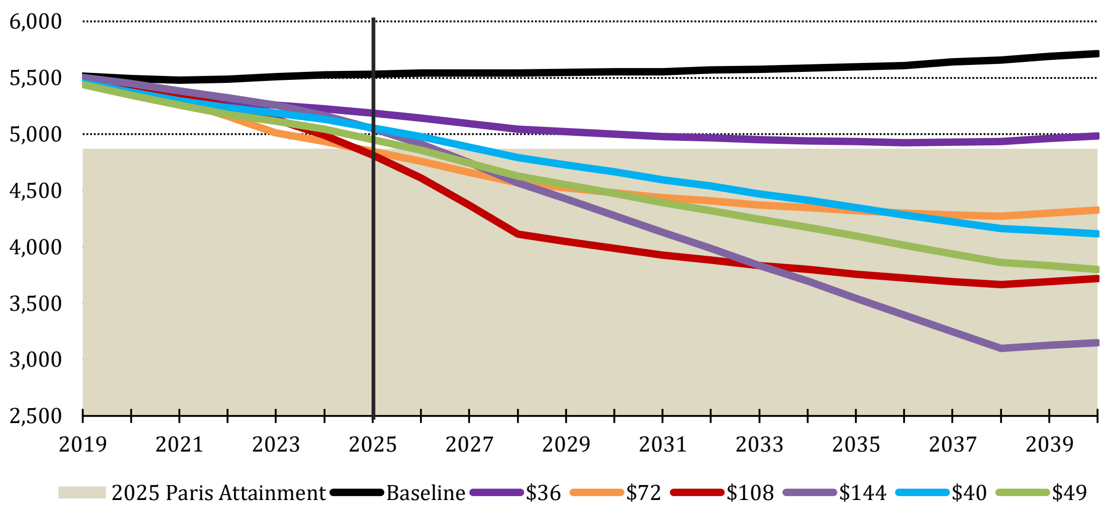
Figure 2.3.4-1 shows our own modeling results for aggregated U.S. fuel-related emissions relative to a 4.87-billion-ton target level for 2025.
Both the $72 per ton and the $108 per ton tax reach the 26% reduction goal in on schedule in 2025.[39] The $49 per ton tax scenario reaches 26% reduction attainment during 2026, and the

[34] International Energy Agency and International Renewable Energy Agency, *Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System,* March 2017.
[35] Horowitz et al, *Working Paper 115,* January 2017. p. 11.
[36] EPA data, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks
[37] *Ibid*, p. 13. The Treasury Department also presents a "rapid technological progress" scenario in which emissions might be as low as 3.93 billion tons in 2025, but we find this scenario unlikely in the absence of key supporting policies, most notably the CPP, methane controls, and aggressive federal support for renewables.
[39] For details, see Appendix Tables B-1 and B-2.

$144 per ton tax reaches attainment in 2027. The $36 per ton tax never reaches a 26% reduction from 2005 emissions levels.

None of the tax scenarios reach 28% emissions reduction attainment by the 2025 goal; however, the $108 per ton tax does reach 28% attainment one year late, in 2026. The $72 per ton tax reaches attainment in 2027, both the $144 per ton and $49 per ton taxes attain 28% reductions in 2028, and the $40 per ton tax follows in 2029. The $36 per ton tax, failing to reach a 26% reduction, also does not generate a 28% emissions reduction during the 22-year period modeled.

Figure 2.3.4-1: Projected Emissions vs 2025 Paris Target (MMT CO_2)



Source: Model estimate using EIA Annual Energy Outlook 2016

Figure 2.3.4-1 shows projected annual emissions vs the minimum U.S. INDC for 2025 of aggregate emissions 26% below the 2005 baseline. Aggregate emissions target is 4.87 billion tons. Both the phased-in $73 and $108 per ton tax scenarios reach the 26% target. Emissions shown in Million Metric Tons CO_2.

Our modeling results for emission reductions under the tax of $49 per ton of CO_2 track closely with those of the Treasury Department, as noted in the benchmarking discussion below.

Benchmark: Our $49/Ton Tax Carbon Emissions Projections vs Treasury's

Our projected carbon emission reductions under a tax of $49 per ton are similar to those of the Treasury Department, though we measure from different baselines. Treasury measures aggregate greenhouse gas in tons of CO_2-e. We measure fuel-only emissions in tons of CO_2. Treasury assumes some degree of non-compliance, whereas we do not. Treasury assumes current policy as of 2016, including implementation of the Clean Power Plan by 2020, whereas we assume fossil energy use as projected by the no-CPP baseline from the EIA Annual Energy Outlook 2016.

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Treasury	6,261	5,951	5,551	5,271	5,091	5,032	5,005	4,970	4,941	4,930
Our Projection	5,439	5,344	5,254	5,177	5,115	5,042	4,952	4,856	4,745	4,627
Difference	**13%**	**10%**	**5%**	**2%**	**0%**	**0%**	**1%**	**2%**	**4%**	**6%**

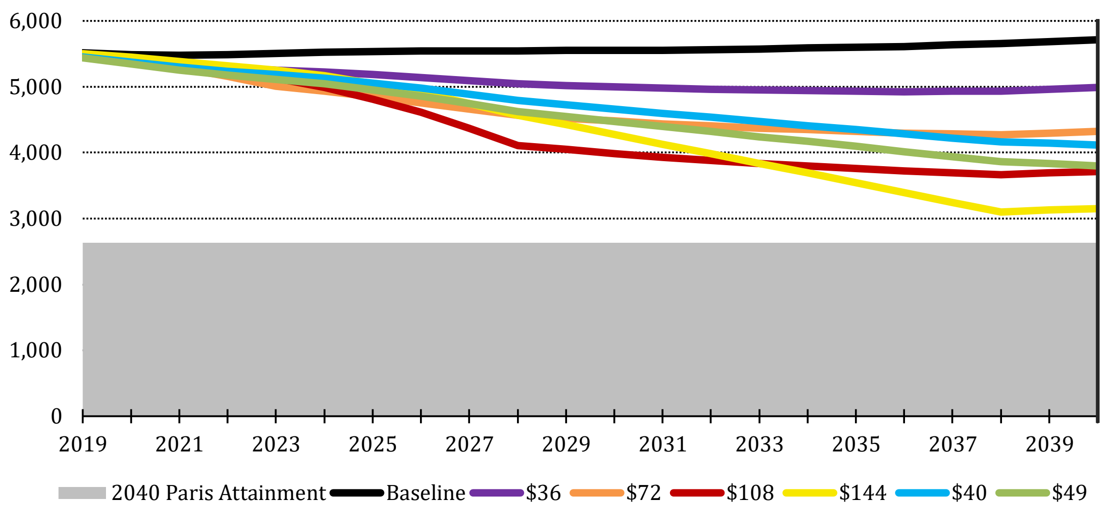
Source: Department of Treasury and model estimate using EIA Annual Energy Outlook 2016

2.3.5 Regulatory Swap Results Through 2040

As stated earlier, the United States has not made specific commitments to reduce U.S. emissions beyond the INDC for 2025 but does recognize an overall goal of reducing emissions by 80% from the 2005 baseline on a straight-line trajectory by 2050. Our forecast period stops short of 2050 but does allow us to present projections for 2040. A goal for 2040 on the same straight-line trajectory and, consistent with the EU climate plan, would be a 60% reduction from the 2005 baseline.[40] This equates to an overall aggregate emissions level of 2.63 tons. We present results as tabular data in Appendix Tables B-1 and B-2. Once again, none of the scenarios reaches the goal, although the phased-in carbon tax of $144 per ton of CO_2 comes closest to reaching it. None are on a trajectory to continue reducing emissions through 2040 or to reach the 80% goal for 2050.

[40] See EU, Climate Action Website, "2050 Low-Carbon Economy:" "By 2050, the EU should cut greenhouse gas emissions to 80% below 1990 levels. Milestones to achieve this are 40% emissions cuts by 2030 and 60% by 2040" https://ec.europa.eu/clima/policies/strategies/2050_en. Accessed August 2018.

Figure 2.3.5-1: Projected Emissions vs 2040 Paris Target (MMT CO_2)



Source: Model estimate using Annual Energy Outlook 2016

Figure 2.3.5-1 shows annual emissions vs. 2040 target of emissions 60% below the 2005 baseline, which is consistent with overall goals of the Paris Agreement. Target expressed as aggregate emissions is 2.63 billion tons. The phased-in tax of $144 per ton comes closest to reaching it. Emissions shown in Million Metric Tons CO_2.

3. The Carbon Tax as a Revenue Generator

The carbon tax scenarios we model produce net revenue that could replace or offset a significant percentage of the existing federal corporate income tax, but only at the cost of imposing a tax policy with a harshly regressive impact on lower-income taxpayers.

The carbon taxes we model also result in a federal revenue burden that is comparable in scale to the aggregate amount of revenues that states and local government collect from important revenue streams: income taxes, general sales taxes, and excise taxes. The size of the federal burden relative to these state taxes helps us assess the prospects of federal taxes crowding out state revenue and of vertical tax competition between the federal government and the states for the same revenue base.

The carbon taxes we model pose a particular challenge to infrastructure finance. For the first time in U.S. history, the federal government will be collecting substantially more in tax revenue on gasoline and motor fuels than the states collect. At the same time, state and local government budgets will be under pressure from the pass-through effects of the federal tax. States that need to raise revenue to finance new infrastructure may find that their option to raise revenue from their own state taxes on motor fuel is effectively foreclosed to them for a period of years because of vertical tax competition.

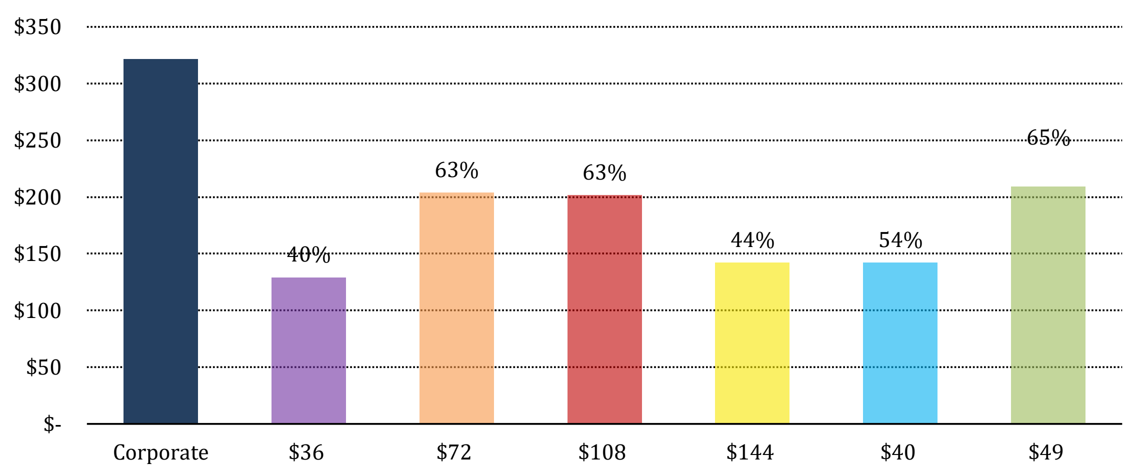
3.1 Revenues to the Federal Government

To measure the ability of the carbon tax to replace all or part of the corporate income tax, we once again use CTAM to calculate gross revenues then apply the JCT's 25% offset to derive net revenues.

Figure 3.1-1 shows average annual net revenues from each carbon tax scenario compared to average annual revenues from the corporate income tax over the years 2019 to 2028. Taking into account the effects of the 2017 tax reform, CBO projects that the federal corporate income tax will raise on average $321.6 billion per year in constant 2015 dollars during the period 2019-2028.[41] A carbon tax that starts at $49 per ton of CO_2 would raise $129.1 billion per year on average, and carbon taxes that phase in to $72 and $108 per ton on the schedules we have assumed would raise about the same amount at $203.9 billion and $201.7 billion per year, respectively.

A carbon tax of $49 per ton would raise an average amount equal to 65% of the corporate income tax. A carbon tax of $72 or $108 per ton would raise about 63% as much as the corporate income tax.

Figure 3.1-1: Federal Corporate Income Tax Revenue vs Carbon Tax Net Revenue (Billions 2015$)



Source: Model Estimate, CBO 2018 Corporate Income Tax Projections

Figure 3.1-1 shows average projected federal corporate income tax receipts for the years 2019 to 2028 ($321.6 billion) compared with average carbon tax net revenues (25% offset applied) for each scenario over the same period. Carbon taxes could replace between 40% and 65% of corporate income tax revenues.

[41] Congressional Budget Office, Budget and Economic Outlook: 2018-2028. April 9, 2018. p. 7. Data converted to 2015$.

Benchmark: Our $49/Ton Tax Revenue Projections vs. Treasury Projections

Our revenue projections for the carbon tax of $49 per ton are similar to those of the Treasury Department for the $49 tax. Note that Treasury assumes some degree of non-compliance whereas we assume perfect compliance. Treasury also assumes current policies as of 2016, including the Clean Power Plan going into effect as of 2020, while we do not. Treasury, relying on EPA and EIA estimates, assumes lower aggregate emissions as well. See emissions baseline comparisons in Figure B-1. Estimates are in billions 2015$.

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Treasury Revenue Projections	$179	$190	$193	$186	$182	$183	$184	$188	$188	$192
Model Estimate	$193	$196	$200	$204	$208	$212	$216	$219	$222	$224
Difference	$14	$6	$6	$18	$26	$30	$32	$31	$33	$31
Difference (%)	7%	3%	3%	9%	13%	14%	15%	14%	15%	14%

Source: Model estimate using EIA Annual Energy Outlook 2016, U.S. Department of Treasury Office of Tax Analysis Working Paper 115

3.2 Protecting Low-Income Taxpayers from a Tax Increase

The revenue generating power of the carbon tax comes with a downside: its impact is regressive. As we previously noted, CBO has determined that 27% of gross revenues would be needed to compensate the lowest two income quintiles for their increased direct and indirect energy costs. More recently, Mathur and Morris's findings show that 26% of gross would be needed to compensate the lowest two quintiles.[42] These estimates come from a complex process of mapping industry input-output tables from the Bureau of Economic Analysis (BEA) onto consumer expenditures as surveyed by the Bureau of Labor Statistics (BLS). The BEA numbers provide data on the carbon-energy input of various goods and services. The BLS numbers allow us to calculate, roughly, consumer expenditures by each quintile.

We provide a simple illustration of using BLS Consumer Expenditure Survey data to measure regressivity in the Table 3.2-1. The BLS data show that energy expenses for a lowest quintile household represent 7% of household income but only 1% for a highest quintile household. This seven-to-one ratio implies that a tax on direct energy costs would be steeply regressive. Further, when we consider energy expenses by the lower two quintiles together, we see that these account for 29% of all consumer energy spending, even though the bottom two quintiles account for only 22% of consumer spending overall.

[42] Aparna Mathur and Adele Morris, "A US Carbon Tax and the Earned Income Tax Credit," Discussion paper, *Brookings Climate Energy and Economics Project*, January 23, 2017.

Table 3.2-1: Spending on Energy by Income Quintile

Quintile	Lowest 20%	Second 20%	Middle 20%	Fourth 20%	Highest 20%
Percentage of Total U.S. Household After Tax Income	4%	9%	15%	23%	49%
Percentage of Total U.S. Household Energy Consumption	12%	17%	19%	22%	30%
Percentage of Total U.S. Annual Aggregate Expenditures	9%	13%	17%	23%	39%
Percentage of Household Income Spent on Energy	7%	4%	3%	2%	1%

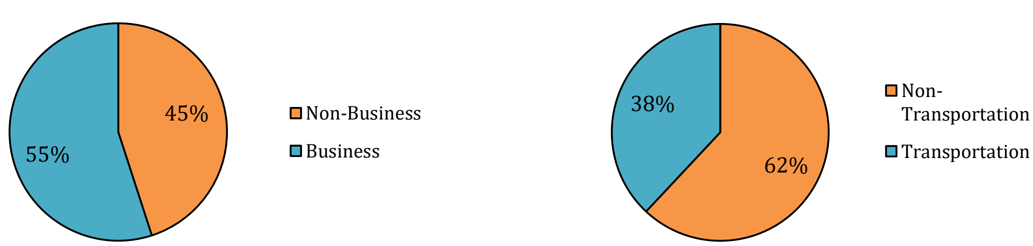
Table 3.2-1 shows data from BLS Consumer Expenditure Survey 2016 on household energy expenses by quintile. The lowest quintile consumers spend 7% of household income on energy, while the highest quintile spends only 1%. Figures are direct energy expenses only.

Energy expenses for all households skew to the bottom end of the income distribution. While the lowest two quintiles account for 22% of total consumer spending, they account for 29% of all consumer energy spending.[43] Energy expenses become less regressive when both direct and indirect energy costs are included. Upper income households spend a greater percentage of their income on goods and services which incorporate indirect energy costs. Finally, when governments' direct and indirect energy costs are considered, upper income taxpayers pay a larger share of these expenses as well through their income tax. Still, as the combined BEA and BLS data show, the carbon tax would impose disproportionate costs on lower-income taxpayers, and which requires a significant amount of gross revenue to be set aside if these lower-income taxpayers are to be compensated.

The Carbon Tax is a Business Tax

CTAM allows us to analyze carbon tax revenues by source of receipts. One of the striking results is that 55% of tax receipts originate with business taxpayers. Most studies assume that in the long-run equilibrium condition, the cost of a carbon tax will fall on consumers and taxpayers. However, during the early implementation phases of a carbon tax, policymakers may wish to consider the impact on energy intensive small businesses and family farms. Allocations reflect energy use by commercial, non-transportation industry vehicle fleets.

2019 Tax Receipts by Source, $49/Ton Tax



Source: Model estimate using EIA Annual Energy Outlook, 2016

3.3 Impact on States and Infrastructure Finance

This section considers static and dynamic costs that could be passed through to the states, as well as the prospect for vertical tax competition and the crowding out of state revenues or state options to raise revenue.

The analysis begins by comparing the federal revenue burden, measured as 100% of gross revenues, to aggregate nationwide state revenues from income, general sales, and select sales or excise taxes. This provides a sense of scale and context which enlightens a further discussion of static and dynamic pass-throughs and vertical tax competition.

The section concludes with a discussion of infrastructure finance, where vertical tax competition poses the most disruptive threat to state interests.

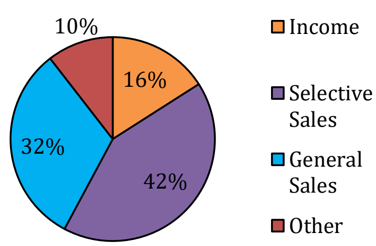
3.3.1 Federal Carbon Tax Revenues Compared to State Revenues from All Sources

We start by looking at state and local government revenues from state and local government taxes. States also receive grant money from the federal government, which is considered later. According to the U.S. Census Bureau, total state and local government revenues in 2017 amounted to $951 billion.[44] Corporate and personal income tax revenues represented the largest share, with $390 billion, or 42%, of the total. General sales tax revenues were the next most important, with $301 billion or 32% of the total. Select sales, or excise, taxes, including taxes on motor vehicle fuels, alcoholic beverages, and tobacco products, represented $152 billion, or 16% of total state tax revenue.

State and Local Tax Revenues Approach $1 Trillion

State and local tax revenues approached $1 trillion in 2017. The single biggest source of tax revenue to the states and local government was the income tax, followed by general sales tax and specialty sales or excise taxes in third place. Small percentage changes in income and sales tax receipts still mean big changes in revenue to state and local government.

State Tax Revenue by Source, 2017



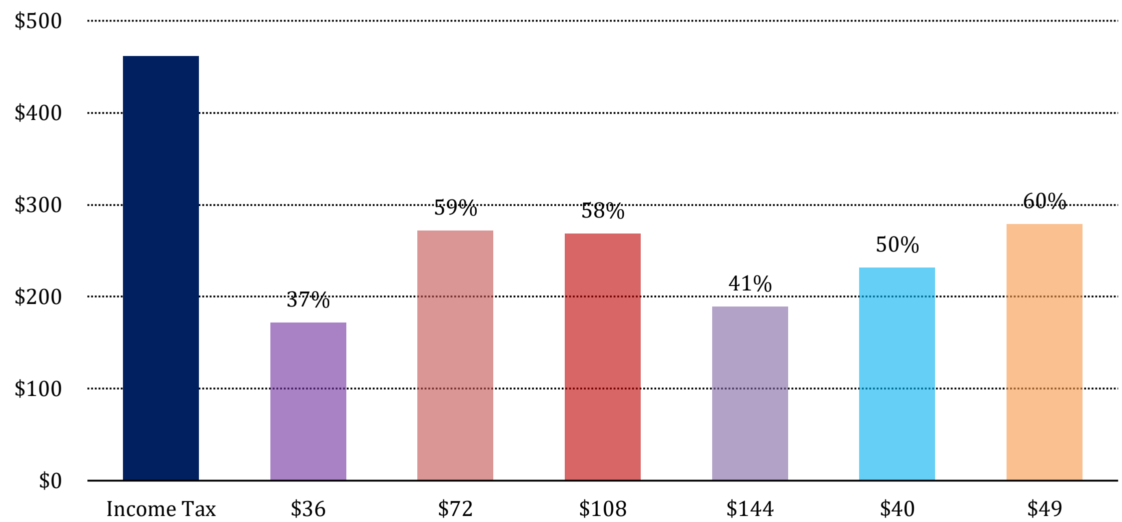
State Tax Revenue Source	Revenue (Millions, 2017$)
Total	$950,532.82
Income	$398,016.38
General Sales	$301,195.95
Selective Sales	$151,619.28
Other	$99,701.21

Data: U.S. Census Bureau, 2017 Annual Surveys of State Government Tax Collections by Category

44 U.S. Census Bureau, *2017 Annual Survey of State Tax Collections* (2017), distributed by U.S. Census Bureau, https://www.census.gov/programs-surveys/stc.html.

The next step is to compare the federal carbon tax burden to state revenues. Figure 3.3.1-1 shows average annual federal gross carbon tax revenues compared to projected average state income tax revenues for the 10-year period from 2019 to 2028.[45] State income taxes would average $461.41 billion over the period. Federal carbon tax revenues would equal as much as 60% of state income tax revenues. In three of six cases, federal carbon tax revenues would be more than 50% of state income tax revenues, and in five of six cases, they would be more than 40% of state income tax revenues. Federal carbon tax revenues would be smaller than state income tax revenue, but still of comparable magnitude. Further, the amount of carbon tax collected continues to grow beyond the 10-year period.

Figure 3.3.1-1: Federal Carbon Tax Revenues Compared to State Income Tax Revenues (Billions 2015$)



Source: U.S. Census Bureau, 1998-2017 Annual Surveys of State Government Tax Collections by Category and model estimate using EIA Annual Energy Outlook 2016

Figure 3.3.1-1 shows state income tax revenues of $461.41 billion compared to the annual federal carbon tax burden in each scenario. The carbon tax scenarios raise revenues equal to between 37% and 60% of state income tax revenues. Revenues are average annual revenues over the years 2019-2028 in billions 2015$.

