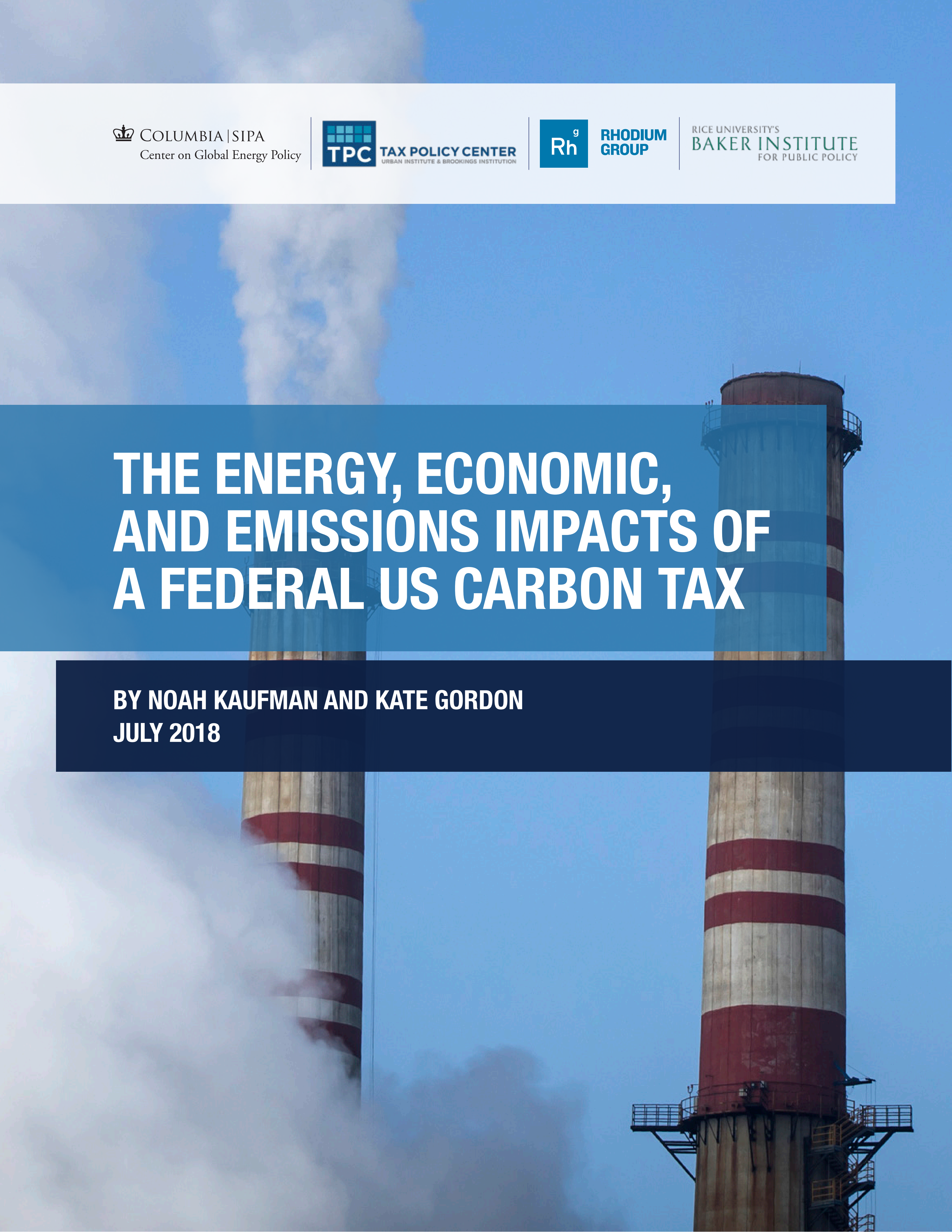

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THE ENERGY, ECONOMIC, AND EMISSIONS IMPACTS OF A FEDERAL US CARBON TAX

BY NOAH KAUFMAN AND KATE GORDON

JULY 2018

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INTRODUCTION

Climate change is a serious threat to global progress and stability. Actions to reduce greenhouse gas (GHG) emissions and stabilize global temperatures can avoid impacts of climate change on human health, the economy, national security, and the environment. But without a strong federal-level climate policy response from the United States, chances of serious global climate action are slim.