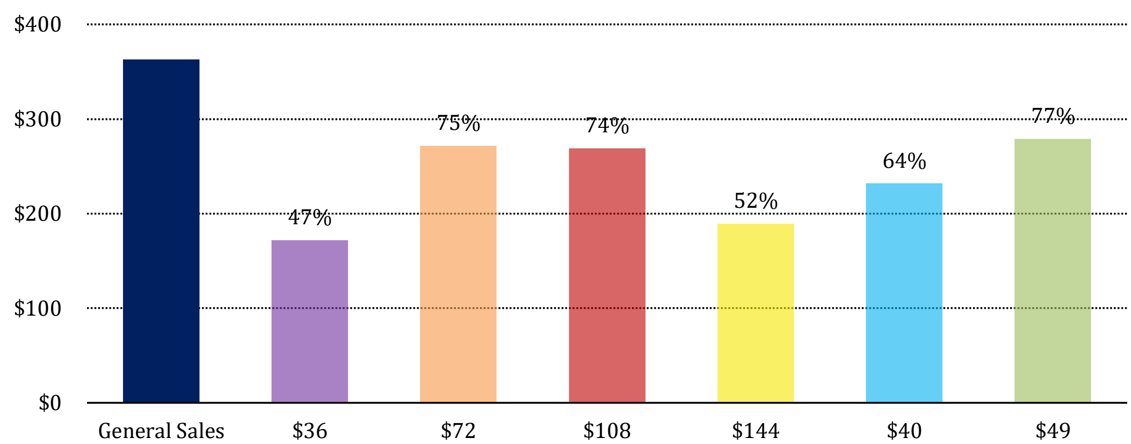
Figure 3.3.1-2 shows average annual federal gross carbon tax revenues compared to projected average state general sales tax revenues over the 10-year period from 2019 to 2028. State general sales taxes would average $363.19 billion per year. Federal carbon tax revenues would average as much as 77% of state general sales tax revenues, in the case of a tax of $49 per ton of CO_2 that increases by 2% annually. In three of six scenarios, the carbon tax would average more than

[45] State tax revenues were projected using U.S. Census Bureau data. The 1998-2017 *Annual Surveys of State Government Tax Collections by Category* were adjusted to 2015 dollars using a 2% annual deflator. The average state tax growth rate was calculated from the adjusted data. That annual growth rate was applied to 2016 detailed state tax collection data to project tax collections by category for the years 2019-2028.

70% of state general sales tax revenues. In five of six scenarios, the carbon tax would average at least 50% of state revenues.

Figure 3.3.1-3 shows average annual federal gross carbon tax revenues compared to average state select sales or excise tax revenues over the same 10-year period. In this example, federal carbon tax revenues could be as much as 151% of state excise tax revenues, 51% more than states collect from their existing excise tax base. We project the amount of state excise tax collected to be $184.89 billion during the 10-year period. In three of six cases, federal carbon tax revenues would be more than 140% of state excise tax revenues. In every case, federal carbon tax revenues would be more than 90% of state excise tax revenues. This highlights the danger of vertical tax competition that becomes most relevant in the later discussion of infrastructure finance.

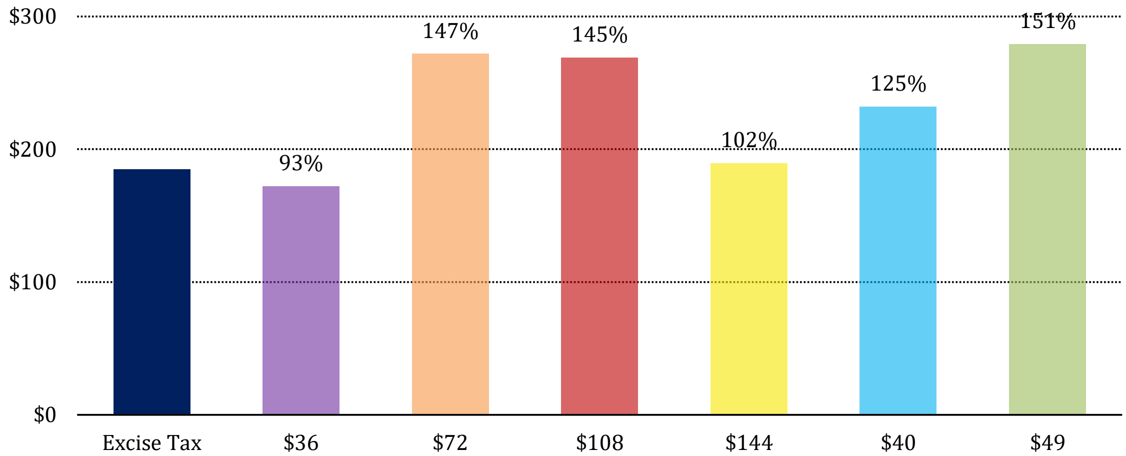
Figure 3.3.1-2: Carbon Tax Revenues Compared to State General Sales Tax Revenues (Billions 2015$)



Source: U.S. Census Bureau, 1998-2017 Annual Surveys of State Government Tax Collections by Category and model estimate using EIA Annual Energy Outlook 2016

Figure 3.3.1-2 shows state general sales tax revenues compared to the annual federal carbon tax burden in each scenario. The carbon tax scenarios raise revenues equal to between 37% and 60% of state general sales tax revenues. Revenues are average annual revenues over the period 2019-2028 in billions 2015$.

Figure 3.3.1-3: Federal Carbon Tax Revenues Compared to State Excise Tax Revenues (Billions 2015$)



Source: U.S. Census Bureau, 1998-2017 Annual Surveys of State Government Tax Collections by Category and model estimate using EIA Annual Energy Outlook 2016

Figure 3.3.1-3 shows state excise tax revenues of $184.89 billion compared to the annual federal carbon tax burden in each scenario. The carbon tax scenarios raise revenues equal to between 37% and 60% of state general sales tax revenues. Revenues are average annual revenues over the period 2019-2028 in billions 2015$.

3.3.2 Static Costs Passed Through to the States

A federal carbon tax would pass costs through to the states on both a static and a dynamic basis. The static costs are easiest to estimate. The first static cost is the state and local government share of total increased direct and indirect energy costs to all levels of government, which CBO estimates as 13% of gross revenues. The CBO estimate is based on complex analysis of data in BEA input-output tables, which we do not replicate here. We do, however, make a simplistic analysis to allocate shares of the 13% cost burden to the federal government and to the states and local government. Using BEA's National Income and Product Accounts (NIPA) tables, we examine the ratio of federal spending to state and local spending for government consumption, investment in structures, and investment in equipment. Both structures and equipment are energy intensive. We omit the investment account for intellectual property. The resulting ratio of federal to state spending averaged over the past 10 years is 36% federal spending to 64% state spending. As shares of the 13% cost burden, this would translate into 4.7% federal government and 8.3% states. To make the number more conservative, we round off in favor of the federal government for a final estimate of 5% federal and 8% state.[46]

[46] Calculated using the FRED datasets "Government Consumption Expenditure and Gross Investment, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate;" "Government Gross Investment: Intellectual Property Products, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate;" "Federal Consumption Expenditures and Gross Investment, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate;" "Government Gross Investment: Federal: Gross Investment: Intellectual Property Products, Billions of Dollars, Quarterly, Seasonally

A second static cost would be an offset for state and local income taxes, similar to the offset that JCT applies to federal income tax revenues. State and local income taxes cover a revenue base that is substantially similar if not identical to the federal income tax revenue base. The same economic reasoning that JCT uses for its revenue offset would apply. Based on the ratio of federal income and payroll tax revenue to state and local income tax revenue, we estimate the state revenue offset would be about 3% of gross carbon tax revenues.[47] This would make total static costs to states – direct and indirect energy costs plus the income tax offset, or 8% plus 3% – equal to 11% of gross federal carbon tax revenues.[48]

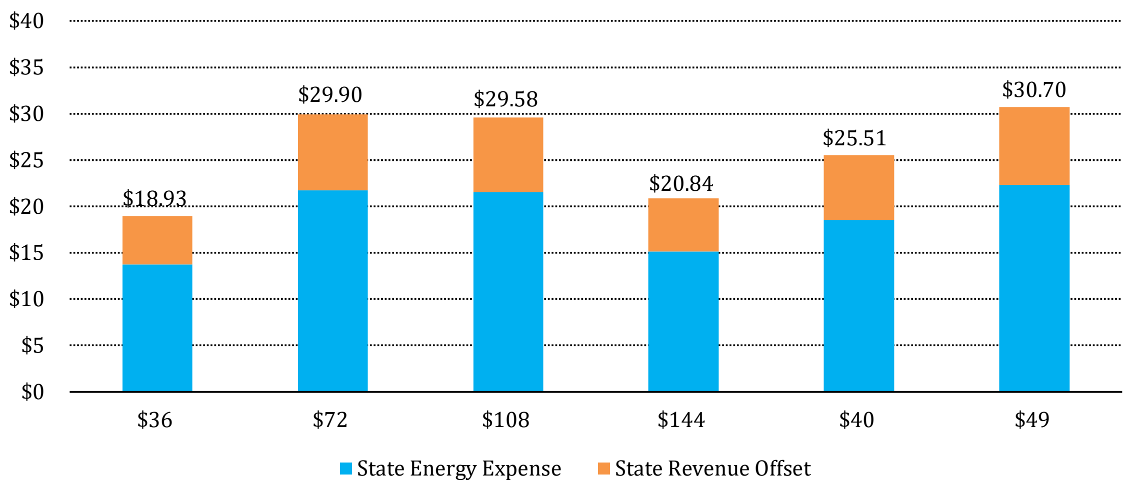
Adjusted Annual Rate;" "State and Local Consumption Expenditures & Gross Investment, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate;" and "Government Gross Investment: State and Local: Gross Investment: Intellectual Property Products, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate."

In general, the BEA data available via FRED shows current (2018) federal government consumption spending at an annualized rate of about $1 trillion per year, while state and local governments spend $1.8 trillion on consumption. Direct energy expenses as reported by the BEA represent a comparatively small share of government consumption spending, or about 1.4% of the total. BEA-reported federal government spending on energy varies with oil prices and more than twice as high as state spending, which is heavily levered toward defense petroleum products. Interestingly though, the states and local government spend 19 times as much as the federal government on structures ($304 billion v $16 billion) and invest more than twice as much in equipment as federal government non-defense equipment investments ($46 billion v $22 billion). Meanwhile, data from DOE and EIA suggests that state and local government consume more energy on a BTU basis than does the federal government. The DOE reports that in 2017, Federal government agencies consumed 915 trillion BTU, of which 61% was transportation fuel. Meanwhile, EIA reports that in 2012, state and local governments consumed 1,451 trillion BTU to operate facilities alone. See DOE, "Comprehensive Annual Energy Data and Sustainability Performance—Annual Data 2017" http://ctsedwweb.ee.doe.gov/Annual/Report/Report.aspx and EIA Commercial Building Energy Consumption Survey (CBECS), 2012 CBECS Survey Data, Table E1. Major fuel consumption (BTU) by end use, 2012 https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e1.php (Accessed October 2018).

[47] This number is found by equating the ratio of federal income and payroll taxes to state income and payroll taxes to the ratio of the federal offset (25%) to the state offset. When using the most recent 10 years of federal payroll and income tax data and state income tax data – in other words, assuming nationwide state payroll taxes are $0 – the state offset calculates to over 3%. It is likely that this offset is higher, because state payroll taxes are greater than $0. We retain the 3% rate here to be conservative in our estimate and because reliable, nationwide data for state payroll taxes was not available at the time of writing. Calculated using data from U.S. Bureau of Economic Analysis, Personal current taxes: Federal: Income taxes [B231RC1A027NBEA], retrieved from FRED, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/B231RC1A027NBEA, October 3, 2018 and U.S. Bureau of Economic Analysis, Federal Government: Tax Receipts on Corporate Income [FCTAX], retrieved from FRED, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/FCTAX, October 3, 2018.

[48] Static offsets for state excise and property taxes present technical challenges that are beyond the scope of this paper, so we do not consider them here. The elasticities of supply and demand needed to make a such a calculation for excise tax would be difficult to calculate reliably. The impact on property taxes would also represent a complex calculation. In either case, the federal crowding out effect would likely be small relative to the effects on sales and income taxes, although taxes on motor fuel would likely decline under the impact of a federal excise tax designed to reduce fuel consumption.

Figure 3.3.2-1: Projected Annual Static Burden to States (Billions 2015$)



Source: Model estimate using EIA Annual Energy Outlook 2016

Figure 3.3.2-1 shows the average annual static burden that flows through from the federal carbon tax to state budgets in years 2019-2028. Static burden consists of increased direct and indirect energy cost to states (8% of federal gross revenues) plus state income taxes reduced as a result of federal excise tax collections (3% of federal gross revenue). The burden on the states ranges from $18.93 billion to $30.70 billion in 2015$. State balanced budget requirements or credit rating constraints would require states to raise taxes or cut spending by this amount each year.

Figure 3.3.2-1 shows the effect flowing static costs equal to 11% of federal gross revenues through to the state and local governments for the 10-year period from 2019 to 2028. The costs range from $20.5 billion to $33.5 billion per year. For a state of median gross state product (GSP) representing about 1.0%-1.3% of national GDP, such as Kentucky, Alabama, South Carolina, Oregon, or Louisiana, the static costs would likely range from $198 million to $399 million per year, depending on the makeup of each individual state and the magnitude of carbon tax enacted.

3.3.3 Dynamic Costs Passed Through to the States

The dynamic costs passed through to states could vary greatly depending on macroeconomic variables and state-specific circumstances. They would be most pronounced during the early years of implementation when the macroeconomic dynamism due to the tax is greatest. That being said, a successful tax reform financed by a carbon tax that increases economic growth could actually cause state revenues to increase.

The economic literature generally shows that state revenues move directionally with national GDP, though not necessarily equally in magnitude or uniformly across states.[49] Transfer

[49] For example, see, Howard Chernick, Cordelia Reimers and Jennifer Tennant, "Tax structure and revenue instability: The Great Recession and the states." *IZA Journal of Labor Policy*. February 12, 2014.; Department of the

payments from the federal government provide a stabilizing influence. State sales tax revenues move in tandem with consumption of taxed goods. In 2013, when federal government transfer payments are included, 23% of total state revenues came from general sales and excise taxes.[50] State income taxes similarly move with wage income, which make up 18% of state revenues when federal government transfer payments are included.[51] It is possible for income and personal property taxes to remain relatively constant while personal consumption declines, due to consumer expectations of a coming recession; conversely, increased personal consumption may come at a time of depressed income and property taxes due to positive consumer expectations. Thus, the magnitude of state revenue changes is situationally dependent, and cannot be calculated from national GDP alone for individual states at a given time.[52]

While magnitude of effect on individual states is uncertain, we do know that in the aggregate, a decrease in purchasing power and a decrease in national revenues will lead to a decrease in state tax revenues. Even a small percentage shift in state revenues will have large ramifications for state budgets. The following estimates may be helpful as an illustrative guide. A temporary decline in GDP of 1% would be consistent with some of the modeling presented later. If national GDP declines by 1% and state income and sales tax revenue decline by 50 basis points, the nationwide decline in state revenues would total $3.415 billion. If GDP declines by 1% and state income and sales tax revenues decline by the same 1%, the decline in states' revenue would be $6.83 billion. Since levels of taxation vary by state, Table 3.3.3-1 shows scenarios for a representative number of states with median gross state product.

Census, "Recessions Matter for State Tax Collections," U.S. Department of Commerce. July 1993.; Norton Francis and Frank Sammartino, "Governing with Tight Budgets," Urban Institute. September 2015.; and Yankee Staff. "Where Has All the Money Gone? The 25th Anniversary of Connecticut's Income Tax." The Yankee Institute. August 26, 2016.

[50] About one-third of total state revenues come from intergovernmental transfers, the vast majority of which are from the federal government. See Urban Institute, "State and Local Revenues," n.d. (Accessed September 03, 2018). https://www.urban.org/policy-centers/cross-center-initiatives/state-local-finance-initiative/state-and-local-backgrounders/state-and-local-revenues.

[51] *Ibid*.

[52] *Ibid*.

Table 3.3.3-1: Dynamic Impacts on Median-GDP State Budgets

GDP Rank (2017)	State	State Revenue Decline from .5% Decrease in Sales and Income Taxes (Millions 2015$)	State Revenue Decline from 1% Decrease in Sales and Income Taxes (Millions 2015$)
22	Missouri	$58.27	$116.55
23	Connecticut	$72.36	$144.72
24	Louisiana	$42.90	$85.79
25	Oregon	$48.79	$97.59
26	South Carolina	$44.01	$88.03
27	Alabama	$45.36	$90.73
28	Kentucky	$51.58	$103.17
29	Iowa	$42.64	$85.28

Source: BEA 2017 Annual GDP by State

Table 3.3.3-1 shows impact on median gross state product (GSP) state budgets if combined income and general sales tax revenues were to decline .5% and 1%. A decline of .5% would cost eight median-GSP states individually between $42.64 and $58.27 million dollars per year. A decline of 1% would cost between $85.28 and $116.55 million dollars per year. Results for all 50 states are shown in the Appendix B. Millions 2015$.

3.3.4 State Balanced Budget Requirements

According to the National Conference of State Legislatures, 49 states have balanced budget requirements of some kind, and state political culture generally enforces those requirements.[53] States also face the fiscal discipline of credit ratings and pension obligations. States such as Illinois (S&P rated BBB) and New Jersey (A-) might be particularly at risk in the event of a sudden budget shortfall.[54]

Tables 3.3.4-1 and 3.4.4-2 show estimated static and dynamic costs that a carbon tax would impose on state budgets on average over the period from 2019 to 2028 compared to state budgets in 2017. State budget shortfalls resulting from the imposition of a federal carbon tax would likely be material. In Tables 3.3.4-1 and 3.3.4-2, we show possible static and dynamic losses to median-sized states. Assuming a .5% negative dynamic impact over time on state sales and income taxes, the total average annual budgetary impact of a $40 per ton carbon tax on the median-sized states listed in the table would range from $292.99 million to $469.70 million. Assuming a 1% negative dynamic impact on state sales and income taxes revenue, the total average annual budgetary impact would be $334.12 million to $535.63 million. For a tax of $49 per ton, assuming a dynamic impact of .5% on state sales and income tax revenue, the state budgetary impact would range from $381.75 million to $551.76 million. Assuming a negative dynamic impact on state sales and income tax revenue of 1%, the budgetary impact would range

[53] National Conference of State Legislatures, "NCSL Fiscal Brief: State Balanced Budget Provisions," Original publication October 2010. (Accessed September 2018).
[54] Susan K. Urahn, et al, "Rainy Day Funds and State Credit Ratings: How well-designed policies and timely use can protect against downgrades," *Pew Charitable* Trust, May 2017, pp. 10-12.

from $385.30 million to $617.68 million. Complete illustrative results for all 50 states are presented in Appendix B.

In order to meet their balanced budget requirements and protect their credit ratings, states would have to cut spending or raise taxes to cover these shortfalls. Alternatively, states may demand that the federal government share carbon tax revenues with them, in order to compensate them for the shortfalls as well as state options to raise revenue that are effectively foreclosed by the new federal tax.

Table 3.3.4-1: Static Plus Dynamic Impact on State Budgets, $40 Per Ton Tax (Millions 2015$)

State	State Share of Static Burden	Dynamic Effect - .5% loss in Sales and Income Taxes	Static Burden Plus 0.5% Dynamic Effect	Dynamic Effect - 1% loss in Sales and Income Taxes	Static Burden Plus 1% Dynamic Effect
Missouri	$403.77	$65.93	$469.70	$131.85	$535.63
Connecticut	$345.41	$56.40	$401.81	$112.80	$458.21
Louisiana	$326.13	$53.25	$379.37	$106.50	$432.62
Oregon	$312.82	$51.08	$363.90	$102.15	$414.98
South Carolina	$290.14	$47.37	$337.52	$94.75	$384.89
Alabama	$279.36	$45.61	$324.98	$91.23	$370.59
Kentucky	$268.18	$43.79	$311.97	$87.57	$355.75
Iowa	$251.87	$41.12	$292.99	$82.25	$334.12

Source: Model estimate using EIA Annual Energy Outlook 2016, BEA 2017 Annual GDP by State, U.S. Census State Government Tax Collections

Table 3.3.4-1 shows the impact on median-GDP states' budgets from the combined static burden of a federal carbon tax at $40 per ton and dynamic effects if income and sales tax revenues drop by .5% or 1%. Results for all 50 states are shown in the appendix. Millions 2015$.

Table 3.3.4-2: Static Plus Dynamic Impact on State Budgets, $49 Per Ton Tax (Millions 2015$)

State	State Share of Static Burden	Dynamic Effect - .5% loss in Sales and Income Taxes	Static Burden Plus 0.5% Dynamic Effect	Dynamic Effect - 1% loss in Sales and Income Taxes	Static Burden Plus 1% Dynamic Effect
Missouri	$485.83	$65.93	$551.76	$131.85	$617.68
Connecticut	$415.61	$56.40	$472.01	$112.80	$528.40
Louisiana	$392.40	$53.25	$445.65	$106.50	$498.90
Oregon	$376.40	$51.08	$427.47	$102.15	$478.55
South Carolina	$349.11	$47.37	$396.48	$94.75	$443.85
Alabama	$336.14	$45.61	$381.75	$91.23	$427.37
Kentucky	$322.68	$43.79	$366.47	$87.57	$410.25
Iowa	$303.05	$41.12	$344.18	$82.25	$385.30

Source: Model estimate using EIA Annual Energy Outlook 2016, BEA 2017 Annual GDP by State, U.S. Census State Government Tax Collections

Table 3.3.4-2 shows the impact on median-GDP states' budgets from the combined static burden of a federal carbon tax at $49 per ton and dynamic effects if income and sales tax revenues drop by .5% or 1%. Results for all 50 states are shown in the appendix. Millions 2015$.

Revenue sharing is a common solution to problems of vertical tax competition in countries with federal systems that employ a national sales, consumption, or value-added tax. A carbon tax could readily accommodate revenue-sharing without compromising its environmental goals. Money that goes to revenue sharing, however, would not be available for tax reform.

3.3.5 Revenue-Sharing Scenarios

We model three options for federal government revenue sharing with the states.

- Option 1 would be reimbursement to the states for the static costs that would flow through to them from a federal carbon tax. These static costs would equal 11% of federal gross revenues.

- Option 2 would be a reimbursement to the states for 19% of federal gross revenues, representing a one-half share of carbon tax revenues that originate with motor fuels. This would cover the 11% of federal gross revenues due to the states for static costs with a residual 8% to cover dynamic costs and provide states with transportation fuel related revenues that might be used for infrastructure costs.

- Option 3 would be for states to receive 11% of federal gross revenues in compensation for their static costs plus an additional 19% to represent a one-half share of carbon tax revenues that originate from motor fuels.

To compare these scenarios:

- Option 1 appears to be the minimum compensation the states could accept. However, it does not explicitly compensate states for revenue losses that flow through to the states on a dynamic basis, nor does it compensate states for the loss of the motor fuel excise tax base which has historically been assigned to the states for purposes of financing transportation infrastructure.

- Option 2 would compensate the states for their static costs and recognize the states' historic interest in the motor fuel excise tax base by assigning a 50% share of fuel-related revenues to them. Given that motor fuels represent 38% of total federal revenues from the carbon tax, a 50% share would equal 19% of federal revenues. This amount would compensate the states for the 11% of federal carbon tax revenues that in fact represent a transfer of tax revenue from the states to the federal government. The remaining 8% could serve in part to compensate the states for dynamic revenue losses and also provide states with residual revenue for transportation infrastructure projects that historically have been funded by gasoline tax revenues.

- Option 3 would be the option that most fully compensates the states. Allowing the states 11% of federal carbon tax revenues would compensate them for static costs. Dynamic costs, though difficult to estimate, might be deemed covered by the half-share of federal carbon tax revenues from motor fuels. But this would total 30 cents on the dollar of federal carbon tax revenues that would go to the states as reimbursement and would thus not be available to finance revenue-neutral tax reform.

Table 3.3.5-1 shows how federal government revenue sharing with the states would affect the amount of revenue available for tax reform under all three options. No explicit allowance is made for dynamic effects. The calculations assume no tax increase for the lowest two income quintiles of taxpayers. Under Option 1, 32% of carbon tax revenues raised would be available for tax reform, as was demonstrated earlier in the paper. Under Option 2, 24% would be available for tax reform. Under Option 3, 12% would be available for revenue-neutral tax reform.

Table 3.3.5-1: Revenue-Sharing Scenarios to Address Vertical Tax Competition for Motor Fuel Revenues

Option	1	2	3
JCT offset	25%	25%	25%
Low-income offset	27%	27%	27%
Federal energy costs	5%	5%	5%
State energy costs	8%	8%	8%
State income offset	3%	3%	3%
Net share motor fuels revenue	0%	8%	19%
Dynamic costs	0%	0%	0%
Total offsets	68%	75%	87%
Net revenue	**32%**	**25%**	**13%**

Table 3.3.5-1 shows three ways to compensate states for their increased costs and lost revenue opportunities as a result of the federal carbon tax. Option 1 would compensate states simply for their increased direct and indirect energy costs, equal to 8% of federal gross carbon tax revenues, plus an offset against state income tax revenue equal to 3% of federal gross carbon tax revenues. Total reimbursement to the states would be 11% of federal carbon tax gross revenues. Option 2 would give the states an equal share of federal carbon tax revenues from motor vehicle fuels, totaling 19% of federal carbon tax revenues. This would cover the static burden of 11% with a resulting 8% of federal gross revenues left over to finance state highway programs. A third option would be to reimburse the states for their static costs and allow the states an equal share in tax revenues that derive from motor fuels. Option 1 leaves 32% of gross revenue available for tax reform and other purposes. Option 2 leaves 25% of gross revenue available. Option 3 leaves only 13% of gross revenue available. We do not estimate here the costs of dynamic revenue loss to the states. Adding compensation for that would further reduce the percentage of carbon tax revenues available for tax reform.

3.3.6 Vertical Tax Competition in Infrastructure Finance

Vertical tax competition occurs when different levels of government compete for the same tax revenue. The problem is particularly acute in the case of infrastructure finance. At a time when increased spending on transportation infrastructure is an urgent domestic policy priority, a federal carbon tax that is in large measure a tax on transportation fuels would likely pre-empt the states' ability to pay for new bridges, roads, and highways by raising their own transportation fuel excise taxes for a period of many years.

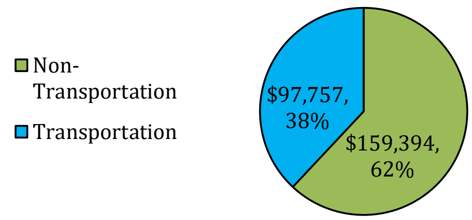
The problem becomes worse when, absent some form of revenue sharing, states are forced to increase other taxes to cover the budget shortfalls that would result from the costs that a federal carbon tax would push through to the states.

Historically in the United States, both the federal government and the states have raised revenue from excise taxes on transportation fuel. However, the ratio of tax revenue raised is currently 60/40 in favor of the states, with the federal revenues ultimately directed to the states to finance state building programs in transportation infrastructure.

As noted previously, a federal carbon tax is in large measure a transportation fuels excise tax, with about 38% of all revenues coming from transportation fuels, as shown below. The carbon tax scenarios studied in this paper would add incremental new taxation to motor fuels that is greater than the existing level of state taxation.

The Carbon Tax is Pre-Eminently a Transportation Fuels Tax

The carbon tax is pre-eminently a tax on motor fuels. In this breakout of CTAM data, we see that 38% of carbon tax revenues are derived from transportation fuels. This puts the carbon tax in direct competition with existing federal and state excise taxes on motor fuels. Historically, revenues collected from the federal and state excise taxes on gasoline and diesel fuel have directed to the states to finance highway construction. But under the carbon tax, incremental new revenue goes to the federal government and vertical tax competition may forestall state efforts to raise their own taxes.



Source: Model estimate using EIA Annual Energy Outlook 2016

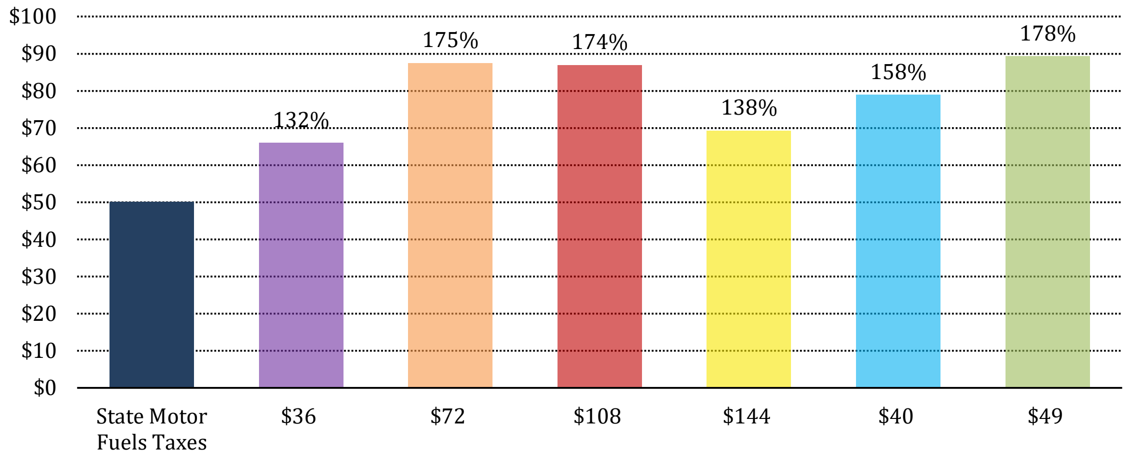
To take gasoline as an example, the current national average of combined state excise and sales taxes applied to a gallon of gasoline expressed in 2015 dollars is 32 cents.[55] When fully phased in, the carbon taxes studied in this paper would impose additional federal levies in amounts ranging from 32 cents to $1.28 per gallon, or anywhere from one time to four times the existing state taxes on gasoline.

The federal carbon taxes we study would invert the historical ratio of taxation, making it at least 60/40 in favor of the federal government, or even more so, assuming a carbon tax that starts higher than $40 per ton, with incremental revenue going not to the states but to the federal government.

To look at the ratio of taxes collected in another way, Figure 3.3.6-2 shows the ratio of total federal taxes collected on gasoline (the carbon tax plus the transportation fuel excise tax) compared to state excise taxes collected on gasoline. The federal government would collect revenues that range from 32% to 78% higher than the states collect.

[55] American Petroleum Institute, "Gasoline Tax," n.d. Accessed October 19, 2018.

Figure 3.3.6-2: State and Federal Tax Revenues from Motor Vehicle Fuels Compared (Billions 2015$)



Source: U.S. Census Bureau, 1998-2017 Annual Surveys of State Government Tax Collections by Category and model estimate using EIA Annual Energy Outlook 2016

Figure 3.3.6-2 shows that when a carbon tax is included, federal tax excise tax revenues from motor fuels range from 132% to 178% of current revenues to the states from sales of motor fuel. Today, states collect 60% of revenues from motor fuels and all revenue collected eventually goes to states. In the phased-in $144 tax scenario, the ratio flips and 64% of average annual tax revenue for motor fuels goes to the federal government during the first 10 years, with all incremental new tax revenue going to the federal government. Annual projected annual tax revenues 2019-2028 in million 2015$.

State options to finance transportation infrastructure would suffer for two reasons. First, as demonstrated in a previous section of this paper, a federal carbon tax would pass through to the states an annual cost burden that ranges from $18.9 billion to $30.7 billion on average, depending on the scenario, for each of the first 10 years of the tax. Without some form of revenue sharing, the states, collectively, would need to cut spending or raise taxes by at least this amount every year. The pressure on general revenue spending will inevitably flow through to transportation spending as well. In 2011, state and local general revenue financed 20% of state and local spending on roads and highways, while state and local fuel taxes covered 27% of spending, and other sources of revenue (automobile taxes, tolls, and federal funding) covered the rest.[56] Second, the option to raise transportation funding through new fuel taxes will either not exist for most states or be greatly impaired after the federal government imposes new federal taxes that are substantially larger than existing state and local taxes on motor fuel. Between 2012 and 2017, 22 states raised gasoline taxes, but it is worthy of note these tax increases were comparatively small, often paired with tax cuts, or imposed at times of historically low gasoline prices.[57] They also occurred roughly two decades or more after the last federal tax increase on

[56] Jospeh Henchman, Gasoline Taxes and User Fees Pay for only Half of State and Local Road Spending, "Tax Foundation Fiscal Fact, January 6, 2014.

[57] Daniel Vock, "Raising the Gasoline Tax is No Longer Taboo in Many States," Governing, May 8, 2017. Cameron McWhirter, "States Push to Raise Gasoline Tax," Wall Street Journal, February 21, 2017.

transportation fuels in 1993. During the 25 years since the federal government has increased the gasoline tax, CBO estimates that inflation has eroded its value by two-thirds.[58]

If the federal government dramatically increases the rate of federal taxation on the use of motor fuels though an economy-wide carbon tax with far-reaching consequences, states could reasonably demand compensation from the federal government for their increased costs, reduced revenue, and the foreclosure of their future revenue-raising options by a federal government intrusion on an excise tax revenue base that historically has been left mostly to the states. The revenue-sharing options described in Section 3.3.5 represent possible ways to address state concerns.

The Carbon Tax as a Gasoline Tax

A carbon tax expressed in dollars per metric ton of CO_2 is also a tax on gasoline expressed in dollars and cents per gallon of gasoline. About 38% of carbon tax revenues come from taxes on transportation fuel. The current federal excise tax on gasoline is 18.4 cents per gallon. The current federal excise tax on diesel fuel is 24.4 cents per gallon. State excise taxes average 28.62 cents per gallon of gasoline and 30.21 cents per gallon of diesel. The total average federal and state tax per gallon is 47.02 cents for gasoline and 54.61 for diesel.

The chart below shows additional federal excise tax per gallon of gasoline due to a carbon tax. Even a carbon tax as low as $36 per ton would nearly triple the amount of federal excise tax on per gallon of gasoline and result in total federal excise taxes per gallon more than twice as high as states collect. Higher carbon taxes would result in the relative share of transportation fuel excise taxes going to the federal government becoming still greater.

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
10-Year Average	$0.34	$0.56	$0.58	$0.39	$0.43	$0.53
Year 2028	$0.35	$0.71	$1.06	$0.71	$0.47	$0.57
Terminal Value	$0.35	$0.71	$1.06	$1.41	$0.59	$0.73

Source: Capital Alpha Estimate, EIA

[58] Congressional Budget Office, *Options for Reducing the Deficit: 2017 to 2026*, Option 36 "Increase Excise Taxes on Motor Fuels by 35 Cents and Index for Inflation," December 8, 2016. As an interesting side note, the current level of combined federal, state, and local taxation on motor fuels, if expressed as a carbon tax, work out to nearly $50 per ton, or an approximate estimate of the social cost of carbon. See Will Pack and Steven Lee, "Carbon Taxes on Transportation Fuels: Estimating the Effective Carbon Tax from Excise Taxes," EPRINC Note, Energy Policy Research Foundation, Inc., April 2017.

[59] U.S. Energy Information Administration, "How much tax do we pay on a gallon of gasoline and a gallon of diesel fuel?" September 7, 2018. Accessed September 24, 2018.

4. Tax Reform Options

In the following sections, the study considers the macroeconomic effect of a carbon tax when used as a revenue raiser for tax reform and other public spending purposes.

The modeling is performed with the REMI PI+ model[60] using tax revenues calculated as before by applying CTAM to the AEO 2016 No CPP-generated emissions baseline. We apply 75% of gross revenues to a variety of revenue-recycling strategies.

We consider five simple revenue-recycling strategies, in which all resources are directed to a single recycling strategy, and three mixed recycling strategies, in which resources are directed to a combination of strategies.

Overall, our results are consistent with theory and other published modeling with similar parameters. Using carbon tax revenues to finance corporate tax reform can produce modestly better than break-even results. Using carbon tax revenues to finance other tax reforms will generally result in economic losses. The losses may appear small from year to year, but they compound over time, with negative implications for federal, state, and local government finances, as well as for individual taxpayers and consumers.

4.1 Modeling Considerations

The PI+ model is a dynamic, multi-region model which integrates input-output, computable general equilibrium, econometric, and economic geography methodologies. The underlying mechanics of the PI+ model are based on decades of peer-reviewed literature.[61] The model is widely used in in both the private and public sectors, including use by state governments.[62] PI+ can forecast the economic impact of public policy and proposed legislation on the private sector economy. Forecast variables include levels of private sector employment and real output. By comparing simulation results for scenarios which include proposed or yet-to-be-implemented policy changes with the model's baseline forecast, PI+ is able to obtain estimates of how these policy changes might impact the economy. In order to determine the policy shock to be assessed by PI+, we use CTAM to calculate carbon tax revenues based on fossil fuel consumption projections in the EIA Annual Energy Outlook 2016 No CPP (No Clean Power Plan) case.

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[60] REMI PI+ Eastern and Western U.S. v2.0.4.

[61] See "REMI PI+ Model Equations," p 55, http://www.remi.com/wp-content/uploads/2017/10/Model-Equations-v2_0.pdf.

[62] See projects here: https://www.remi.com/news-list/

4.1.1 Modeling Issues

There are two issues that might impact our modeling results. One is overallocation of resources to revenue recycling, which means we assume that more revenue is available for revenue recycling than is actually the case and would apply an upward bias to our results. The other is the effect of tax changes made in the Tax Cuts and Jobs Act (TCJA) of 2017, which could apply a downward bias to our results to the extent that overallocation of resources does not completely offset it.

Overallocation

The study was designed to produce possible results for revenue recycling using the proceeds of a carbon tax. To do this, we recycle 75% of gross revenues. The only deduction from gross revenues we make is JCT's standard 25% offset. We make no allowance for increased direct and indirect energy costs to federal, state, and local government; no allowance for a static offset against state and local income tax revenues; and no allowance for a set-aside to protect low-income taxpayers from a tax increase. As demonstrated earlier, making these allowances would reduce the available net proceeds from a carbon tax to 32% of gross revenues. By assuming that 75% of gross revenue is available when the actual amount is 32% or less, we overallocate available net revenue by a factor of 2.34 to 1. This means that in our modeling of corporate tax reform, for instance, our results should be particularly strong, if not overstated. In cases where a low-income set-aside might be part of revenue recycling, such as a lump-sum rebate, the amount of available net revenue would increase from 32% to 59% of gross receipts. By assuming that 75% of gross revenue is available for revenue recycling when the actual amount is 59%, we overallocate resources by a factor of 1.27 to 1. Thus, our results for revenue recycling by means of a lump-sum rebate should also be strong, but not as overstated as those for corporate tax reform.

In a truly revenue-neutral tax reform, the federal government and the states would have to raise taxes or cut spending in order to make up the shortfall in available net revenue between the 75% that we model and the amount that would actually be available. However, we assume that the federal government can simply deficit finance the shortfall with negligible effects on growth during the study period. We also assume that Congress is unlikely to finance tax relief for corporations with a tax that has regressive impact on the poor and includes an increase in the gasoline tax for all taxpayers that essentially doubles the existing level of combined federal, state, and local taxation on motor fuel.

The Tax Cuts and Jobs Act

We performed our modeling in the summer of 2017, before Congress passed the TCJA. The changed imposed by the TCJA are not included in our modeling assumptions. The TCJA provided for temporary reductions in the individual income tax that expire in 2025. It provided certain temporary tax relief for businesses as well, such temporary bonus depreciation that expires after a phase down in 2026. The TCJA made no change in the individual capital gains tax. The TCJA additionally made permanent changes in the corporate tax code, including a reduction in the statutory corporate tax rate from 35% to 21%, the elimination of many business tax deductions, a change in international taxation of business from a worldwide to a territorial basis, and the imposition of new rules to curb profit-shifting overseas.[63]

A discussion of the implications of the TCJA for a carbon tax depends on how much the TCJA changes the average effective rate of taxation on the factors of production, which is the basis for calculating the tax wedge that impacts the economy. For one estimate, we turn to JCT. Prior to the tax reform, JCT determined the average effective marginal rate of taxation for income and payroll taxes to be 25.9% in 2017, rising over time to 26.1% in 2027.[64] After the tax reform, JCT determined the rate to be 21.5% in 2018, when the temporary provisions of the TCJA take effect, and rising as the temporary provisions expire to 24.4% in 2028.[65]

In its *Budget and Economic Outlook: 2018 to 2028*, CBO calculated that the effective marginal tax rate on labor income in 2018 was 2.2 percentage points lower than it would have been under prior law but actually .1 percentage point *higher* by 2028 than it would have been under prior law.[66] This is significant, since the forecast period of this study goes to 2040. CBO calculated that the effective marginal tax rate on capital income would be 1.8 percentage points lower in 2018 and would decrease by 3.4 percentage points in total by 2021, but it would end the period in 2028 only 1.5 percentage points lower than it would have been under prior law.

In general, CBO found that the tax reform would have its greatest impact in the middle years of that time period. CBO found that the effective marginal tax rate on all forms of business was reduced by 5.7 percentage points in 2018 but only 1.5 percentage points by 2028. The effective marginal tax rate on C corporations was reduced by 7.4 percentage points.[67]

On the whole, the overall tax rate reductions achieved by the TCJA are significant but more modest than might be supposed after simply examining the 14-point reduction in the statutory tax rate for C corporations alone.

If we consider what the TCJA means for a subsequent corporate tax reform which is financed by a carbon tax, a lower corporate tax rate to begin with would mean that companies have more after-tax income to invest and a higher equilibrium capital stock during the period under discussion, so that investments pursuant to a further round of tax reform would be more productive and thus increase output more than would be possible after equivalent tax reform at the previous, higher rate. The lower rate of corporate taxation would also mean a reduction in the tax interaction effect, described later. A tax reform or tax swap that does not include corporate tax reform would also benefit from the structural tax changes made by the TCJA, but to a lesser degree.

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[63] Congressional Budget Office, "The Budget and Economic Outlook: 2018 to 2028," Appendix B, April 2018.

[64] Joint Committee on Taxation, "JCX-5-17: New Income and Payroll Tax Offsets to Changes in Excise Tax Revenues for 2017-2027," U.S. Congress, February 09, 2017.

[65] Joint Committee on Taxation, "JCX-8-18: New Income and Payroll Tax Offsets to Changes in Excise Tax Revenues for 2018-2028," U.S. Congress, March 27, 2018.

[66] CBO, "The Budget and Economic Outlook: 2018 to 2028," April 2018. See "Tax Parameters and Effective Marginal Rates,"https://www.cbo.gov/about/products/budget-economic-data#10.

[67] Congressional Budget Office, "Tax Parameters and Effective Marginal Tax Rates," Budget and Economic Data, April 2018.

To the extent that overallocation of resources to revenue recycling by a better than 2-to-1 margin fails to completely compensate for the beneficial effects of the TCJA supporting a future tax reform, macroeconomic results for a future tax reform would be more positive on the upside and less negative on the downside, consistent with the TCJA's modest changes in marginal effective rates in its later years. The overall effects are likely to be small in relation to the economy as a whole, as suggested by other published modeling, which generally shows only slight changes in GDP, either positive or negative, across a wide variety of scenarios.[68] The broad policy conclusions of this study are not likely to be affected, nor is there any effect on our non-macroeconomic estimates, such as static tax burdens, static burdens on the states, vertical tax competition, and tax-for-regulatory swaps.

4.2 Theory

The carbon tax acts as a price shock to the economy that causes GDP, wages, profits, employment, and other economic indicators to decline for a period of time as the economy undergoes a complex rebalancing process. A technical problem of profound importance is the specification of an optimal tax, which produces the greatest possible reduction of CO_2 emissions at point where benefits exceed cost, which can be calculated from a pure GDP perspective or a more comprehensive welfare framework. It should be noted that the Social Cost of Carbon is not necessarily identical with the optimum tax, and that revenue scorekeeping under the Budget Act is done from a pure GDP, not welfare, perspective. Finally, the tax interaction effect describes the way that increased costs from an excise tax flow through to labor and capital income, raising the marginal tax rates that apply to factor income and compounding the effects of existing tax and regulation.

4.2.1 Theoretical Discussion

When considering the theory underlying a carbon tax, the first-order effects are straightforward. By increasing the price of carbon-emitting goods, the tax will decrease the consumption of those goods. Thus, carbon emissions decline. The revenues from the tax can be used for any number of things, from paying down the national debt to rebating taxpayers for their increased expenditures. Some amount of deadweight loss, or loss of economic efficiency, ensues. The

[68] See Jared Carbone, Richard Morgenstern, Roberton Williams III and Dallas Burtraw, "Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts." Resources for the Future, August 2013.; Marc Hafstead, Lawrence H. Goulder, Raymond J. Kopp, and Roberton C. Williams, III, "Macroeconomic Analysis of Federal Carbon Taxes," Resources for the Future, June 13, 2016.; Anne E. Smith, David Harrison, et al., "Economic Outcomes of a US Carbon Tax," NERA Economic Consulting, prepared for National Association of Manufacturers, February 26, 2013.; Noah Kaufman and Kate Gordon, "The Energy, Economic and Emissions Impact of a Federal US Carbon Tax," Columbia SIPA Center on Global Energy Policy, July 2018; and Henry Jacoby, David Montgomery, and Mei Yuan, "Next Steps in Tax Reform," MIT Joint Program on Climate Change, Report 329, April 2018; Congressional Budget Office, "The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions," September 2009.

amount of the deadweight loss is necessarily greater than zero, but the magnitude depends on how sensitive producers and consumers are to relative price changes.

The higher-order effects are more complex. Because much of the economy is in some way dependent on carbon emissions, the prices of most goods will rise upon the imposition of a carbon tax. The rise in price level will have two related effects: increasing inflation and decreasing purchasing power. In response, savings and investment decline, as does the supply of labor. Ultimately, national productivity and GDP decline.[69]

Some amount of investment decline will be mitigated by investment in lower-emissions technologies. As companies are motivated to save money by decreasing their carbon intensity, they will choose to invest, on the margin, in greener technology. This investment in green technologies will provide some level of productivity boost as well as emissions reductions.

Some amount of GDP boost will also come during the period after the tax is proposed but before it is levied, as economic actors anticipate the coming price changes and choose, on the margin, to purchase goods that they may have otherwise waited to purchase. This will temporarily boost consumption and GDP. It will also temporarily boost emissions, as carbon-intensive goods will become more attractive to purchase before their pending price increase.

The labor market will also shift in response to new levels of relative demand due to the carbon tax. Carbon intensive goods are now relatively more expensive and will be purchased less than before the tax. As consumption shifts away from carbon-heavy goods, employers will require fewer workers for those carbon-heavy goods.

The cost of this tax will fall largely upon existing owners of fixed capital and fossil fuel supplies. The cost will be realized primarily in the form of lower profits, but also in the need to upgrade fixed assets more quickly than anticipated. Because the tax burden falls heavily on capital owners, households and businesses have less incentive to reduce emissions in response to the tax.[70]

The fixed capital already owned within the economy may make current production methods sticky, depending on the level of the tax levied. If the tax is low enough that absorbing the increased emissions payments is still less expensive than upgrading to less carbon-intensive production methods, then production methods will not be upgraded.

As mentioned above, taxation necessarily leads to deadweight loss. The magnitude of the deadweight loss, as well as on whom the burden of the cost falls, depends on elasticities of supply and demand. That is, how much producers and consumers each lose due to the tax depends on how much their willingness to produce or pay for a good changes with price.

In addition to the deadweight loss that occurs in the frictionless world of theory, some loss will also occur due to government leakages and loss. Those leakages include anything that prevents

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[69] For a graphical explanation of the economic effects of a carbon tax, see CBO, "Effects of a Carbon Tax on the Economy and the Environment," May 2013, p. 7, Figure 1.
[70] Ibid., p. 8.

the revenues available from being lower than the revenues due. Sources of loss include operating costs, costs of enforcement, and collection costs. Noncompliance could also be included. These losses and leakages mean that the total gross revenues of the carbon tax are not available for recycling; only some smaller amount would be available for a taxpayer rebate or any other recycling method, unless additional money was taken from another revenue source or was borrowed from future revenues. If money was borrowed from future revenues for the purpose of revenue recycling, that would increase the net present cost of the tax policy due to the increased burden of future debt.

If the revenue raised from the tax is devoted to reducing the federal debt, it may have a positive effect on the economy in the long run. High federal debt generally leads to lower productivity in the long run.[71] Reducing the federal debt will decrease the net present cost of the tax and may also increase long-run productivity.