The next time the US Congress seriously considers climate legislation, a federal carbon tax is likely to be at the center of that discussion. When that time comes, policy makers will need to understand the range of important decisions associated with the design of carbon tax policy and the implications of these decisions on the US energy system, environment, and economy. Columbia University's SIPA Center on Global Energy Policy (CGEP) launched the Carbon Tax Research Initiative to provide rigorous, comprehensive, and objective analyses of just these questions.

This report summarizes collaborations between CGEP and three organizations: Rhodium Group, the Urban-Brookings Tax Policy Center (TPC), and Rice University's Baker Institute for Public Policy (collectively referred to as "we" throughout this report). Using state-of-the-art modeling tools, we provide an up-to-date (e.g., inclusive of 2017 federal tax reform) view of likely outcomes if a federal carbon tax is implemented in the United States, over what we assume to be the first decade of policy implementation (the 2020s).

This paper summarizes findings in five key areas:

1. Energy market outcomes, with modeling from John Larsen, Shashank Mohan, Peter Marsters and Whitney Herndon of the Rhodium Group (page 4)
2. Government revenues, with modeling from all three partners (page 5)
3. Tax burden across the income distribution, with modeling from Joseph Rosenberg, Eric Toder, and Chenxi Lu of TPC (page 6)
4. Macroeconomic outcomes, with modeling from John Diamond and George Zodrow of Rice University (page 7)
5. Emissions impacts, with modeling from the Rhodium Group (page 8)

We also provide guidance for interpreting the findings in light of model limitations, similar studies, and other relevant factors. Considerable additional details on modeling assumptions and results are available in three detailed reports published on the website of the CGEP Carbon Tax Research Initiative.

Carbon tax design: our assumptions

- The carbon tax applies to all CO_2 emissions from the combustion or consumption of fossil fuels and methane emissions from fossil fuel production (about 80 percent of US greenhouse gas emissions).
- The tax is applied at the point of production or importation (i.e., "upstream").
- The policy includes a border adjustment on imports and exports of energy-intensive products to shield domestic manufacturers from international competitors that do not face a similar policy.
- Three carbon tax scenarios all starting in 2020 are analyzed, as well as the current policy scenario for comparison:
  - $14/ton scenario: the tax starts at $14/ton and rises by about 3 percent annually
  - $50/ton scenario: the tax starts at $50/ton and rises by about 2 percent annually
  - $73/ton scenario: the tax starts at $73/ton and rises by about 1.5 percent annually

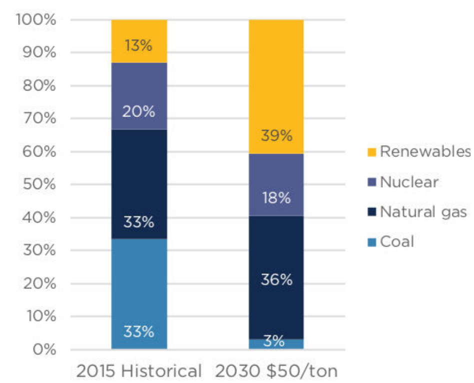
ENERGY MARKET OUTCOMES[1]

- Price increases depend on tax rates, the carbon intensity of the energy sources, and many other factors.
- The carbon tax significantly accelerates the shift away from coal and toward renewable electricity.
- Effects on the production and consumption of oil and natural gas are relatively small

Selected Energy Prices in 2030 and Historical Comparison

	Gasoline (Price at pump) 2016 $/gal	**Diesel** (Price at pump) 2016 $/gal	**Natural Gas** (Delivered price) 2016 $/mmbtu	**Electricity** (Retail) 2016 cents/kWh	**Coal** (Power sector) 2016 $/short ton
2030 Average Price					
Current Policy	3.0	3.6	7.6	10.6	45
$14/ton	3.2	3.8	8.9	11.4	79
$50/ton	3.6	4.2	11.3	12.9	152
$73/ton	3.8	4.5	13.0	13.5	202
Historical Annual Average					
10-yr Low	2.3	2.3	5.1	10.3	39
10-yr High	3.9	4.2	12.1	11.0	49

US Electricity Generation



Note: Prices are somewhat lower in 2020, and generally increase throughout the 2020s. In addition to these scenarios, we also analyzed the effects of a "High Innovation" scenario. See the Rhodium Group analysis for details. Historical data is from the U.S. Energy Information Administration.