Because the carbon tax is not enacted in an economy free of existing distortions, the tax interaction effect will compound the cost of the carbon tax. In an optimal setting without existing distortionary taxes, the optimal carbon tax would be the Pigouvian level, or the level at which the value of the tax is exactly equal to the value of the marginal cost of polluting. However, with the presence of distortionary taxes, the carbon tax exacerbates the distortions created by the existing taxes. In the case of labor, for example, the carbon tax raises the prices of goods and services, and thus decreases income tax revenues by decreasing the purchasing power of wages and thereby decreasing the supply of labor. This interaction can have substantial impacts on government budgets, especially in the presence of balanced budget requirements. Thus, the optimal level of the carbon tax is below the Pigouvian level in order to balance the goal of the carbon tax with the adverse interaction effects due to existing taxes.[72] Even if the revenues from the carbon tax are recycled to decrease or eliminate income tax (a tax on labor), the optimal tax rate will be below the Pigouvian rate. In fact, the tax interaction is so strong that it in some cases could push the optimal tax rate below zero.[73] Without accounting for the tax interaction effect, any estimate for the optimal carbon tax rate will be biased upward.

In addition to the distortionary effects and uncertainty that comes with setting a carbon tax rate, a country-specific carbon tax cannot be fully efficient at reducing carbon emissions. The global nature of carbon emissions causes a tax enacted in only one country to be inefficient and relatively ineffective at reducing global emissions and atmospheric carbon levels. CBO estimates that anywhere between 1% and 23% of emissions reductions resulting from a U.S. carbon tax will be offset by increased emissions in other parts of the world.[74]

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[71] *Ibid*, p. 2.

[72] A. Lans Bovenberg and Lawrence H. Goulder, "Optimal Environmental Taxation in the Presence of Other Taxes: General-Equilibrium Analyses," *American Economic Review*, American Economic Association, vol. 86(4), p. 988, September 1996.

[73] *Ibid*, p. 994.

[74] CBO, "Effects of a Carbon Tax on the Economy and the Environment," p. 15.

4.2.2 Tax Reform Financed by a Carbon Tax

The goal of tax reform is to create the least distortionary tax system overall. In general, excise taxes are distortionary taxes. A carbon tax, which is an excise tax on a primary industrial input and major consumer good with as-yet limited and imperfect substitutes, would be particularly distortionary. In order for tax reform to succeed, other distortionary taxes, such as capital income taxes, would need to be reduced enough to overcome the distortionary effect of the carbon tax.[75]

In most of this paper, we have emphasized that the carbon tax is not an efficient revenue raiser for tax reform because the net revenue it raises is reduced from gross revenue by a number of offsets which can be calculated on either a static or dynamic basis.[76] We assume in our modeling that useful net revenue from a carbon tax will equal 75% of gross proceeds even though the actual percentage could be lower.

However, a carbon tax is also an inefficient revenue raiser for tax reform because its collateral effects work against the goals of tax reform. If we consider, for instance, the economic shock that results from the imposition of a carbon tax, causing the economy to contract, then a certain amount of net revenue would need to be recycled before a tax reform can contribute to incremental economic growth. In other words, tax reform must undo the negative impact of a carbon tax before it contributes to a positive result on balance.

From a more analytical perspective, we can look at the impact of a carbon tax in the tax interaction effect as it flows through to create higher marginal tax rates on factor income to capital and labor. If the goal of tax reform is to reduce marginal tax rates that apply to labor income on the one hand and income from savings and investment on the other, then the revenue from a carbon tax that is available after accounting for various forms of deadweight loss must be directed to eliminating the increase in marginal tax rates that has occurred before it can reduce them. Tax reform financed by a carbon tax is thus two steps back before the one step forward: deadweight loss and increased marginal tax rates must be overcome before successful pro-growth tax reform can proceed.

Our modeling and that of others cited in this paper show that modestly pro-growth tax reform financed by a carbon tax is possible with revenue recycling that focuses on reducing marginal tax rates to labor income and particularly to capital income, where the elasticities of supply are greater. By contrast, revenue recycling which does not target marginal tax rate reductions, such as lump-sum rebates or infrastructure spending is less effective in overcoming the negative impact of a carbon tax and does not contribute to pro-growth tax reform. Similarly, protecting low-income taxpayers from a tax increase may be a worthy and indispensable goal, but it also reduces revenue available for lowering marginal tax rates on labor income across the board or reducing marginal tax rates on savings and investment.

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[75] Carbone, et al, “Deficit Reduction and Carbon Taxes,” p. 7.
[76] For dynamic estimates see *supra,* n. 16.

Our modeling suggests that both the amount of net revenue available for tax reform and the way it is recycled matters greatly. We devote 75% of gross revenues to corporate tax relief in some modeling runs and find that GDP increases relative to the reference case by only about 1% or less. In modeling runs that apply less than 75% of gross revenues to corporate tax relief, the effect on GDP is negative. If, in practice, the total amount of gross revenue available to finance tax reform is substantially less than 75%, no matter how the reform is devised, then a tax reform that is truly pro-growth will be difficult to achieve.

4.3 Simple Revenue-Recycling Strategies

We consider five simple revenue-recycling strategies. In each of the strategies, we assign 75% of gross revenue to a single application. The strategies are:

- Corporate Tax Relief
- Debt Reduction
- Infrastructure Spending
- A Lump-Sum Rebate to taxpayers
- Personal Tax Reduction

4.3.1 Corporate Tax Relief

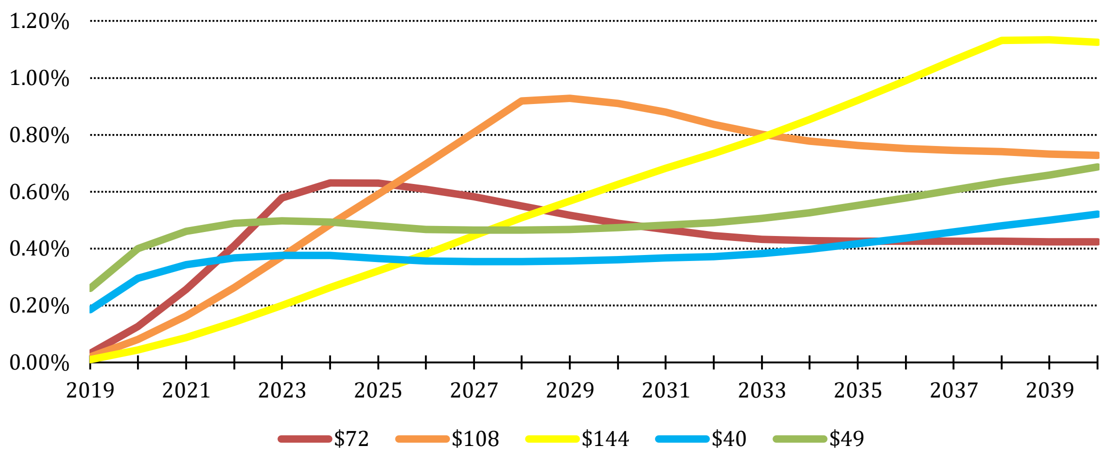
Corporate tax relief delivers the most economically positive results of any revenue-recycling strategy. Even so, the results are only slightly better than break-even. Figure 4.3.1-1 shows the level of absolute GDP relative to the reference case for our entire forecast period.

In no case does GDP improve relative to the reference case by more than 92 basis points during the first 10 years. In only one case does GDP improve relative to the reference case by more than 100 basis points at any point during the entire forecast period.

In most cases, GDP improves, but by less than 60 basis points over the first 10 years and less than 80 basis points over the first 22 years. The $49 carbon tax scenario with all net proceeds directed to corporate tax reform results in improved GDP by 47 basis points over the first 10 years and by 69 basis points over the first 22 years. The $40 carbon tax scenario with all net proceeds directed to corporate tax reform results in improved GDP by 36 basis points over the first 10 years and by 52 basis points over the first 22 years.[77]

[77] For purposes of comparison, Carbone, et al., p. 8, find a that a carbon tax of $30 per ton with revenues recycled to capital income tax cuts starting in 2012 results in GDP slightly more than 1% higher by 2025 in "Deficit Reduction and Carbon Taxes."

Figure 4.3.1-1: Corporate Tax Relief: GDP Impact (% Change from Baseline)



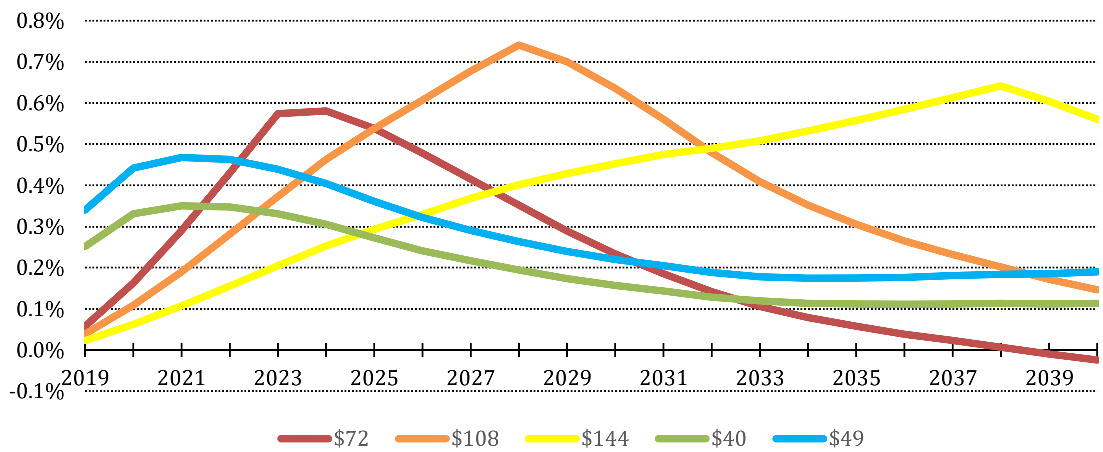
Source: Capital Alpha Estimate

Figure 4.3.1-1 shows GDP impact of corporate tax relief as a revenue-recycling strategy. The maximum possible amount of carbon tax gross revenues (75%) is applied to recycling. Results show absolute GDP relative to the reference case. Only one scenario has projected GDP more than 1% higher than the reference case after 22 years. This is the phased-in tax of $144 per ton. As the biggest carbon tax, it finances the greatest tax relief.

The best outcomes result from the phased-in taxes of $108 and $144 per tone, which start out slowly but ultimately allow for the greatest amount of corporate tax relief. The phased-in tax of $108 per ton results in GDP that is 93 basis points higher than the reference case in 2028. The phased-in tax of $108 per ton results in GDP that is 1.13% higher than the reference case in 2040.

In Figure 4.3.1-2, we see similar results for employment when all available net revenue is directed toward corporate tax relief. In no case is employment worse than the reference case, except in one scenario in the last year of our forecast period. In five out of six cases, employment improves by no more than 60 basis points relative to the reference during the first 10 years, but it is markedly weaker, though still positive, during the remainder of the forecast period. We see the best overall performance from the phased-in $108 and $72 per ton tax scenarios, where the outcomes are mostly positive on the margin but essentially break-even in that they are never outperform the reference case by more than 75 basis points.

Figure 4.3.1-2: Corporate Tax Relief: Employment Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.3.1-2 shows the employment impact of corporate tax relief as a revenue-recycling strategy. The maximum possible amount of carbon tax gross revenues (75%) is applied to recycling. Results show absolute employment numbers relative to the reference case, not annual growth. Positive employment impacts are in no case greater than 70 basis points.

In Table 4.3.1-1, we assess the results of slight but sustained overperformance relative to the reference case in the first 10 and 22 years. Cumulative constant-dollar GDP increases by as much as $993 billion over the first 10 years and by as much as $3.56 trillion over the full forecast period.

Table 4.3.1-1: Corporate Tax Relief: Cumulative Impact (Billions 2015$)

	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
10-year GDP Gap	$979.68	$992.93	$542.24	$727.99	$979.37
NPV, 10-Year GDP Gap	$708.30	$691.85	$377.37	$557.04	$740.76
NPV, 10-Year GDP Gap as a % of 2019 GDP	3.56%	3.48%	1.90%	2.80%	3.72%
22-year GDP Gap	$2,409.20	$3,561.43	$3,438.71	$2,108.02	$2,785.89
NPV, 22-Year GDP Gap	$1,355.41	$1,859.70	$1,628.83	$1,158.36	$1,533.55
NPV, 22-Year GDP Gap as a % of 2019 GDP	6.81%	9.35%	8.19%	5.82%	7.71%

Source: Model estimate using EIA Annual Energy Outlook 2016

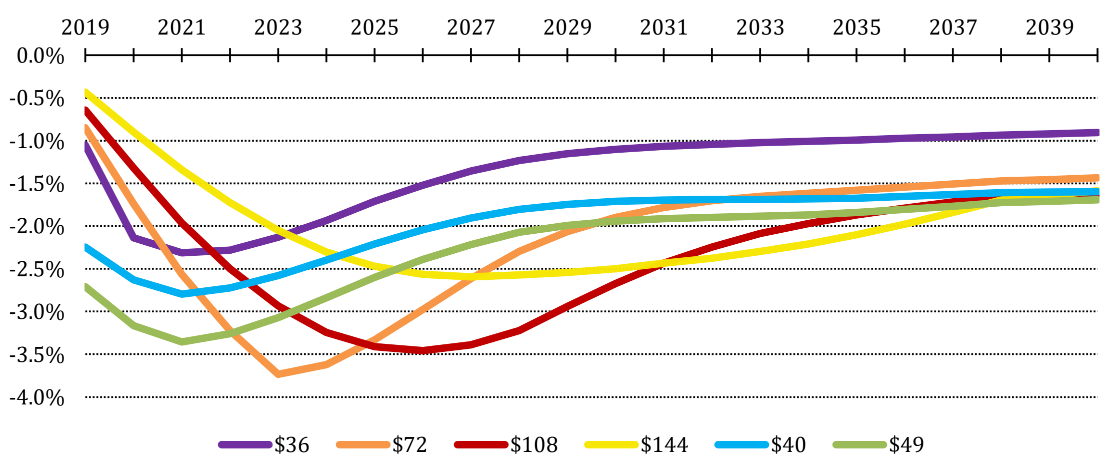
Table 4.3.1-1. The cumulative effects of corporate tax relief as a revenue-recycling strategy are positive but modest. Cumulative GDP relative to the reference case improves by as much as $992.93 billion over 10 years. This would be 3.48% of reference-case 2019 GDP in NPV terms. Discount rate 5%.

4.3.2 Deficit Reduction

If corporate tax relief offers the most positive results, theory tells us that deficit reduction should offer most negative results, because in the near term it amounts to restrictive fiscal policy.[78]

Our modeling results confirm this expectation. In Figure 4.3.2-1 we see GDP is reduced relative to our reference case by between 2% and 4% in all scenarios within 4 years of implementation. GDP recovers much of its loss relative to the reference case by 2028, but even at the end of the forecast period, GDP remains about 1.5% lower than the reference case in five out of six scenarios. To look at the depth of recession another way, GDP is reduced relative to the reference case by more than 2% for a period of more than 7 years in every case but one. In some cases, it is nine years or longer. To make a real-world comparison, we might consider the Great Recession from December 2007 to June 2009, during which GDP fell 4.3% from its peak in 4Q2007 to its trough in 2Q2009.[79]

Figure 4.3.2-1: Deficit Reduction: GDP Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.3.2-1 shows the effect of using the maximum available carbon tax gross revenues (75%) for deficit reduction. Steep and lasting recession is the result. Chart shows reduced GDP relative to the reference case.

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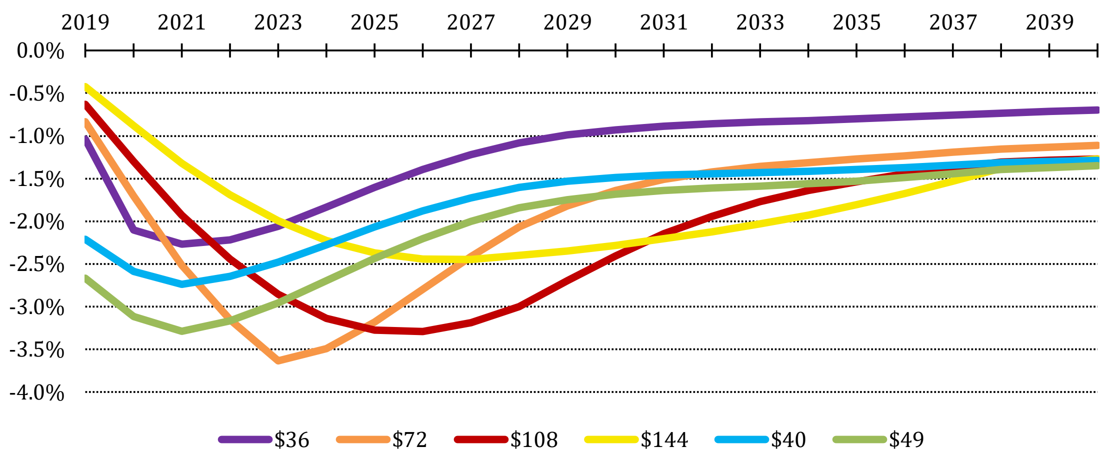
[78] This is not a pure deficit-reduction scenario, since to be precise, reducing the deficit should lead to lower interest rates, which over the long term can stimulate growth. However, we assume that over our study period, the effect, if any, would be slight and do not model it in our study. Since all revenues are assigned to deficit or debt reduction, it might also be considered a "no recycling" scenario, in which case it highlights the need for effective mitigation as demonstrated, for better or worse, by the other recycling strategies considered.

[79] Robert Rich, "The Great Recession," *Federal Reserve History*, originally published November 22, 2013 (Accessed September 2018).

In Figure 4.3.2-2, we see that employment effects largely mirror the GDP effects, with steep initial losses followed by a recovery over time, but also with a gap relative to the reference case that never fully closes. In five out of six cases, employment is reduced relative to the reference case by approximately 1.5% or more at the end of the forecast period. In terms of absolute numbers, peak-year job losses range from 4.5 million to 6.5 million. For purposes of comparison, we note that during the Great Recession, total employment as measured by the Current Population Survey declined by 8.6 million, or about 6%.[80] Non-farm employment *increased* by 2.1 million jobs in calendar 2017, according to BLS figures.[81] [82]

Figure 4.3.2-2: Deficit Reduction: Employment Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.3.2-2 shows the employment effect of applying all carbon tax gross revenues to deficit reduction. Chart shows reduced total public and private sector employment relative to the reference case.

Table 4.3.2-1 shows the cumulative economic impact of sustained economic underperformance relative to the reference case in the deficit-reduction scenario. Cumulative constant-dollar lost economic production ranges from $4.21 trillion to $5.98 trillion over 10 years, and from $10.41 trillion to $12.32 trillion over the full period. In net present value (NPV) terms, losses over ten years as a percentage of reference-case 2019 GDP range from 14.91% to 23.41%

[80] Evan Cunningham, "Great Recession, great recovery? Trends from the Current Population Survey," *Monthly Labor Review,* U.S. Bureau of Labor Statistics, April 2018, https://doi.org/10.21916/mlr.2018.10. See also, Wander Cedeño, "How did employment fare a decade after its 2008 peak?," *Monthly Labor Review,* U.S. Bureau of Labor Statistics, October 2018, https://doi.org/10.21916/mlr.2018.25.
[81] Bureau of Labor Statistics, U.S. Department of Labor, *The Economics Daily*, "Nonfarm employment up 2.1 million, or 1.4 percent, over the year ending December 2017," January 8, 2018, https://www.bls.gov/opub/ted/2018/nonfarm-employment-up-2-1-million-or-1-4-percent-over-the-year-ending-december-2017.htm.
[82] We provided numerical results for the employment effects of revenue recycling to deficit reduction in Appendix Table A-4.

Table 4.3.2-1: Deficit Reduction: Cumulative GDP Impact (Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
10-year GDP Gap	-$3,820.79	-$5,902.14	-$5,773.41	-$4,206.31	-$5,040.67	-$5,977.05
NPV, 10-Year GDP Gap	-$2,965.50	-$4,432.14	-$4,226.17	-$3,060.46	-$3,920.07	-$4,656.96
NPV, 10-Year GDP Gap as a % of 2019 GDP	-14.91%	-22.28%	-21.24%	-15.38%	-19.71%	-23.41%
22-year GDP Gap	-$7,055.21	-$11,166.90	-$12,322.67	-$10,913.45	-$10,406.26	-$11,887.20
NPV, 22-Year GDP Gap	-$4,433.12	-$6,836.04	-$7,260.47	-$6,148.26	-$6,337.18	-$7,330.17
NPV, 22-Year GDP Gap as a % of 2019 GDP	-22.28%	-34.36%	-36.50%	-30.91%	-31.86%	-36.85%

Source: Model estimate using EIA Annual Energy Outlook 2016

Table 4.3.2-1 shows the cumulative effect on GDP of deficit reduction as a revenue-recycling strategy. Cumulative constant-dollar lost GDP relative to the reference case is as high as $5.98 trillion over 10 years. In NPV terms, these 10-year losses are equal to 22.28% of 2019 reference-case GDP. Discount rate 5%.

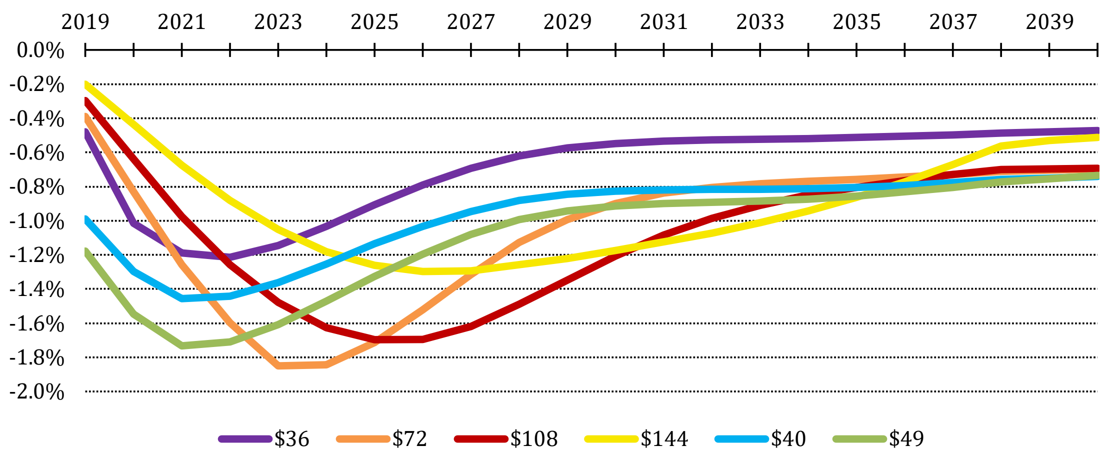
4.3.3 Infrastructure Spending

Theory tells us that revenue recycling by means of infrastructure spending, a lump-sum rebate, and individual tax relief should lead to similar outcomes given that they are demand-focused strategies which do little or nothing to offset the tax interaction effect as it applies to capital income, although individual tax relief does at least reduce marginal tax rates on labor income. This is confirmed by our results.

Figure 4.3.3-1 shows GDP effects for revenue recycling via infrastructure spending. Compared to deficit reduction, the effects are less severe but still negative. GDP is reduced by between 1% and 2% relative to the reference case for years, and GDP remains at least 43 basis points lower than the reference case even at the end of the forecast period. For reference, GDP declined 1.4% in the recession of 1990-91 and 2.7% in the 1981-82 recession.[83]

[83] Marc Labonte, *The 2007-2009 Recession: Similarities to and Differences from the Past*, Congressional Research Service, October 6, 2010. p. 2.

Figure 4.3.3-1: Infrastructure Spending: GDP Impacts (% Change from Baseline)

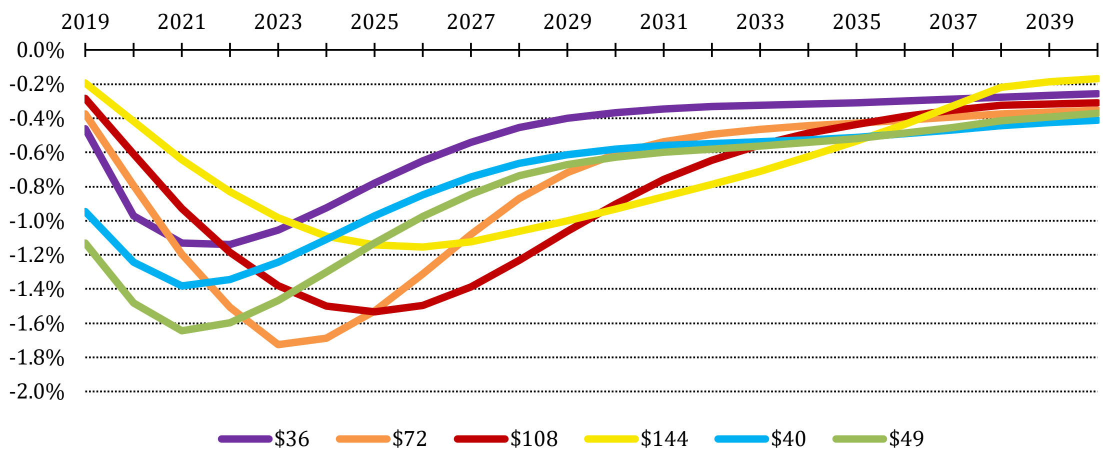


Source: Capital Alpha Estimate

Figure 4.3.3-1 shows GDP impacts of revenue recycling through infrastructure spending. The maximum available gross revenue (75%) is applied. GDP is more than 1% less than the reference case for a period of several years in all scenarios.

Figure 4.3.3-2 shows employment effects which track closely with the GDP effects. Employment is reduced relative to the reference case by 1%-2% in most cases for a period of between five and seven years before it achieves a partial recovery in the later part of the forecast period.

Figure 4.3.3-2: Infrastructure Spending: Employment Impacts (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.3.3.-2 shows employment impacts of revenue recycling through infrastructure spending. Total employment reaches reductions of more than 1% relative to the reference case in all scenarios.

Table 4.3.3-1. shows cumulative lost production relative to the reference case due to persistent economic underperformance. Cumulative constant-dollar lost economic production ranges from $2.12 trillion to $2.95 trillion over 10 years, and from $10.41 trillion to $12.32 trillion over the full period. In NPV terms, losses over ten years as a percentage of reference-case 2019 GDP range from 7.66% to 11.70%

Table 4.3.3-1: Infrastructure Spending: Cumulative GDP Impact (Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
10-year GDP Gap	-$1,967.56	-$2,948.68	-$2,825.91	-$2,117.04	-$2,551.48	-$2,991.26
NPV, 10-Year GDP Gap	-$1,522.94	-$2,210.23	-$2,072.17	-$1,540.67	-$1,980.90	-$2,327.20
NPV, 10-Year GDP Gap as a % of 2019 GDP	-7.66%	-11.11%	-10.42%	-7.74%	-9.96%	-11.70%
22-year GDP Gap	-$3,623.61	-$5,469.42	-$5,683.57	-$4,878.87	-$5,118.55	-$5,708.90
NPV, 22-Year GDP Gap	-$2,272.27	-$3,359.83	-$3,401.83	-$2,838.92	-$3,139.64	-$3,561.39
NPV, 22-Year GDP Gap as a % of 2019 GDP	-11.42%	-16.89%	-17.10%	-14.27%	-15.78%	-17.90%

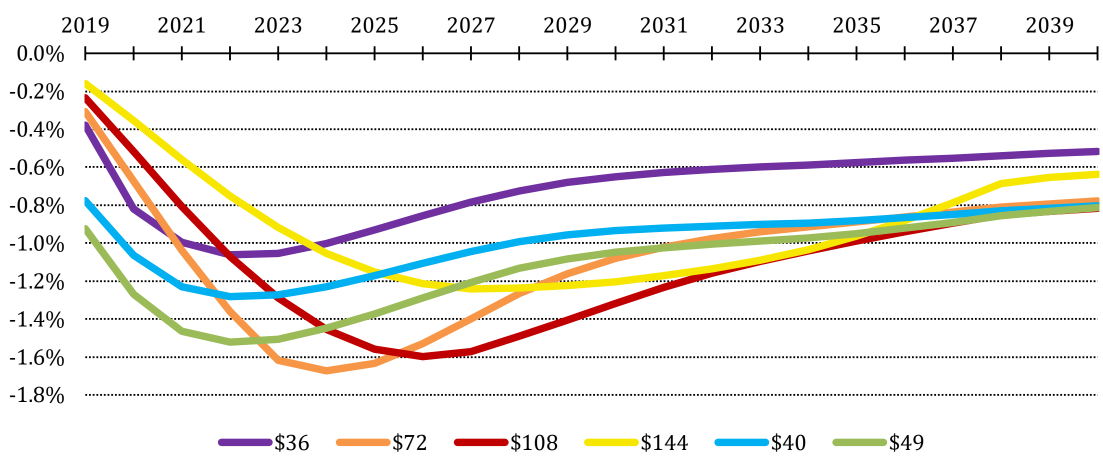
Source: Model estimate using EIA Annual Energy Outlook 2016

Table 4.3.3-1 shows the cumulative effect on GDP of infrastructure spending as a revenue-recycling strategy. GDP losses over 10 years are less severe than those associated with deficit reduction but still as great as $2.99 trillion in constant dollar lost production over 10 years.

4.3.4 Lump-Sum Rebate

Figure 4.3.4-1 shows GDP effects resulting from a revenue-recycling strategy in which all net proceeds go to a lump-sum rebate. The results are modestly better than the results for infrastructure spending, but the peak GDP gap is as great as 1.67% in the case of the phased-in tax of $72 per ton, and once again the GDP gap relative to the reference case never closes, even at the end of the forecast period, where GDP is between 52 and 81 basis points lower than the reference case. This would be the scenario closest to the CLC proposal, which uses a fee-and-credit or lump-sum payment revenue-recycling strategy. In our modeling, as specified here, we see that a $40 per ton tax with fee and rebate has a peak negative impact of 1.28% in 2022 and has GDP 81 basis points lower than the reference case in 2040. [84]

Figure 4.3.4-1: Lump-Sum Rebate: GDP Impact (% Change from Baseline)



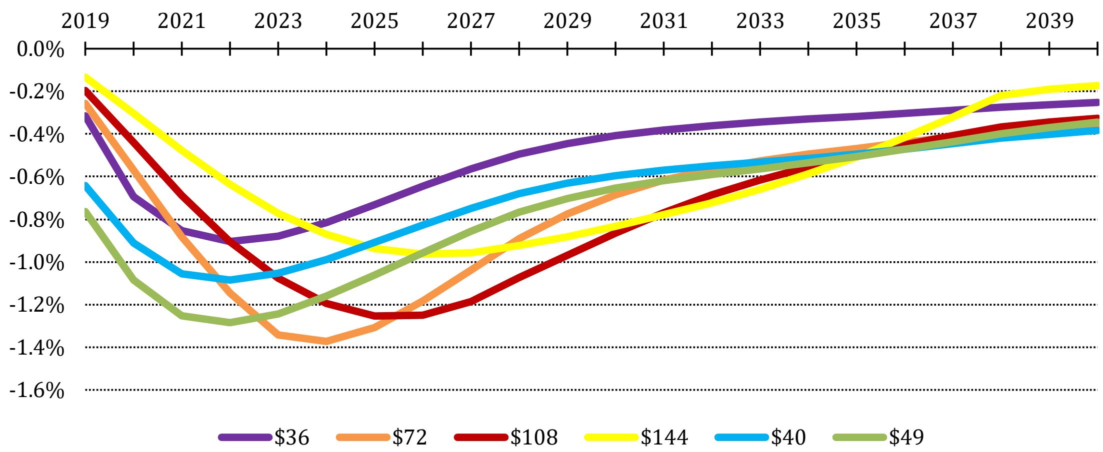
Source: Capital Alpha Estimate

Figure 4.3.4-1 shows GDP impacts of revenue recycling through a lump-sum rebate. The effects are similar to those of infrastructure spending. GDP is reduced relative to the reference case over the entire forecast period.

[84] For purposes of comparison, Carbone, et al. find a that a carbon tax of $30 per ton with revenues recycled to a "lump-sum transfer" starting in 2012 results in GDP that is 3% lower by 2025 and 3.5% lower by 2035. p. 8. The CBO has not performed a macroeconomic study of a lump-sum rebate program, but it draws on other studies in 2009 to present a meta-analysis of H.R. 2454, a cap-and-trade proposal that assigned 75% of revenues from emission allowance sales to rebate programs. CBO estimated that allowances would cost $15 per ton in 2012 and rise at an annual rate of 5.6% to $23 in 2020, $39 in 2030, $68 in 2040, and $118 in 2050 (2007$). CBO then assumed a linear reduction in GDP that increases over time rather than a shock-and-recovery scenario as appears in our modeling and that of Carbone et al. CBO estimated that GDP compared to the no-tax reference case will be .7% to 2.0% lower by 2040 and 1.1% to 3.4% lower by 2050. CBO, "The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions," September 2009. pp. 12-13.

Figure 4.3.4-2 shows employment impacts relative to the reference case. Again, the results are still negative but modestly better than the results for infrastructure spending, and they negative for the entire forecast period.

Figure 4.3.4-2: Lump-Sum Rebate: Employment Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.3.4.-2 shows employment impacts of revenue recycling by means of a lump-sum rebate. Total employment is reduced by more than 1% relative to the reference case for a number of years in all scenarios.

Table 4.3.4-1 shows cumulative loss of production relative to the reference case due to sustained economic underperformance. Cumulative constant-dollar lost economic production ranges from $1.92 trillion to $2.86 trillion over 10 years, and from $4.97 trillion to $5.92 trillion over the full period. In NPV, losses over ten years as a percentage of reference-case 2019 GDP range from 7.19% to 11.00%.

Table 4.3.4-1: Lump-Sum Rebate: Cumulative GDP Impact (Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
10-year GDP Gap	-$1,875.69	-$2,752.80	-$2,574.10	-$1,923.84	-$2,431.21	-$2,856.46
NPV, 10-Year GDP Gap	-$1,429.38	-$2,038.84	-$1,872.78	-$1,390.17	-$1,858.82	-$2,187.52
NPV, 10-Year GDP Gap as a % of 2019 GDP	-7.19%	-10.25%	-9.41%	-6.99%	-9.34%	-11.00%
22-year GDP Gap	-$3,756.81	-$5,706.17	-$5,918.41	-$4,965.76	-$5,264.06	-$5,903.49
NPV, 22-Year GDP Gap	-$2,284.66	-$3,390.69	-$3,418.05	-$2,805.11	-$3,140.50	-$3,574.34
NPV, 22-Year GDP Gap as a % of 2019 GDP	-11.48%	-17.04%	-17.18%	-14.10%	-15.79%	-17.97%

Source: Model estimate using EIA Annual Energy Outlook 2016

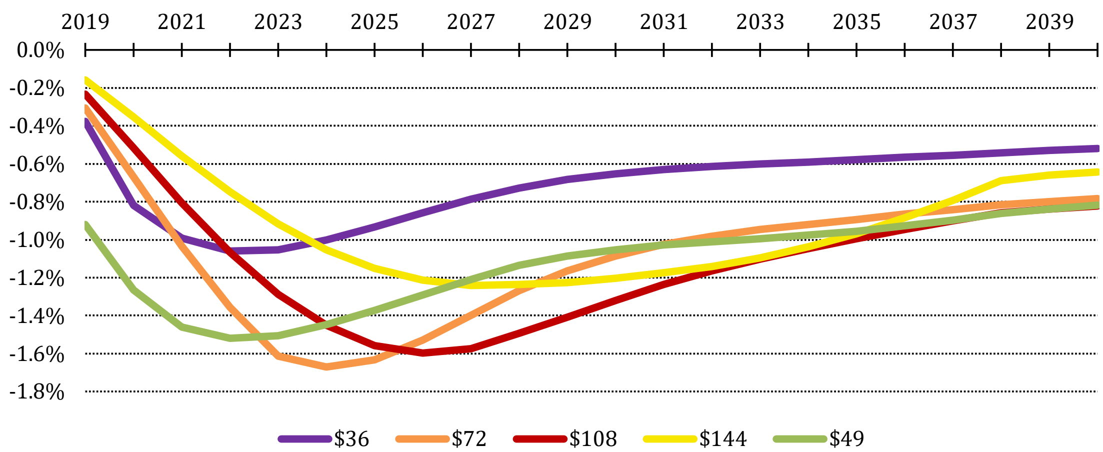
Table 4.3.4-1 shows the cumulative effect on GDP of a lump-sum rebate as a revenue-recycling strategy. GDP losses over 10 years are less severe than those associated with deficit reduction but still as great as $2.86 trillion in constant-dollar lost production over 10 years.

4.3.5 Personal Tax Reduction

Figure 4.3.5-1 shows GDP effects resulting from a revenue-recycling strategy in which all net proceeds of the tax go into individual tax reduction. Not surprisingly, given the lack of a component directed specifically at capital income tax relief, the results are similar to those for a lump-sum rebate. The peak GDP gap ranges from 1.06% to 1.67%, and five out of six scenarios have GDP more than 1% lower than the reference case even after 10 years.[85]

[85] For purposes of comparison, Carbone, et al. ("Deficit Reduction and Carbon Taxes," p. 8) find a that a carbon tax of $30 per ton with revenues recycled to a "reduction in labor tax" starting in 2012 would result in modest GDP losses with at maximum about a .5% reduction in GDP.

Figure 4.3.5-1: Personal Tax Reduction: GDP Impact (% Change from Baseline)

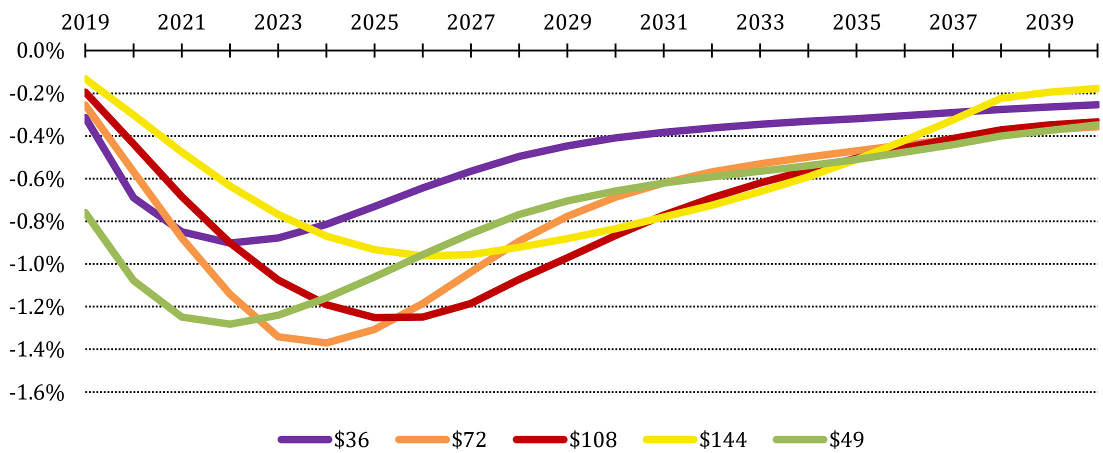


Source: Capital Alpha Estimate

Figure 4.3.5-1 shows GDP impacts of revenue recycling through personal tax reduction. As before, the maximum available amount of gross revenues (75%) is applied to revenue recycling. Results are similar to infrastructure spending and lump-sum rebate. Impact on GDP relative to the reference is case negative for the entire period.

Figure 4.3.5-2 shows employment effects that result from personal tax reduction as a revenue-recycling strategy. Peak unemployment due to the carbon tax ranges from slightly less than 1% in the case of the phased-in $144 tax, to slightly less than 1.4% in the case of the phased-in $72 tax. Employment remains at least 80 basis points lower than the reference case after 10 years in all but one scenario.

Figure 4.3.5-2: Personal Tax Reduction: Employment Impact (% Change from Baseline Employment)



Source: Capital Alpha Estimate

Figure 4.3.5.-2 shows employment impacts of revenue recycling by means of a lump-sum rebate. As with infrastructure spending and lump-sum rebate, total employment is reduced by more than 1% relative to the reference case for a number of years in all scenarios. The $40 ton tax was omitted from this modeling run.

Table 4.3.5-1 shows cumulative lost production relative to the reference case due to sustained economic underperformance. Cumulative constant-dollar lost economic production ranges from $1.92 trillion to $2.86 trillion over 10 years, and from $4.98 trillion to $5.93 trillion over the full period. In NPV terms, losses over ten years as a percentage of reference-case 2019 GDP range from 7.18% to 10.99%.

Table 4.3.5-1: Personal Tax Reduction: Cumulative GDP Impact (Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$49/Ton
10-year GDP Gap	-$1,874.61	-$2,750.48	-$2,570.93	-$1,921.40	-$2,854.89
NPV, 10-Year GDP Gap	-$1,428.17	-$2,036.66	-$1,870.17	-$1,388.20	-$2,185.70
NPV, 10-Year GDP Gap as a % of 2019 GDP	-7.18%	-10.24%	-9.40%	-6.98%	-10.99%
22-year GDP Gap	-$3,763.75	-$5,718.22	-$5,932.14	-$4,976.47	-$5,915.55
NPV, 22-Year GDP Gap	-$2,287.02	-$3,394.89	-$3,422.77	-$2,808.65	-$3,578.51
NPV, 22-Year GDP Gap as a % of 2019 GDP	-11.50%	-17.07%	-17.21%	-14.12%	-17.99%

Source: Model estimate using EIA Annual Energy Outlook 2016

Table 4.3.5-1 shows the cumulative effect on GDP of personal tax reduction as a revenue-recycling strategy. GDP losses over 10 years are as great as $2.85 trillion in constant-dollar lost production over 10 years.

4.4 Mixed Revenue-Recycling Strategies

In this section, we consider mixed revenue-recycling strategies. A mixed revenue-recycling strategy is one that allocates revenues to more than one purpose.

A mixed strategy is more likely to represent the give and take of the legislative process, competition between different priorities, and a negotiated outcome.

In this exercise, we consider only one carbon tax scenario, the tax of $40 per ton of CO_2, since it is simpler than any of the proposals with a phase-in period, and the more moderate of the two proposals that start at a set value.

Once again, we apply 75% of gross carbon tax revenues to each revenue-recycling strategy. There are no deductions from gross revenue other than the 25% JCT offset. This means that our revenue-recycling results offer the best results possible for each revenue-recycling strategy.

4.4.1 Three Mixed Strategies

We consider three mixed revenue-recycling strategies.

- In **Mixed Recycling Strategy A,** we recognize the populist appeal of a taxpayer rebate, which could be directed primarily to lower-income taxpayers, if policymakers so desired, and the paramount importance of capital income tax relief to overcome the tax interaction effect. [86] We split the available resources equally between these two.

- In **Mixed Recycling Strategy B**, we take a more conventional approach to addressing the regressive impact of carbon tax on low-income taxpayers and to reaching some accommodation with the states through a revenue-sharing plan that compensates them for the financial burdens imposed on them by the carbon tax and provides a reasonable allowance for infrastructure spending. We allocate 20% of gross revenues to solving each of these problems. In recognition of the importance of capital income tax relief for a pro-growth tax reform, we allocate all of the remainder for business tax relief.

- In **Mixed Recycling Strategy C**, we follow the same formula, except that we recognize middle class tax relief as a priority that competes with business tax relief, and so we split 35% of gross receipts equally between these two.

Mixed Recycling Strategy C might be the strategy that most closely mirrors the preferences of Congress, since it addresses the regressive impact of the tax on low-income taxpayers (though not in a way that protects all taxpayers in the lowest two quintiles from a tax increase); it provides indirect compensation to the states for their increased expenses and burdens through a revenue-sharing program; and it recognizes that Congress would probably give middle class tax

[86] In our modeling, we assume an equal lump-sum distribution to all taxpayers.

relief at least the same priority as corporate tax relief. Indeed, if history is any guide, Congress might prioritize middle class tax relief over business tax relief.

On the whole, our mixed revenue-recycling strategies produce better results with respect to economic growth than our simple revenue recycling strategies. This is because all of them devote at least some net revenue to corporate tax relief.

Table 4.4.1-1: Mixed Recycling Strategies

Mixed Recycling Strategy A	37.5% lump-sum rebate, 37.5% corporate
Mixed Recycling Strategy B	20% low income, 20% revenue sharing, 35% corporate
Mixed Recycling Strategy C	20% low income, 20% revenue sharing, 17.5% middle class, 17.5% corporate

Table 4.4.1-1 summarizes three options for mixed recycling strategies to deploy 75% of gross revenues. Strategy A offers most corporate tax relief; Strategy C offers least.

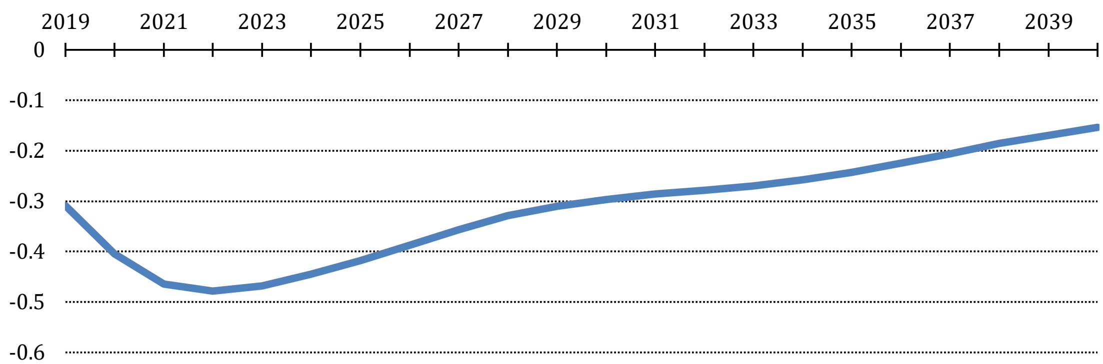
None of the strategies offers positive incremental economic growth, as we saw with the simple revenue-recycling strategy that devoted 75% of gross revenues to corporate tax relief and achieved slightly better than break-even results. Allocating as little as 17.5% of gross revenues to corporate tax relief provides protection on the downside and better performance than any of the simple revenue-recycling strategies with no corporate tax relief. The best results of the three mixed strategies were obtained with 37.5% of gross revenues going to corporate tax relief. This kept the GDP performance gap to less than 50 basis points in the worst year.

4.4.2 Mixed Recycling Strategy A

In Figure 4.4.2-1, we show GDP results for Mixed Recycling Strategy A. With 37.5% of gross revenues allocated to corporate tax relief, the maximum underperformance in GDP is only 48 basis points. The performance gap at the end of 10 years is only 33 basis points, and the performance gap after 22 years is still smaller at 15 basis points. During the 2001 recession, for comparison, GDP fell by 30 basis points.[87] The results for Mixed Recycling Strategy A suggest what may happen if Congress were to combine a fee-and-credit or lump-sum rebate similar to the CLC plan with a corporate tax cut. The plan's performance will be improved as a result.

[87] Labonte, p. 2.

Figure 4.4.2-1: Mixed Recycling Strategy A: GDP Impact (% Change from Baseline)

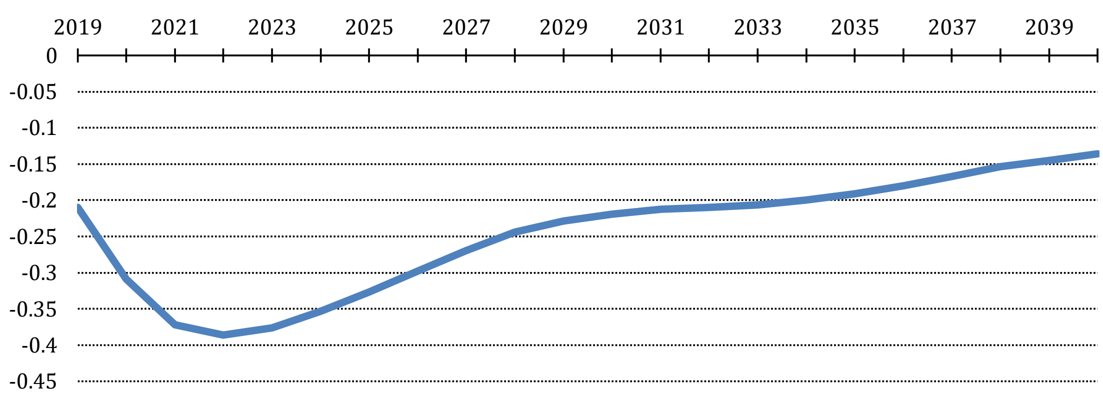


Source: Capital Alpha Estimate

Figure 4.4.2.-1 shows the GDP effects of Mixed Revenue Recycling Strategy A. The peak GDP gap relative to the reference case is 48 basis points in 2022. This declines to 15 basis points by 2040. The effect is negative for the entire period.

In Figure 4.4.2-2, we show employment results for Mixed Recycling Strategy A. The employment results are similar to the GDP results in that they show underperformance by no more than 39 basis points during the worst year, and over the long term, employment results verge upon the reference case.

Figure 4.4.2-2: Mixed Recycling Strategy A: Employment Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.4.2-2 shows the employment impact of Mixed Revenue Recycling Strategy A. The peak negative impact on employment is 39 basis points in 2022, declining to 24 basis points in 2028. The impact remains negative over the entire forecast period.

In Table 4.4.2-1, we present the long-term cost of economic underperformance measured in present value as a percentage of reference-case. The 10-year cost of underperformance is 3.41% of reference-case 2019 GDP. The 22-year NPV cost of underperformance is 5.19% of 2019 GDP.

Table 4.4.2-1: Mixed Recycling Strategy A: Cumulative GDP Impact (Billions 2015$)

10-year GDP Gap	-$881.06
NPV, 10-Year GDP Gap	-$677.85
NPV, 10-Year GDP Gap as a % of 2019 GDP	-3.41%
22-year GDP Gap	-$1,645.77
NPV, 22-Year GDP Gap	-$1,032.79
NPV, 22-Year GDP Gap as a % of 2019 GDP	-5.19%

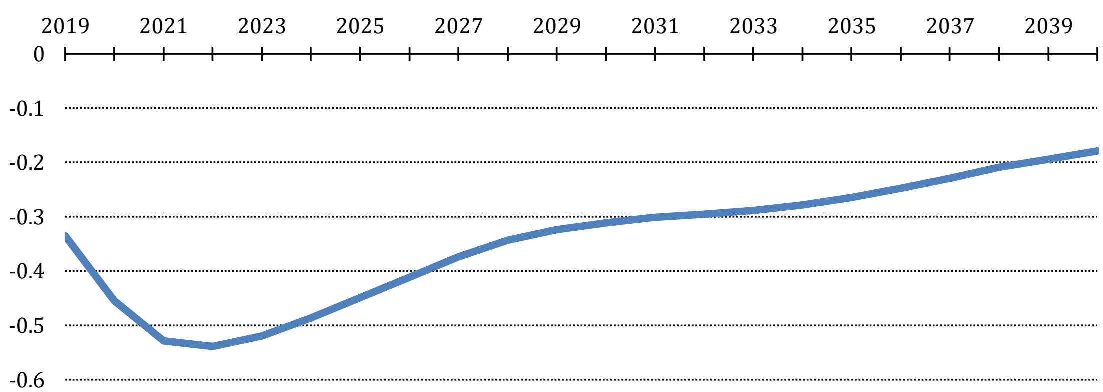
Source: Capital Alpha Estimate

GDP impact is negative but moderated by the relatively high share of gross revenue (37.5%) devoted to corporate tax relief. Ten-year constant dollar GDP losses are $881 billion. Discount rate 5%.

4.4.3 Mixed Recycling Strategy B

In Figure 4.4.3-1, we show GDP results for Mixed Recycling Strategy B. With 35% of gross revenues allocated to corporate tax relief, the maximum annual underperformance in GDP becomes slightly worse at 54 basis points. The GDP underperformance at the end of 10 years is 34 basis points, and the performance gap after 22 years is 18 basis points.

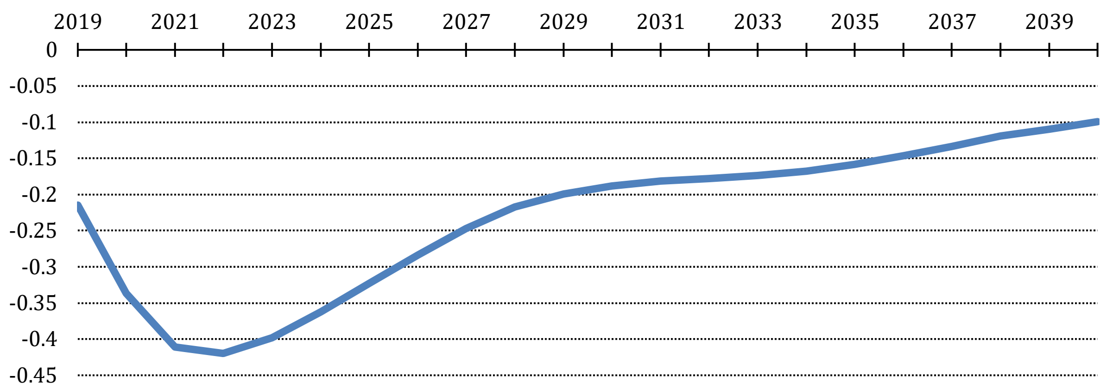
Figure 4.4.3-1: Mixed Recycling Strategy B: GDP Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.4.3.-1 shows the GDP effects of Mixed Recycling Strategy B. The peak GDP gap relative to the reference case is 54 basis points. This declines to 34 basis points after 10 years. The effect is negative for the entire period. GDP is 18 basis points below the reference case in 2040.

Figure 4.4.3-2: Mixed Recycling Strategy B: Employment Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.4.3-2 shows the employment impact of Mixed Revenue Recycling Strategy B. The peak negative impact on employment is 42 basis points. The impact is negative over the entire forecast period.

In Figure 4.4.3-2, we show employment results for Mixed Recycling Strategy B. The employment results are similar to the GDP results in that they show underperformance by no more than 42 basis points during the worst year. Over the long term, employment results verge upon the reference case.

In Table 4.4.3-1, we present the long-term cost of economic underperformance measured in present value as a percentage of reference-case. The 10-year cost of underperformance is 3.73% of reference-case 2019 GDP. The 22-year NPV cost of underperformance is 5.66% of 2019 GDP.

Table 4.4.3-1: Mixed Recycling Strategy B: Cumulative GDP Impact (Billions 2015$)

10-year Cumulative GDP Gap	-$962.56
NPV, 10-Year GDP Gap	-$742.84
NPV, 10-Year GDP Gap as a % of 2019 GDP	-3.73%
22-year GDP Gap	-$1,792.91
NPV, 22-Year GDP Gap	-$1,126.26
NPV, 22-Year GDP Gap as a % of 2019 GDP	-5.66%

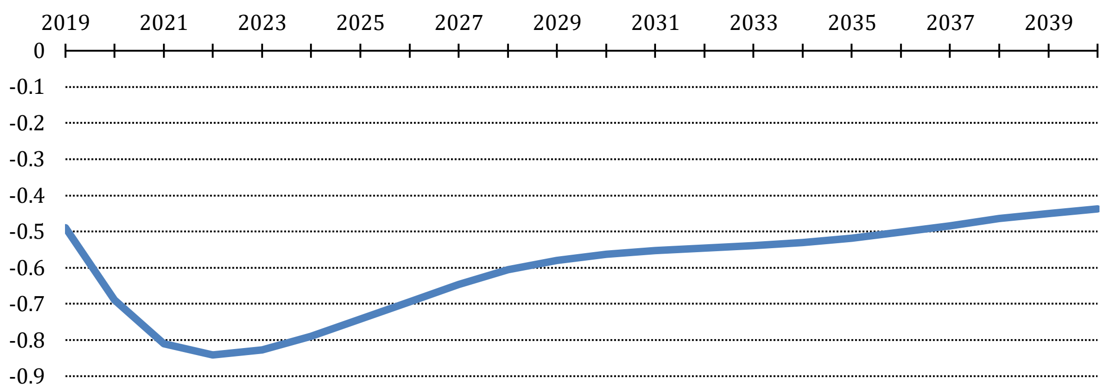
Source: Capital Alpha Estimate

GDP impact is negative and moderated by the share (35%) devoted to corporate tax relief. Ten-year constant dollar GDP losses are $962 billion. Discount rate 5%.

4.4.4 Mixed Recycling Strategy C

In Figure 4.4.4-1, we show GDP results for Mixed Recycling Strategy C. Only 17.5% of gross revenues are allocated to corporate tax relief. The maximum annual underperformance in GDP becomes slightly worse at 54 basis points. The GDP underperformance at the end of 10 years is only 61 basis points, and the performance gap after 22 years is 44 basis points.

Figure 4.4.4-1: Mixed Recycling Strategy C: GDP Impact (% Change from Baseline)



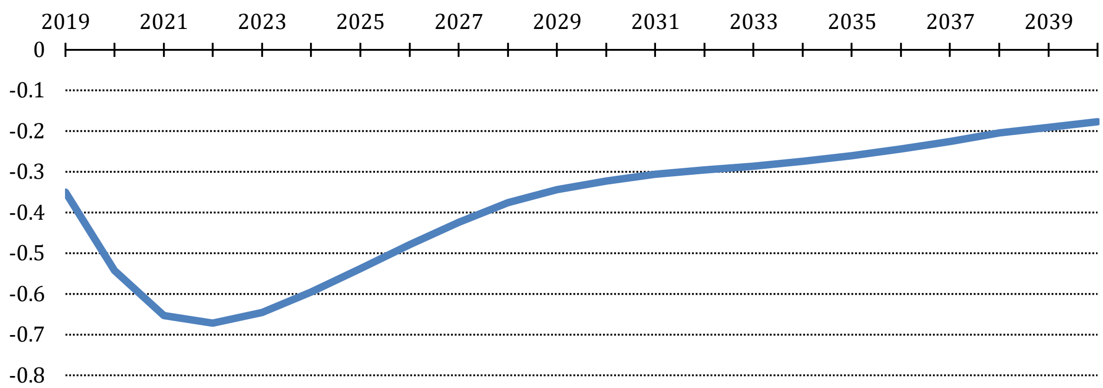
Source: Capital Alpha Estimate

Figure 4.4.4.-1 shows the GDP effects of Mixed Revenue Recycling Strategy C. The peak GDP gap relative to the reference case increases to 84 basis points. This declines to 61 basis points after 10 years. The effect is negative for the entire period. GDP is 44 basis points below the reference case in 2040.

In Figure 4.4.4-2, we show employment results for Mixed Recycling Strategy C. The employment results are similar to the GDP results in that they show underperformance by slightly more than 67 basis points during the worst year, and over the long term, employment results verge upon the reference case.

In Table 4.4.4-1, we present the long-term cost of economic underperformance measured in present value terms as a percentage of reference-case. The 10-year cost of underperformance is 5.98% of reference-case 2019 GDP. The 22-year NPV cost of underperformance is 9.75% of 2019 GDP.

Figure 4.4.4-2: Mixed Recycling Strategy C: Employment Impact (% Change from Baseline)



Source: Capital Alpha Estimate

Figure 4.4.2-2 shows the employment impact of Mixed Revenue Recycling Strategy C. The peak negative impact on employment is 67 basis points, but the impact is negative over the entire forecast period. Employment remains 18 basis points below the reference case at the end of the period.

Table 4.4.4-1: Mixed Recycling Strategy C: Cumulative GDP Impact (Billions 2015$)

10-year GDP Gap	-$1,551.53
NPV, 10-Year GDP Gap	-$1,188.97
NPV, 10-Year GDP Gap as a % of 2019 GDP	-5.98%
22-year GDP Gap	-$3,201.16
NPV, 22-Year GDP Gap	-$1,939.47
NPV, 22-Year GDP Gap as a % of 2019 GDP	-9.75%

Source: Capital Alpha Estimate

GDP impact is negative but somewhat moderated by the reduced share of gross revenue (17.5%) devoted to corporate tax relief. Ten-year constant dollar GDP losses are $1.55 trillion. Discount rate 5%.

5. The High Cost of Small, Persistent Losses

Little losses become large losses over time if they are persistent and never made up. Theory predicts exactly this result for the carbon tax: a one-time, small, permanent reduction in GDP which the economy never recovers. Once the post-shock period of rebalancing is complete, the economy begins growing again, but from a lower base. The production lost from the initial shock is not made up. In the long run, the economy converges on its prior trajectory, but the modeling in this paper and elsewhere in the literature demonstrates that this convergence can take decades to occur.

5.1 OMB's Sensitivity Analyses

The cost of persistent small-scale economic underperformance in the case of a carbon tax that is not offset by a successful pro-growth tax reform is the sum total of lost production amounting to anything from a percentage point or two to tens of basis points per year over a period of twenty or more years. The long-term effect on government finances of losing 1% of GDP relative to a no-carbon tax reference case presents a formidable modeling problem, but the White House Office of Management and Budget (OMB) has conducted nine sensitivity analyses to examine the effect on federal government receipts and outlays of losing 1% of GDP in a cyclical downturn where the lost production is not made up in the first two years of the 10-year period that follows. These analyses appear in successive editions of *Budget of the United States Government* for Fiscal Years 2010 through 2018. The OMB results are summarized in Table 5-1. The figures are cumulative over ten years.

Table 5.1-1: OMB Sensitivity Analyses: Impact on Following 10 Fiscal Years (Billions, current$)

Fiscal Year	Receipts	Outlays	Deficit
2010	-$507.30	$239.30	$746.60
2011	-$487.00	$239.90	$726.90
2012	-$496.40	$348.60	$845.00
2013	-$476.70	$317.40	$794.10
2014	-$530.30	$298.60	$828.90
2015	-$570.90	$331.90	$902.90
2016	-$601.00	$356.80	$957.80
2017	-$494.30	$360.80	$855.10
2018	-$490.50	$318.50	$809.00

Source: Budget of the United States Government

Table 5.1-1 shows OMB sensitivity analyses for Fiscal Years 2010 through 2018. Figures show the effect of GDP growth 1% below projection in the Fiscal Year prior to the beginning of a year period that is not made up in the first two years. OMB assumptions apply. Billions of current dollars.

In the most recent estimate, OMB estimated that losing one percentage point of projected growth in Fiscal 2017 would decrease receipts by $490.5 billion and increase outlays by $318.5 billion, for a total 10-year increase in deficit spending of $809.0 billion.[88] On average, in the nine sensitivity analyses conducted, OMB found that losing 1% of forecasted in GDP at the beginning of the period would result in a 10-year increase in deficit spending of $829.6 billion in nominal dollars.

5.2 Persistent Economic Underperformance

If losing 1% of forecasted GDP in a cyclical downturn has such consequences, one most grant that losing 1% of GDP relative to the no-tax reference case in a permanent downward one-time shift has even greater consequences. Yet our modeling points to exactly this contingency, and more. In the study of simple revenue recycling strategies for the lump-sum rebate, both the taxes of $40 per ton and $50 per ton reduce GDP relative to the reference case by more than 1% for 10 years in a row. The following tables present results for the three middle case simple revenue recycling strategies (lump-sum, infrastructure, and individual tax relief) as well as for the mixed revenue recycling strategies.

Table 5.2-1: Below Trend GDP (Number of Years)

Lump-sum Rebate						
	$36	$72	$108	$144	$40	$49
1% below reference case	3	11	13	11	8	13
0.5 % below reference case	21	21	21	20	22	22
Infrastructure Spend						
	$36	$72	$108	$144	$40	$49
1% below reference case	5	8	10	11	7	9
0.5 % below reference case	18	21	21	20	22	22
Individual Tax Relief						
	$36	$72	$108	$144	$40	$49
1% below reference case	3	11	13	11		13
0.5 % below reference case	22	22	22	22		22
Mixed Revenue-Recycling Strategies						
		Mixed Strategy A		Mixed Strategy B		Mixed Strategy C
0.5% below reference case		0		3		17
0.3% below reference case		11		13		22

Source: Model estimate using EIA Annual Energy Outlook 2016

Table 5.2-1 presents in tabular form the number of years in which forecasted GDP is below the reference case by the specified amount over a 22-year forecast period for each tax scenario. Headings shows taxes in $/ton.

[88] *Supra,* n. 3.

5.3 Net Present Value and Entitlement Burdens

A more elegant way to measure lost economic production would be in NPV terms. The following tables summarize the relevant results from the previous discussion of simple revenue-recycling strategies. The carbon tax of $49 per ton, for instance, would have NPV economic losses of slightly more than $2 trillion in the first 10 years if instituted with the revenue recycling strategies based on infrastructure spending, a lump-sum rebate, and personal tax reduction. The other tax scenarios similarly result in NPV losses amounting in the trillions of dollars over ten years and even greater losses over the 22-year forecast period.

Table 5.3-1: Cumulative GDP Gap Over 10 Years, Simple Revenue Recycling Strategies (NPV, Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
Capital Tax Reduction		$708.30	$691.85	$377.37	$557.04	$740.76
Deficit Reduction	-$2,965.50	-$4,432.14	-$4,226.17	-$3,060.46	-$3,920.07	-$4,656.96
Lump-sum Rebate	-$1,429.38	-$2,038.84	-$1,872.78	-$1,390.17	-$1,858.82	-$2,187.52
Infrastructure	-$1,522.94	-$2,210.23	-$2,072.17	-$1,540.67	-$1,980.90	-$2,327.20
Personal Tax Reduction	-$1,428.17	-$2,036.66	-$1,870.17	-$1,388.20		-$2,185.70

Source: Model estimate using EIA Annual Energy Outlook 2016.

Table 5.3-1 shows the cumulative GDP gap in net present value over 10 years for each tax scenario. Period is 2019-2028. Discount rate 5%.

Table 5.3-2: Cumulative GDP Gap Over 22 Years, Simple Revenue Recycling Strategies (NPV, Billions 2015$)

	$36/Ton	$72 /Ton	$108 /Ton	$144 /Ton	$40/Ton	$49 /Ton
Capital Tax Reduction		$1,355.41	$1,859.70	$1,628.83	$1,158.36	$1,533.55
Deficit Reduction	-$4,433.12	-$6,836.04	-$7,260.47	-$6,148.26	-$6,337.18	-$7,330.17
Lump-sum Rebate	-$2,284.66	-$3,390.69	-$3,418.05	-$2,805.11	-$3,140.50	-$3,574.34
Infrastructure	-$2,272.27	-$3,359.83	-$3,401.83	-$2,838.92	-$3,139.64	-$3,561.39
Personal Tax Reduction	-$2,287.02	-$3,394.89	-$3,422.77	-$2,808.65		-$3,578.51

Source: Model estimate using EIA Annual Energy Outlook 2016.

Table 5.3-2 shows the cumulative GDP gap in net present value terms over 22 years for each tax scenario. Period is 2019-2040. Discount rate 5%.

We may similarly revisit the NPV results from the mixed revenue-recycling strategies. Over ten years, they range from $637.85 billion to $1.19 trillion. Over 22 years, they range from $1.65 trillion to $3.20 trillion.

Table 5.3-3: Cumulative GDP Gap Over 10 Years, Mixed Revenue Recycling Strategies (NPV, Billions 2015$)

NPV Mixed Recycling Strategy A	-$677.85
NPV Mixed Recycling Strategy B	-$742.84
NPV Mixed Recycling Strategy C	-$1,118.97

Source: Model estimate using EIA Annual Energy Outlook 2016

Table 5.3-3 shows the cumulative GDP gap in net present value terms over 10 years for the mixed revenue recycling strategies. Period is 2019-2028. Discount rate 5%.

Table 5.3-4: Cumulative GDP Gap Over 22 Years, Mixed Revenue Recycling Strategies (NPV, Billions 2015$)

NPV Mixed Recycling Strategy A	-$1,032.97
NPV Mixed Recycling Strategy B	-$1,126.26
NPV Mixed Recycling Strategy C	-$1,939.47

Source: Model estimate using EIA Annual Energy Outlook 2016

Table 5.3-4 shows the cumulative GDP gap in net present value terms over 22 years for the mixed revenue recycling strategies. Period is 2019-2040. Discount rate 5%.

Economic losses on this scale would have a corresponding effect on government finances. Policy makers would likely need to contemplate tax increases, programmatic spending cuts, and revisions to major entitlement programs, particularly if the losses are incurred at a time when an aging population puts mounting pressure on Social Security and Medicaid. The states that face the burdens of flow-through costs would similarly be forced to cut spending and raise taxes as required to protect their credit ratings and avoid default on pension obligations.

6. Not an Efficient Revenue Raiser for Tax Reform

The carbon tax is not an efficient revenue raiser for tax reform or other public purposes. Though a carbon tax such as those we study here could raise substantial gross revenue, only a small portion of net revenue is available for tax reform. The adverse economic impacts of a carbon tax also make a successful tax reform difficult to achieve, because such reform would need to overcome both the initial economic shock of a carbon tax and the residual headwind of the tax interaction effect in order to result in incremental growth.

The static offsets for federal, state, and local income tax revenues would consume about 28% of gross revenue from the carbon tax. The increased direct and indirect costs of energy for the federal, state, and local government would consume another 13% of gross revenue. The gross revenue needed to protect low-income taxpayers in the bottom two income quintiles, if Congress chose to do so, would require a further 27% of gross revenue, bringing the total offsets for gross revenue to 68%.

To achieve slightly better than break-even economic growth, a carbon tax would likely need to direct the entirety of its net revenue—up to a maximum 75% of gross revenue—exclusively to corporate tax relief and either (1) deficit-finance the policy or (2) impose an unfunded mandate to the states in the form of pass-through costs that would force state tax increases and simultaneously require low-income taxpayers to subsidize a policy that primarily benefits the better-off.

A carbon tax that fails to achieve incremental growth and causes GDP to decline relative to baseline for a period of time would result in dynamic revenue losses to the federal, state, and local governments. The federal government would find its fiscal situation appreciably worse in an era of rising entitlement spending, and the states would face painful fiscal choices or risk credit downgrades.

Vertical tax competition between the federal government and the states for excise tax revenue from motor vehicle fuels would cripple state options for financing new infrastructure development in the absence of a revenue-sharing program that diverts carbon tax revenues to the states for purposes of building and maintaining roads, highways, and mass transit. This diversion of revenue to the states would serve a valid public purpose, but it would also decrease the net revenue available for effective structural tax reform. Because Congress constantly considers competing priorities for use of public funds, carbon tax revenue could be diverted to other purposes as well. The result would be to further decrease the net revenue available for tax reform, underscoring the inefficiency of the carbon tax as a revenue raiser given its many collateral effects.

Appendix A: Revenue Projections

Table A-1: Carbon Tax Gross Revenue (Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
2019	$95.30	$76.32	$57.30	$38.24	$210.46	$257.15
2020	$186.84	$150.07	$113.00	$75.63	$214.43	$261.31
2021	$184.65	$220.26	$166.68	$112.11	$218.94	$266.06
2022	$183.07	$285.96	$217.94	$147.63	$224.07	$271.44
2023	$182.13	$346.47	$266.49	$182.13	$229.91	$277.61
2024	$180.97	$340.80	$310.49	$214.60	$235.37	$283.19
2025	$179.46	$334.65	$348.88	$244.38	$240.24	$287.99
2026	$177.95	$328.32	$381.08	$271.38	$244.87	$292.29
2027	$176.08	$321.13	$405.19	$294.51	$248.65	$295.36
2028	$174.23	$314.18	$422.03	$314.18	$252.19	$298.01
2029	$173.41	$310.87	$414.97	$334.28	$257.68	$303.42
2030	$172.54	$307.51	$407.94	$351.68	$262.98	$308.49
2031	$171.58	$304.22	$401.38	$366.58	$268.11	$313.34
2032	$171.06	$301.91	$396.50	$380.33	$273.91	$318.92
2033	$170.39	$299.21	$390.90	$390.90	$279.23	$323.77
2034	$170.02	$297.36	$386.74	$400.39	$285.13	$329.29
2035	$169.64	$295.34	$382.11	$406.76	$290.73	$334.21
2036	$169.21	$293.41	$377.82	$410.96	$296.20	$338.90
2037	$169.32	$292.22	$374.24	$413.06	$302.19	$343.90
2038	$169.28	$291.02	$371.05	$413.24	$307.97	$348.62
2039	$170.17	$292.77	$373.63	$416.67	$317.08	$357.87
2040	$170.96	$294.31	$375.85	$419.53	$326.06	$366.82

Source: Capital Alpha Estimate

Table A-1 shows gross revenues for each tax scenario by year. Standard JCT 25% offset applied.

Table A-2: Carbon Tax Net Revenue– 25% Offset (Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
2019	$71.48	$57.24	$42.97	$28.68	$157.84	$192.86
2020	$140.13	$112.55	$84.75	$56.73	$160.82	$195.99
2021	$138.49	$165.19	$125.01	$84.08	$164.21	$199.54
2022	$137.31	$214.47	$163.46	$110.72	$168.05	$203.58
2023	$136.60	$259.86	$199.87	$136.60	$172.43	$208.21
2024	$135.73	$255.60	$232.87	$160.95	$176.52	$212.40
2025	$134.59	$250.99	$261.66	$183.28	$180.18	$215.99
2026	$133.46	$246.24	$285.81	$203.54	$183.65	$219.22
2027	$132.06	$240.85	$303.89	$220.88	$186.49	$221.52
2028	$130.68	$235.64	$316.52	$235.64	$189.14	$223.51
2029	$130.06	$233.15	$311.23	$250.71	$193.26	$227.56
2030	$129.41	$230.63	$305.95	$263.76	$197.24	$231.37
2031	$128.69	$228.17	$301.04	$274.94	$201.09	$235.00
2032	$128.29	$226.43	$297.38	$285.24	$205.43	$239.19
2033	$127.79	$224.41	$293.18	$293.18	$209.42	$242.83
2034	$127.51	$223.02	$290.05	$300.29	$213.85	$246.96
2035	$127.23	$221.51	$286.58	$305.07	$218.05	$250.66
2036	$126.91	$220.06	$283.36	$308.22	$222.15	$254.17
2037	$126.99	$219.16	$280.68	$309.79	$226.64	$257.92
2038	$126.96	$218.27	$278.28	$309.93	$230.98	$261.47
2039	$127.63	$219.58	$280.22	$312.50	$237.81	$268.40
2040	$128.22	$220.73	$281.89	$314.65	$244.54	$275.12

Source: Capital Alpha Estimate

Table A-2 shows gross revenues for each tax scenario by year. Standard JCT 25% offset applied.

Table A-3: Carbon Tax Net Revenue– 68% Offset (Billions 2015$)

	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
2019	$30.50	$24.42	$18.34	$12.24	$67.35	$82.29
2020	$59.79	$48.02	$36.16	$24.20	$68.62	$83.62
2021	$59.09	$70.48	$53.34	$35.88	$70.06	$85.14
2022	$58.58	$91.51	$69.74	$47.24	$71.70	$86.86
2023	$58.28	$110.87	$85.28	$58.28	$73.57	$88.84
2024	$57.91	$109.06	$99.36	$68.67	$75.32	$90.62
2025	$57.43	$107.09	$111.64	$78.20	$76.88	$92.16
2026	$56.94	$105.06	$121.95	$86.84	$78.36	$93.53
2027	$56.34	$102.76	$129.66	$94.24	$79.57	$94.51
2028	$55.76	$100.54	$135.05	$100.54	$80.70	$95.36
2029	$55.49	$99.48	$132.79	$106.97	$82.46	$97.09
2030	$55.21	$98.40	$130.54	$112.54	$84.15	$98.72
2031	$54.91	$97.35	$128.44	$117.31	$85.80	$100.27
2032	$54.74	$96.61	$126.88	$121.70	$87.65	$102.06
2033	$54.53	$95.75	$125.09	$125.09	$89.35	$103.61
2034	$54.41	$95.15	$123.76	$128.12	$91.24	$105.37
2035	$54.28	$94.51	$122.27	$130.16	$93.03	$106.95
2036	$54.15	$93.89	$120.90	$131.51	$94.78	$108.45
2037	$54.18	$93.51	$119.76	$132.18	$96.70	$110.05
2038	$54.17	$93.13	$118.73	$132.24	$98.55	$111.56
2039	$54.46	$93.69	$119.56	$133.33	$101.46	$114.52
2040	$54.71	$94.18	$120.27	$134.25	$104.34	$117.38

Source: Capital Alpha Estimate

Gross revenues for each tax scenario by year. Standard JCT 25% offset, CBO estimate of 13% direct and indirect costs to federal, state, and local government, CBO estimate of 27% offset for taxpayers in lowest two income quintiles applied. Offsets total 68%.

Table A-4: Carbon Tax Employment Effects, Revenue Recycling to Deficit Reduction (Thousands of Jobs, Change from Baseline)

	Baseline	$36/Ton	$72/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
2019	197,228	-2,043	-1,647	-1,245	-837	-4,359	-5,260
2020	197,728	-4,163	-3,377	-2,571	-1,741	-5,123	-6,168
2021	198,704	-4,508	-4,995	-3,834	-2,619	-5,443	-6,535
2022	198,927	-4,419	-6,270	-4,862	-3,357	-5,269	-6,305
2023	199,648	-4,106	-7,257	-5,699	-3,986	-4,949	-5,899
2024	200,360	-3,683	-6,998	-6,287	-4,467	-4,561	-5,409
2025	201,391	-3,228	-6,405	-6,594	-4,775	-4,157	-4,901
2026	202,676	-2,825	-5,671	-6,671	-4,952	-3,812	-4,462
2027	203,580	-2,483	-4,910	-6,497	-4,984	-3,516	-4,077
2028	204,479	-2,215	-4,231	-6,134	-4,907	-3,283	-3,768
2029	205,378	-2,038	-3,737	-5,537	-4,822	-3,150	-3,588
2030	206,135	-1,919	-3,375	-4,958	-4,703	-3,070	-3,472
2031	206,925	-1,839	-3,120	-4,442	-4,558	-3,022	-3,396
2032	207,511	-1,786	-2,951	-4,028	-4.405	-2,998	-3,351
2033	208,178	-1,745	-2,830	-3,688	-4.221	-2,976	-3.305
2034	208,913	-1,712	-2,746	-3,431	-4,024	-2,957	-3,264
2035	209,624	-1,678	-2,670	-3,219	-3,789	-2,927	-3,206
2036	210,527	-1,638	-2,594	-3,044	-3,525	-2,884	-3,130
2037	211,201	-1,600	-2,523	-2,899	-3,237	-2,837	-3,047
2038	212,077	-1,558	-2,449	-2,774	-2,931	-2,781	-2,953
2039	212,928	-1,526	-2,412	-2,741	-2,810	-2,767	-2,920
2040	213,793	-1,492	-2,372	-2,713	-2,722	-2,752	-2,885

Source: Capital Alpha Estimate

Baseline employment and deviation from baseline for each tax scenario by year. Thousands of jobs. Figures show employment effects for a deficit reduction or no revenue recycling strategy. Reductions in employment relative to the reference case generally run to millions of jobs per year. Note that job losses can be mitigated as indicated by the revenue recycling strategies studied in the paper, but only directing all available net revenue to corporate tax relief completely avoids job losses.

Appendix B: Emissions Reduction and Tax Impact

Table B-1: Tax-For-Regulatory-Swap Results (MMT CO_2)

	2025 Paris Attainment	2040 Paris Attainment	Baseline	$36/Ton	$72/Ton	$108/Tn	$144/Tn	$4/Ton	$49/Ton
2019	4,870.68	2,632.80	5,512.81	5,485.71	5,491.13	5,496.54	5,501.96	5,452.68	5,439.20
2020	4,870.68	2,632.80	5,489.94	5,385.90	5,406.63	5,427.40	5,448.21	5,370.26	5,343.51
2021	4,870.68	2,632.80	5,478.40	5,324.65	5,294.15	5,339.93	5,385.89	5,295.29	5,254.50
2022	4,870.68	2,632.80	5,484.47	5,280.22	5,159.46	5,239.82	5,320.77	5,232.67	5,176.80
2023	4,870.68	2,632.80	5,509.24	5,256.39	5,009.35	5,132.16	5,256.39	5,186.66	5,115.39
2024	4,870.68	2,632.80	5,528.23	5,226.19	4,932.50	4,990.60	5,166.80	5,129.54	5,041.87
2025	4,870.68	2,632.80	5,531.59	5,183.45	4,846.50	4,813.39	5,047.37	5,056.24	4,952.20
2026	4,870.68	2,632.80	5,539.94	5,142.47	4,759.60	4,610.25	4,911.08	4,978.72	4,856.50
2027	4,870.68	2,632.80	5,542.64	5,093.34	4,662.51	4,370.94	4,747.29	4,886.73	4,744.64
2028	4,870.68	2,632.80	5,542.37	5,043.50	4,567.30	4,111.31	4,567.30	4,789.61	4,627.43
2029	4,870.68	2,632.80	5,548.93	5,022.22	4,522.80	4,047.45	4,425.90	4,728.17	4,552.73
2030	4,870.68	2,632.80	5,554.70	5,000.59	4,478.73	3,984.98	4,278.08	4,663.40	4,474.47
2031	4,870.68	2,632.80	5,555.32	4,977.12	4,436.20	3,927.44	4,127.41	4,595.64	4,394.01
2032	4,870.68	2,632.80	5,566.70	4,965.38	4,406.92	3,885.05	3,986.80	4,537.55	4,323.46
2033	4,870.68	2,632.80	5,575.00	4,948.93	4,371.56	3,835.31	3,835.31	4,470.52	4,243.10
2034	4,870.68	2,632.80	5,586.24	4,941.22	4,348.47	3,799.41	3,694.08	4,412.15	4,171.98
2035	4,870.68	2,632.80	5,598.99	4,932.96	4,322.78	3,758.82	3,544.00	4,348.21	4,093.95
2036	4,870.68	2,632.80	5,607.86	4,923.59	4,298.40	3,721.57	3,394.25	4,282.18	4,014.30
2037	4,870.68	2,632.80	5,638.10	4,929.81	4,284.99	3,691.60	3,245.84	4,223.49	3,939.70
2038	4,870.68	2,632.80	5,658.89	4,931.72	4,271.56	3,665.16	3,099.30	4,161.52	3,863.02
2039	4,870.68	2,632.80	5,688.52	4,960.76	4,300.03	3,693.23	3,127.26	4,141.31	3,833.96
2040	4,870.68	2,632.80	5,713.56	4,985.82	4,324.64	3,717.16	3,150.49	4,115.71	3,799.13

Source: Model estimate using EIA Annual Energy Outlook 2016

Table B-1 shows aggregate emissions 2019-2040 compared to no-tax reference case and Paris targets. 2025 INDC assumes 26% reduction from 2005 baseline. 2040 target assumes 60% reduction from 2005 baseline. 2005 baseline from EPA data. Reference case generated using CTAM from AEO 2016 No-CPP case. Million Metric Tons CO_2.

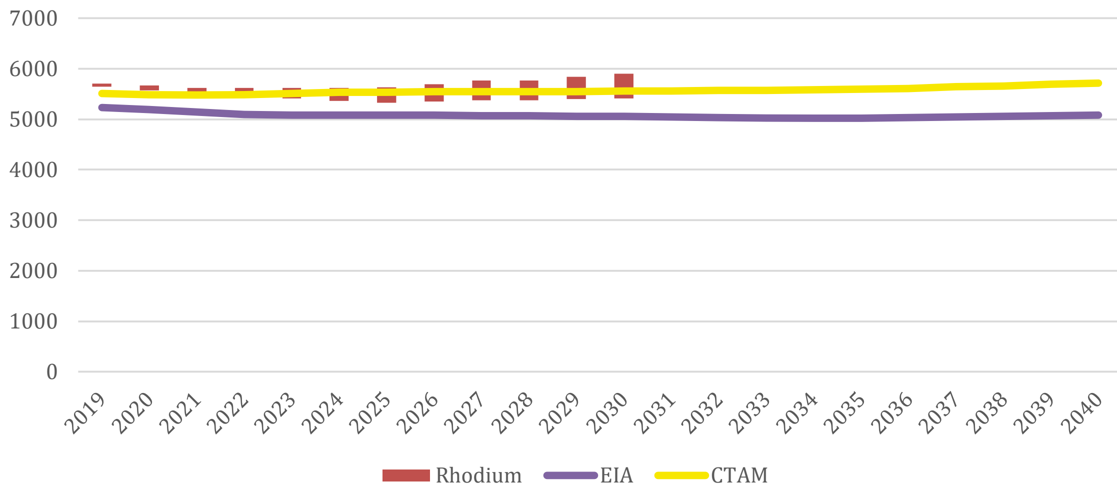
Table B-2: Tax-for-Regulatory-Swap Results, Percentage Reductions (MMT CO_2)

Million Metric Tons CO_2	**$36/Ton**	**$72/Ton**	**$108/Ton**	**$144/Ton**	**$40/Ton**	**$49/Ton**
2025 Projected Annual Emissions	**5,183.45**	**4,846.50**	**4,813.39**	**5,047.37**	**5,056.24**	**4,952.20**
Reduction from Current-Policy Baseline	348.15	685.09	718.20	484.22	475.35	579.40
Percent Reduction from Current-Policy Baseline	6.29%	12.39%	12.98%	8.75%	8.59%	10.47%
Percent Reduction from 2005 Levels	21.25%	26.37%	26.87%	23.32%	24.76%	23.18%
U.S. 2025 Paris Goal: 26% Reduction from 2005	**4,870.68**	**4,870.68**	**4,870.68**	**4,870.68**	**4,870.68**	**4,870.68**
Emissions over 2025 Paris Goal	312.77	-24.18	-57.29	176.69	185.56	81.52
% Emissions over 2025 Paris Goal	6.42%	-0.50%	-1.18%	3.63%	3.81%	1.67%
2040 Projected Annual Emissions	**4,985.82**	**4,324.64**	**3,717.16**	**3,150.49**	**4,115.71**	**3,799.13**
Reduction from Current-Policy Baseline	727.74	1,388.91	1,996.40	2,563.07	1,597.85	1,914.42
Percent Reduction from Current-Policy Baseline	12.74%	24.31%	34.94%	44.86%	27.97%	33.51%
Percent Reduction from 2005 Levels	13.24%	24.75%	35.32%	45.18%	28.38%	33.89%
U.S. 2040 Paris Goal: 60% Reduction from 2005	**2,632.80**	**2,632.80**	**2,632.80**	**2,632.80**	**2,632.80**	**2,632.80**
Emissions over EU 2040 60% Goal (2,298.78 MMT)	2,353.02	1,691.84	1,084.36	517.69	1,482.91	1,166.33
% Emissions over 2040 60% Goal (2,298.78 MMT)	89.37%	64.26%	41.19%	19.66%	56.32%	44.30%

Source: Model estimate using EIA Annual Energy Outlook 2016

Table B-2 shows emissions reductions for 2025 and 2040 relative to current policy baseline and to Paris goals relative to 2005 baseline. 2025 INDC assumes 26% reduction from 2005 baseline. 2040 target assumes 60% reduction from 2005 baseline. 2005 baseline from EPA data. Reference case generated using CTAM from AEO 2016 No-CPP case. Million Metric Tons CO_2.

Figure B-1: Carbon and GHG Baseline Comparisons (MMT CO_2, CO_2-e)



Source: Model estimate using EIA Annual Energy Outlook 2016; EIA's Annual Energy Outlook 2018, Table 2. Energy Consumption by Sector and Source; Department of Treasury Working Paper 115, Rhodium Group Taking Stock 2018

Figure B-1 compares carbon and total GHG emissions baselines referenced in the study. CTAM baseline emissions are fuel-related carbon emissions generated from fossil fuel consumption estimates in the AEO 2016 No-CPP Case. Rhodium Group estimates are based on EPA Greenhouse Gas Inventory including CO_2-e greenhouse gases and estimates of carbon sinks and show a range of outcomes allowing for future variability of policy and other uncertainties. Current EIA estimates also include CO_2- greenhouse gases and estimates of carbon sinks and reflect EIA policy assumptions. Note that CTAM results for fuel-only emissions are slightly higher than the 2018 EIA projections for total GHGs but track the low-end of 2018 Rhodium Group estimates in the later years. Million Metric Tons CO_2 and CO_2-e.

Table B-3: Dynamic Losses to the States (Millions 2015$)

State	Revenue	.25% Revenue Loss	.5% Revenue Loss	1% Revenue Loss	1.5% Revenue Loss
United States	$3,418.80	$854.70	$1,709.40	$3,418.80	$5,128.21
Alabama	$42.03	$10.51	$21.02	$42.03	$63.05
Alaska	$11.47	$2.87	$5.73	$11.47	$17.20
Arizona	$56.08	$14.02	$28.04	$56.08	$84.11
Arkansas	$26.85	$6.71	$13.42	$26.85	$40.27
California	$510.79	$127.70	$255.39	$510.79	$766.18
Colorado	$58.81	$14.70	$29.41	$58.81	$88.22
Connecticut	$43.06	$10.77	$21.53	$43.06	$64.60
Delaware	$10.31	$2.58	$5.15	$10.31	$15.46
District of Columbia	$15.04	$3.76	$7.52	$15.04	$22.56
Florida	$166.54	$41.63	$83.27	$166.54	$249.81
Georgia	$78.84	$19.71	$39.42	$78.84	$118.25
Hawaii	$16.82	$4.20	$8.41	$16.82	$25.23
Idaho	$12.91	$3.23	$6.45	$12.91	$19.36
Illinois	$136.79	$34.20	$68.40	$136.79	$205.19
Indiana	$57.63	$14.41	$28.81	$57.63	$86.44
Iowa	$34.86	$8.71	$17.43	$34.86	$52.28
Kansas	$27.72	$6.93	$13.86	$27.72	$41.58
Kentucky	$40.19	$10.05	$20.10	$40.19	$60.29
Louisiana	$43.32	$10.83	$21.66	$43.32	$64.98
Maine	$12.45	$3.11	$6.23	$12.45	$18.68
Maryland	$64.93	$16.23	$32.47	$64.93	$97.40
Massachusetts	$84.18	$21.04	$42.09	$84.18	$126.27
Michigan	$95.52	$23.88	$47.76	$95.52	$143.28
Minnesota	$66.21	$16.55	$33.10	$66.21	$99.31
Mississippi	$29.29	$7.32	$14.64	$29.29	$43.93
Missouri	$53.23	$13.31	$26.62	$53.23	$79.85
Montana	$10.03	$2.51	$5.02	$10.03	$15.05
Nebraska	$23.10	$5.78	$11.55	$23.10	$34.65
Nevada	$25.43	$6.36	$12.72	$25.43	$38.15
New Hampshire	$12.27	$3.07	$6.13	$12.27	$18.40
New Jersey	$105.74	$26.43	$52.87	$105.74	$158.61
New Mexico	$24.17	$6.04	$12.08	$24.17	$36.25
New York	$338.42	$84.60	$169.21	$338.42	$507.63
North Carolina	$88.74	$22.18	$44.37	$88.74	$133.10
North Dakota	$12.36	$3.09	$6.18	$12.36	$18.54
Ohio	$123.72	$30.93	$61.86	$123.72	$185.57
Oklahoma	$34.85	$8.71	$17.42	$34.85	$52.27
Oregon	$48.78	$12.19	$24.39	$48.78	$73.17
Pennsylvania	$132.10	$33.03	$66.05	$132.10	$198.16
Rhode Island	$11.74	$2.93	$5.87	$11.74	$17.61
South Carolina	$45.73	$11.43	$22.87	$45.73	$68.60
South Dakota	$7.63	$1.91	$3.82	$7.63	$11.45
Tennessee	$56.56	$14.14	$28.28	$56.56	$84.84
Texas	$238.49	$59.62	$119.24	$238.49	$357.73
Utah	$27.44	$6.86	$13.72	$27.44	$41.17
Vermont	$7.54	$1.89	$3.77	$7.54	$11.31
Virginia	$78.23	$19.56	$39.12	$78.23	$117.35
Washington	$82.37	$20.59	$41.19	$82.37	$123.56
West Virginia	$17.95	$4.49	$8.97	$17.95	$26.92
Wisconsin	$59.09	$14.77	$29.55	$59.09	$88.64
Wyoming	$10.46	$2.61	$5.23	$10.46	$15.69

Source: BEA 2017 Annual GDP by State.

Table B-3 shows dynamic losses to the states and local government in dollar terms assuming declines in combined income and general sales and gross receipts taxes assuming declines of .25%, .5%, 1%, and 1.5%. Revenues are 2016 values. Millions 2015$.

Table B-4: Illustrative State and Local Static and Dynamic Losses, $40 Per Ton Tax (Millions 2015$)

State	State Share of Static Burden	Dynamic Effect - .5% loss in Sales and Income Taxes	State Share of Static Burden Plus .5% Dynamic Effect	Dynamic Effect - 1% loss in Sales and Income Taxes	State Share of Static Burden Plus 1% Dynamic Effect
United States	$25,510.30	$4,165.24	$29,675.54	$8,330.48	$33,840.78
Alabama	$279.36	$45.61	$324.98	$91.23	$370.59
Alaska	$69.91	$11.41	$81.32	$22.83	$92.74
Arizona	$423.57	$69.16	$492.73	$138.32	$561.89
Arkansas	$165.43	$27.01	$192.44	$54.02	$219.45
California	$3,637.66	$593.95	$4,231.61	$1,187.89	$4,825.55
Colorado	$453.90	$74.11	$528.01	$148.22	$602.12
Connecticut	$345.41	$56.40	$401.81	$112.80	$458.21
Delaware	$97.39	$15.90	$113.29	$31.80	$129.19
District of Columbia	$173.50	$28.33	$201.82	$56.66	$230.15
Florida	$1,281.04	$209.16	$1,490.20	$418.33	$1,699.36
Georgia	$734.01	$119.85	$853.86	$239.69	$973.71
Hawaii	$116.72	$19.06	$135.78	$38.11	$154.83
Idaho	$95.20	$15.54	$110.74	$31.09	$126.29
Illinois	$1,086.40	$177.38	$1,263.78	$354.77	$1,441.17
Indiana	$475.58	$77.65	$553.23	$155.30	$630.89
Iowa	$251.87	$41.12	$292.99	$82.25	$334.12
Kansas	$208.97	$34.12	$243.09	$68.24	$277.21
Kentucky	$268.18	$43.79	$311.97	$87.57	$355.75
Louisiana	$326.13	$53.25	$379.37	$106.50	$432.62
Maine	$81.32	$13.28	$94.59	$26.55	$107.87
Maryland	$521.28	$85.11	$606.40	$170.23	$691.51
Massachusetts	$698.50	$114.05	$812.55	$228.10	$926.60
Michigan	$668.72	$109.19	$777.91	$218.37	$887.10
Minnesota	$464.98	$75.92	$540.90	$151.84	$616.82
Mississippi	$147.93	$24.15	$172.09	$48.31	$196.24
Missouri	$403.77	$65.93	$469.70	$131.85	$535.63
Montana	$63.70	$10.40	$74.10	$20.80	$84.50
Nebraska	$161.26	$26.33	$187.60	$52.66	$213.93
Nevada	$207.00	$33.80	$240.80	$67.60	$274.60
New Hampshire	$106.63	$17.41	$124.04	$34.82	$141.45
New Jersey	$783.64	$127.95	$911.59	$255.90	$1,039.54
New Mexico	$128.58	$20.99	$149.57	$41.99	$170.56
New York	$2,048.83	$334.53	$2,383.36	$669.05	$2,717.89
North Carolina	$712.85	$116.39	$829.25	$232.79	$945.64
North Dakota	$73.49	$12.00	$85.49	$24.00	$97.49
Ohio	$859.63	$140.36	$999.99	$280.72	$1,140.35
Oklahoma	$250.50	$40.90	$291.40	$81.80	$332.31
Oregon	$312.82	$51.08	$363.90	$102.15	$414.98
Pennsylvania	$995.96	$162.62	$1,158.58	$325.23	$1,321.20
Rhode Island	$78.74	$12.86	$91.60	$25.71	$104.45
South Carolina	$290.14	$47.37	$337.52	$94.75	$384.89
South Dakota	$66.12	$10.80	$76.91	$21.59	$87.71
Tennessee	$457.17	$74.65	$531.81	$149.29	$606.46
Texas	$2,246.27	$366.76	$2,613.04	$733.53	$2,979.80
Utah	$219.20	$35.79	$255.00	$71.58	$290.79
Vermont	$42.64	$6.96	$49.60	$13.92	$56.56
Virginia	$673.62	$109.99	$783.60	$219.97	$893.59
Washington	$670.56	$109.49	$780.05	$218.97	$889.53
West Virginia	$101.70	$16.60	$118.30	$33.21	$134.91
Wisconsin	$429.15	$70.07	$499.22	$140.14	$569.29
Wyoming	$53.35	$8.71	$62.06	$17.42	$70.77

Source: Model estimate using EIA Annual Energy Outlook 2016, BEA 2017 Annual GDP by State

Table B-4 shows combined static and dynamic revenues losses to the states and local government assuming a carbon tax of $40 per ton. The static burden of a carbon tax at $40 (12% of federal gross revenues) is allocated to the states by percentage shares of national GDP. Dynamic losses show scenarios of state and local sales and income taxes declining .5% and 1%. For simplicity, state tax revenues are assumed to have percentage shares of total state and local tax revenues equal to state percentage shares of GDP. Actual levels of taxation vary by state. Individual state revenues move directionally in tandem with GDP, but not always uniformly or at the same time. Data from Census Bureau and BEA.

Table B-5: Illustrative State and Local Static and Dynamic Losses, $49 Per Ton Tax (Millions 2015$)

State	State Share of Static Burden	Dynamic Effect - .5% loss in Sales and Income Taxes	State Share of Static Burden Plus .5% Dynamic Effect	Dynamic Effect - 1% loss in Sales and Income Taxes	State Share of Static Burden Plus 1% Dynamic Effect
United States	$30,694.64	$4,165.24	$34,859.88	$8,330.48	$39,025.12
Alabama	$336.14	$45.61	$381.75	$91.23	$427.37
Alaska	$84.12	$11.41	$95.53	$22.83	$106.94
Arizona	$509.66	$69.16	$578.82	$138.32	$647.98
Arkansas	$199.05	$27.01	$226.06	$54.02	$253.07
California	$4,376.93	$593.95	$4,970.87	$1,187.89	$5,564.82
Colorado	$546.14	$74.11	$620.25	$148.22	$694.36
Connecticut	$415.61	$56.40	$472.01	$112.80	$528.40
Delaware	$117.18	$15.90	$133.08	$31.80	$148.98
District of Columbia	$208.75	$28.33	$237.08	$56.66	$265.41
Florida	$1,541.38	$209.16	$1,750.54	$418.33	$1,959.70
Georgia	$883.18	$119.85	$1,003.03	$239.69	$1,122.88
Hawaii	$140.44	$19.06	$159.50	$38.11	$178.55
Idaho	$114.54	$15.54	$130.09	$31.09	$145.63
Illinois	$1,307.18	$177.38	$1,484.57	$354.77	$1,661.95
Indiana	$572.23	$77.65	$649.88	$155.30	$727.54
Iowa	$303.05	$41.12	$344.18	$82.25	$385.30
Kansas	$251.44	$34.12	$285.56	$68.24	$319.68
Kentucky	$322.68	$43.79	$366.47	$87.57	$410.25
Louisiana	$392.40	$53.25	$445.65	$106.50	$498.90
Maine	$97.84	$13.28	$111.12	$26.55	$124.40
Maryland	$627.22	$85.11	$712.34	$170.23	$797.45
Massachusetts	$840.46	$114.05	$954.51	$228.10	$1,068.56
Michigan	$804.63	$109.19	$913.81	$218.37	$1,023.00
Minnesota	$559.47	$75.92	$635.39	$151.84	$711.31
Mississippi	$178.00	$24.15	$202.15	$48.31	$226.30
Missouri	$485.83	$65.93	$551.76	$131.85	$617.68
Montana	$76.64	$10.40	$87.04	$20.80	$97.44
Nebraska	$194.04	$26.33	$220.37	$52.66	$246.70
Nevada	$249.07	$33.80	$282.87	$67.60	$316.67
New Hampshire	$128.30	$17.41	$145.71	$34.82	$163.12
New Jersey	$942.90	$127.95	$1,070.85	$255.90	$1,198.80
New Mexico	$154.71	$20.99	$175.70	$41.99	$196.69
New York	$2,465.21	$334.53	$2,799.74	$669.05	$3,134.26
North Carolina	$857.72	$116.39	$974.12	$232.79	$1,090.51
North Dakota	$88.42	$12.00	$100.42	$24.00	$112.42
Ohio	$1,034.33	$140.36	$1,174.69	$280.72	$1,315.05
Oklahoma	$301.41	$40.90	$342.31	$81.80	$383.21
Oregon	$376.40	$51.08	$427.47	$102.15	$478.55
Pennsylvania	$1,198.37	$162.62	$1,360.98	$325.23	$1,523.60
Rhode Island	$94.74	$12.86	$107.60	$25.71	$120.45
South Carolina	$349.11	$47.37	$396.48	$94.75	$443.85
South Dakota	$79.56	$10.80	$90.35	$21.59	$101.15
Tennessee	$550.08	$74.65	$624.72	$149.29	$699.37
Texas	$2,702.77	$366.76	$3,069.54	$733.53	$3,436.30
Utah	$263.75	$35.79	$299.54	$71.58	$335.33
Vermont	$51.30	$6.96	$58.27	$13.92	$65.23
Virginia	$810.51	$109.99	$920.50	$219.97	$1,030.49
Washington	$806.83	$109.49	$916.32	$218.97	$1,025.81
West Virginia	$122.37	$16.60	$138.97	$33.21	$155.57
Wisconsin	$516.37	$70.07	$586.44	$140.14	$656.51
Wyoming	$64.19	$8.71	$72.90	$17.42	$81.61

Source: Model estimate using EIA Annual Energy Outlook 2016, BEA 2017 Annual GDP by State

Table B-5 shows combined static and dynamic revenues losses to the states and local government assuming a carbon tax of $49 per ton. The static burden of a carbon tax at $49 (11% of federal gross revenues) is allocated to the states by percentage shares of national GDP. Dynamic losses show scenarios of state and local sales and income taxes declining .5% and 1%. For simplicity, state tax revenues are assumed to have percentage shares of total state and local tax revenues equal to state percentage shares of GDP. Actual levels of taxation vary by state. Individual state revenues move directionally in tandem with GDP, but not always uniformly or at the same time. Data from Census Bureau and BEA. Billions 2015$.

Table B-6: Additional Gasoline Tax Due to Carbon Tax (Dollars per Gallon)

	$36/Ton	$2/Ton	$108/Ton	$144/Ton	$40/Ton	$49/Ton
2019	$0.18	$0.14	$0.11	$0.07	$0.39	$0.48
2020	$0.35	$0.28	$0.21	$0.14	$0.40	$0.49
2021	$0.35	$0.42	$0.32	$0.21	$0.41	$0.50
2022	$0.35	$0.56	$0.42	$0.28	$0.42	$0.51
2023	$0.35	$0.71	$0.53	$0.35	$0.42	$0.52
2024	$0.35	$0.71	$0.64	$0.42	$0.43	$0.53
2025	$0.35	$0.71	$0.74	$0.49	$0.44	$0.54
2026	$0.35	$0.71	$0.85	$0.56	$0.45	$0.55
2027	$0.35	$0.71	$0.95	$0.64	$0.46	$0.56
2028	$0.35	$0.71	$1.06	$0.71	$0.47	$0.57
2029	$0.35	$0.71	$1.06	$0.78	$0.48	$0.59
2030	$0.35	$0.71	$1.06	$0.85	$0.49	$0.60
2031	$0.35	$0.71	$1.06	$0.92	$0.50	$0.61
2032	$0.35	$0.71	$1.06	$0.99	$0.51	$0.62
2033	$0.35	$0.71	$1.06	$1.06	$0.52	$0.63
2034	$0.35	$0.71	$1.06	$1.13	$0.53	$0.65
2035	$0.35	$0.71	$1.06	$1.20	$0.54	$0.66
2036	$0.35	$0.71	$1.06	$1.27	$0.55	$0.67
2037	$0.35	$0.71	$1.06	$1.34	$0.56	$0.69
2038	$0.35	$0.71	$1.06	$1.41	$0.57	$0.70
2039	$0.35	$0.71	$1.06	$1.41	$0.58	$0.71
2040	$0.35	$0.71	$1.06	$1.41	$0.59	$0.73

Source: Capital Alpha Estimate

Table B-6 shows the additional gasoline tax that would be imposed on each gallon of gasoline sold. The numbers shows are costs in addition to already existing federal, state, and local gasoline taxes and fees. EIA conversion factor applied.

Appendix C: The JCT's 25% Income and Payroll Tax Offset

The Joint Committee on Taxation (JCT) historically has used a 25% revenue offset to estimate the difference between the net receipts and gross proceeds from any indirect or excise tax. JCT explains its policy in a statement from 2005:

> In estimating the revenue effects of changes in excise taxes, the Joint Committee staff (along with staff at CBO and Treasury's Office of Tax Analysis ("OTA") generally assumes that the net effect on total Federal tax receipts from an increase in Federal excise taxes is less than the increase in gross excise tax receipts. The difference between the change in excise tax receipts and the change in total Federal tax receipts is referred to as the "income and payroll tax offset." The difference arises from the fact that an increase (decrease) in excise taxes results in a decrease (increase) in income subject to Federal income and payroll taxation. [89]

JCT continues:

> The existence of the income and payroll tax offset for excise taxes has become an established, generally accepted component of revenue estimates for excise taxes. Because the incidence assumptions that would have to be made in calculating separate offset factors for each type of excise tax would be extremely time-consuming to determine and would, in any event, be subject to a substantial degree of uncertainty, revenue estimating staffs have settled on using a standard offset factor for most excise tax estimates. This factor may be thought of as an average marginal tax rate on factors of production. For some years, estimating staffs (Joint Committee staff, OTA staff and CBO staff) have applied a 25 percent offset to most excise tax estimates. [90] [91]

In 2009, when the Congressional Budget Office (CBO) prepared to score then current emissions trading proposals, it first restated JCT's basic policy:

> When excise taxes, customs duties, and other types of "indirect" taxes are imposed on goods and services, they tend to reduce income for workers or business owners in the taxed industry and for others throughout the economy. Consequently, revenue derived from existing "direct" tax sources—such as individual and corporate income taxes and payroll taxes—will also be reduced. To approximate that effect, the Congressional Budget Office (CBO), the Joint Committee on Taxation (JCT), and the Treasury Department's Office of Tax Analysis (OTA) apply a 25 percent offset when estimating the net revenue that legislation imposing some form of indirect tax is expected to generate. In other words, the estimated proceeds from the indirect tax are reduced by 25 percent to account for the resulting reductions in income and payroll taxes. *The offset is made in addition to accounting for behavioral responses to the new tax.*[92]

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[89] JCT, "Overview of Revenue Estimating Methodologies Used by the Staff of the Joint Committee on Taxation," February 2, 2005. JCX-1-05. p. 14.

[90] *Ibid*, p. 14-15.

[91] For additional insight and examples of how JCT makes the calculation, see JCT, "The Income and Payroll Tax Offset to Changes in Excise Tax Revenues," December 23, 2011. JCX-59-11.

[92] CBO, "The Role of the 25% Revenue Offset in Estimating the Budgetary Impact of Legislation," January 13, 2009. Page 1. Emphasis added.

Then, with respect to sale of tradable emissions credits, CBO found that the 25% revenue offset would also apply:

> Although applying the 25 percent offset for budget estimates is a longstanding convention, proposals to address global climate change have created greater public awareness of that practice. Because tradable emission permits would have economic effects that are identical to those of a tax on emissions, which would be an indirect tax, CBO applies the offset when calculating the revenue that such policies might generate. For example, if the issuance of emission permits was estimated to generate $100 billion in revenues in a given year, the estimate would also reflect an offsetting reduction of $25 billion in income and payroll taxes, for a net revenue gain of $75 billion.[93]

In the January 2017 Treasury Department working paper, the authors acknowledge historical practice but call for further study, possibly fearing that a 25% offset would be inadequate given a carbon tax would be "considerably larger" than prior excise taxes, but otherwise stating the question neutrally:

> The 25 percent offset for excise taxes represents long-standing practice for the Joint Committee on Taxation, the Congressional Budget Office, and OTA. Because carbon tax revenues are projected to be considerably larger than other excise taxes, more detailed analysis of the offset in the carbon tax context may be warranted.[94]

Soon after, on February 29, 2017, JCT published an update of its income and payroll tax offsets for excise taxes. The new JCT document found the offsets had increased slightly above "the long-time historical offset factor of 25%," and that the increase would continue slowly over time. The offset for 2017 was increased to 25.9%, while the offset for 2027 rose to 26.1%.[95]

Following the tax reform of 2017, the JCT published a new update. The JCT found that because of tax reform, the offset had decreased to 21.5% for 2018 and rose back to 24.4% by 2028, following the expiration of the individual tax reductions in 2023. JCT notes that as a result, the offsets "return close to the long-time standard offset factor of 25%."[96]

In this paper, we use the 25% offset for consistency with the historical JCT, CBO, and Treasury documents cited, and also because the offset factor returns to nearly 25% for 15 years of our 22-year study period from 2019 to 2040.

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[93] *Ibid*.

[94] Horowitz, page 11, note 17.

[95] JCT, "New Income and Payroll Tax Offsets to Changes in Excise Tax Revenues for 2017-2028," JCX-5-17, February 9, 2017.

[96] JCT, "New Income and Payroll Tax Offsets to Changes in Excise tax revenues for 2018-2028," JCX-8-18, March 27, 2018.

Works Cited

American Petroleum Institute, "Gasoline Tax," n.d. Accessed October 19, 2018. https://www.api.org/oil-and-natural-gas/consumer-information/motor-fuel-taxes/gasoline-tax

Bernstein, Paul, W. David Montgomery, Bharat Ramkrishnan and Sugandha D. Tuladhar, "Impacts of Greenhouse Gas Regulations on the Industrial Sector", NERA Economic Consulting, Prepared for American Council for Capital Formation Center for Policy Research, March 2017.

Bordoff, Jason and John Larsen. *U.S. Carbon Tax Design: Options and Implications*. January 2018. Rhodium Group and Columbia University School of International and Public Affairs, Center on Global Energy Policy.

Bovenberg, A. Lans and Lawrence H. Goulder, "Optimal Environmental Taxation in the Presence of Other Taxes: General-Equilibrium Analyses," *American Economic Review*, American Economic Association, vol. 86(4), p. 988, September 1996.

Carbon Pricing Leadership Coalition, *Report of the High-Level Commission on Carbon Prices*, May 29, 2017.

Carbone, Jared, Richard Morgenstern, Roberton Williams III and Dallas Burtraw, "Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts." Resources for the Future, August 2013. http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-Carbone.etal.CarbonTaxes.pdf. (Accessed March 6, 2017.)

Cedeño, Wander "How did employment fare a decade after its 2008 peak?," *Monthly Labor Review,* U.S. Bureau of Labor Statistics, October 2018 https://doi.org/10.21916/mlr.2018.25.

Chernick, Howard, Reimers, Cordelia, and Tennant, Jennifer. "Tax structure and revenue instability: the Great Recession and the states." IZA Journal of Labor Policy. February 12, 2014.

Congressional Budget Office, "Budget and Economic Outlook: 2018-2028", April 2018.

Congressional Budget Office, "Cost Estimate H.R. 2454 American Clean Energy and Security Act of 2009," June 5, 2009

Congressional Budget Office, "Effects of a Carbon Tax on the Economy and the Environment," May 2013.

Congressional Budget Office, "The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions," September 2009.

Congressional Budget Office, "The Effects of the 2017 Tax Act on CBO's Economic and Budget Projections," April 2018. Appendix B.

Congressional Budget Office, "The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454," June 19, 2009.

Congressional Budget Office, "Options for Reducing the Deficit: 2017 to 2026," December 8, 2016.

Congressional Budget Office, "The Role of the 25% Revenue Offset in Estimating the Budgetary Impact of Legislation," January 13, 2009.

Cunningham, Evan, "Great Recession, great recovery? Trends from the Current Population Survey," *Monthly Labor Review,* U.S. Bureau of Labor Statistics, April 2018, https://doi.org/10.21916/mlr.2018.10.

Department of the Census. "Recessions Matter for State Tax Collections." U.S. Department of Commerce. July 1993.

Department of Energy, "Comprehensive Annual Energy Data and Sustainability Performance—Annual Data 2017" http://ctsedwweb.ee.doe.gov/Annual/Report/Report.aspx

Diamond, John W. and George R. Zodrow. *The Effects of Carbon Tax Policies on the U.S. Economy and the Welfare of Households*. July 2018. Baker Institute for Public Policy at Rice University. Prepared for Columbia University School of International and Public Affairs Center on Global Energy Policy.

Dinan, Terry, "Offsetting a Carbon Tax's Costs on Low-Income Households," Microeconomic Studies Division, Congressional Budget Office, Working Paper 2012-16, November 2012.

Energy Information Administration, U.S. Department of Energy, *Annual Energy Outlook 2016*, distributed by U.S. Energy Information Administration, February 6, 2018. https://www.eia.gov/outlooks/aeo/.

Energy Information Administration, Commercial Building Energy Consumption Survey (CBECS), 2012 https://www.eia.gov/consumption/commercial/

Feldstein, Martin S., Ted Halstead, and N. Gregory Mankiw, "A Conservative Case for Climate Action, *The New York Times*, February 8, 2017.

Francis, Norton and Frank Sammartino. "Governing with Tight Budgets." Urban Institute. September 2015.

Hafstead, Marc, Lawrence H. Goulder, Raymond J. Kopp, and Roberton C. Williams, III, "Macroeconomic Analysis of Federal Carbon Taxes," Resources for the Future, June 13, 2016.

Horowitz, John, Julie-Anne Cronin, Hannah Hawkins, Laura Konda, and Alex Yuskavage. *Working Paper 115: Methodology for Analyzing a Carbon Tax*. U.S. Department of Treasury Office of Tax Analysis. Treasury.gov. Originally published January 2017. (Accessed August 17, 2018.) https://www.cbo.gov/about/products/budget-economic-data.

International Energy Agency and International Renewable Energy Agency, *Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System*, March 2017.

Jacoby, Henry, David Montgomery, and Mei Yuan, "Next Steps in Tax Reform," MIT Joint Program on Climate Change, Report 329, April 2018.

Joint Committee on Taxation, "JCX-1-05: Overview of Revenue Estimating Methodologies Used by the Joint Committee on Taxation," U.S. Congress, February 2, 2005.

Joint Committee on Taxation, "JCX-5-17: New Income and Payroll Tax Offsets to Changes in Excise Tax Revenues for 2017-2027," U.S. Congress, February 9, 2017.

Joint Committee on Taxation, "JCX-59-11: The Income and Payroll Tax Offset to Changes in Excise Tax Revenues," U.S. Congress, December 23, 2011.

Joint Committee on Taxation, "JCX-8-18: New Income and Payroll Tax Offsets to Changes in Excise Tax Revenues for 2018-2028," U.S. Congress, March 27, 2018.

Kaufman, Noah and Kate Gordon. *The Energy, Economic, and Emissions Impacts of a Federal US Carbon Tax*. July 17, 2018. Rhodium Group and Columbia University School of International and Public Affairs Center on Global Energy Policy.

Kaufman, Noah, John Larsen, Shashank Mohan, Whitney Herndon, Peter Marsters, John Diamond, and George Zodrow. *Emissions, Energy, and Economic Implication of the Curbelo Carbon Tax Proposal*. July 19, 2018. Rhodium Group and Columbia University School of International and Public Affairs Center on Global Energy Policy.

Labonte, Marc, *The 2007-2009 Recession: Similarities to and Differences from the Past*, Congressional Research Service, October 6, 2010.

Larsen, John, Kate Larsen, Whitney Herndon, Peter Marsters, Hannah Pitt, and Shashank Mohan. *Taking Stock 2018*. June 28, 2018. Rhodium Group.

Markets Insider, "CO2 EUROPEAN EMISSION ALLOWANCES IN EUR-HISTORICAL PRICES," Business Insider, n.d. (Accessed 2018) https://markets.businessinsider.com/commodities/historical-prices/co2-emissionsrechte/euro/1.1.2017_31.12.2017.

Mathur, Aparna and Adele Morris, "A US Carbon Tax and the Earned Income Tax Credit," Discussion paper, Brookings Climate Energy and Economics Project, January 23, 2017.

Morison, Rachel and Jeremy Hodges, "Carbon Reaches 10-Year High, Pushing Up European Power Prices," *Bloomberg*, August 23, 2018.

National Conference of State Legislatures, "NCSL Fiscal Brief: State Balanced Budget Provisions," Original publication October 2010. (Accessed September 2018).

Nystrom, Scott, Katie O'Hare, Ken Ditzel, "The Economic, Fiscal, and Emissions Impacts of a Revenue-Neutral Carbon Tax," FTI Consulting, July 2018.

Nystrom, Scott, Patrick Luckow, "The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax," Regional Economic Models, Inc and Synapse Energy Economics, Inc for Citizen's Climate Lobby, June 9, 2014.

OECD (2016), *Effective Carbon Rates: Pricing CO2 through Taxes and Emissions Trading Systems*, OECD Publishing, Paris, https://doi.org/10.1787/9789264260115-en.

Pack, Will, and Lee, Steven, "Carbon Taxes on Transportation Fuels: Estimating the Effective Carbon Tax from Excise Taxes," EPRINC Note, Energy Policy Research Foundation, Inc., April 2017.

Rich, Robert, "The Great Recession," *Federal Reserve History*, originally published November 22, 2013 (Accessed September 2018). https://www.federalreservehistory.org/essays/great_recession_of_200709.

Schultz, George P. and James A. Baker, III, "A Conservative Answer to Climate Change," *The Wall Street Journal*, February 7, 2017.

Smith, Anne E., David Harrison, et al. *Economic Outcomes of a US Carbon Tax*. February 26, 2013. NERA Economic Consulting. Prepared for National Association of Manufacturers.

U.S. Energy Information Administration, "How much tax do we pay on a gallon of gasoline and a gallon of diesel fuel?" September 7, 2018. Accessed September 24, 2018. https://www.eia.gov/tools/faqs/faq.php?id=10&t=10

Urahn, Susan K., et al, "Rainy Day Funds and State Credit Ratings: How well-designed policies and timely use can protect against downgrades," Pew Charitable Trust, May 2017, pp. 10-12.

Urban Institute, "State and Local Revenues," n.d. (Accessed September 03, 2018). https://www.urban.org/policy-centers/cross-center-initiatives/state-local-finance-initiative/state-and-local-backgrounders/state-and-local-revenues.

U.S. Bureau of Economic Analysis, "2017 Annual GDP by State," distributed by U.S. Bureau of Economic Analysis. Accessed August 2018. https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1#reqid=70&step=1&isuri=1.

U.S. Bureau of Economic Analysis, Personal current taxes: Federal: Income taxes [B231RC1A027NBEA], retrieved from FRED, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/B231RC1A027NBEA, October 3, 2018.

U.S. Bureau of Economic Analysis, Federal Government: Tax Receipts on Corporate Income [FCTAX], retrieved from FRED, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/FCTAX, October 3, 2018.

U.S. Census Bureau, 1998-2017 *Annual Surveys of State Government Tax Collections by Category*, (1998-2017), distributed by U.S. Census Bureau. https://www.census.gov/programs-surveys/stc.html

White House Office of Management and Budget, "Budget of the United States Government, Fiscal Year 2019", distributed by U.S. Government Publishing Office, February 2018.

Woodward, G. Thomas, "The Role of the 25% Revenue Offset in Estimating the Budgetary Effects of Legislation," Congressional Budget Office, January 13, 2009.

World Bank and Ecofys. 2018. "State and Trends of Carbon Pricing 2018 (May)," by World Bank, Washington, DC.

World Bank, Ecofys and Vivid Economics. 2017. State and Trends of Carbon Pricing 2017 (November), by World Bank, Washington, DC.

Yankee Staff. "Where Has All the Money Gone? The 25th Anniversary of Connecticut's Income Tax." The Yankee Institute. August 26, 2016.http://www.yankeeinstitute.org/policy-papers/where-has-all-the-money-gone/