The effects of a carbon tax on prices are largest for energy produced by coal, followed by oil, then natural gas, due to the difference in carbon intensity of each fuel. Every additional dollar per ton of the carbon tax increases prices at the pump by slightly more than one cent per gallon for gasoline and slightly less than one cent per gallon for diesel. In 2030, average retail electricity rates increase by 8 percent, 22 percent, and 27 percent for the $14/ton[2], $50/ton, and $73/ton scenarios, with substantial variation across regions. Total annual per capita energy expenditures increase by as much as 6 percent, 21 percent, and 34 percent in the $14/ton, $50/ton, and $73/ton scenarios, but, in all scenarios, they remain below the per capita expenditure levels at the height of the global commodity boom in 2008.

Coal production falls dramatically compared to the current policy scenario, between 28 and 84 percent by 2030. In contrast, effects on oil markets are small, as petroleum remains the dominant transportation fuel, though the tax does cause a reduction in net imports of petroleum of between 2 and 12 percent by 2030. The carbon tax initially causes an increase in natural gas production compared to the current policy scenario (between 1 and 8 percent in 2020, due to the shift from coal to natural gas in the power sector), and then natural gas production falls by about 5 percent in 2030, as renewables ramp up to between 30 and 40 percent of the electricity generation mix.

These results, as well as those from other carbon tax studies, should be interpreted cautiously due to the uncertainty surrounding energy market forecasts, and with the following specific caveats in mind:

- Impacts of a carbon tax depend on assumptions about technological progress; for example, a carbon tax will cause larger shifts to lower-carbon alternatives when those alternatives are relatively less expensive.
- Our analysis includes a forecast of technological improvements in all scenarios, but we do not capture the acceleration in innovation in low-carbon technologies that is caused by the carbon tax.[3]
- We do not capture the influence of US policy on international climate action, which could affect the carbon tax impacts in a host of ways, including a possible reduction in demand for US fossil fuel exports.
- We assume consumers respond to carbon taxes like they respond to other comparable energy price changes (i.e., not much[4]). If consumers are more responsive to the more permanent and visible price changes caused by a carbon tax, energy consumption and energy bills will be lower than we project.[5]

REVENUES FROM A FEDERAL US CARBON TAX

- The $14/ton, $50/ton, and $73/ton scenarios increase government revenue by about $60, $180, and $250 billion in each year of the 2020s, accounting for changes in other tax revenues as well.
- Proposals for the use of carbon tax revenue include reducing other taxes or deficits, funding clean energy, and sending checks to individuals or households, among others.

A carbon tax differs from other regulatory strategies by not only encouraging emissions reductions across the economy but also requiring the remaining emissions sources to pay the tax, thus creating significant federal revenues. We estimate annual carbon tax payments of about $80 billion, $240 billion, or $340 billion per year for the three tax scenarios. Payments of the carbon tax leave individuals and businesses with less income, and thus lower tax payments on that income. This reduces the net increase in government revenue by 25 percent, to about $60 billion, $180 billion, and $250 billion for the three carbon tax scenarios, according to our estimates. On the other hand, our model that captures changes in economic activity across the economy shows that a carbon tax leads to higher wages in relatively highly taxed sectors, which increases government revenue.

For context, the US corporate income tax raised about $300 billion in 2017 (prior to the 2017 tax cuts), and the federal excise tax on gasoline and diesel fuel brought in about $40 billion.

The increasing annual carbon tax rates push revenue up over time, while the decrease in annual US emissions pushes revenues down: these offsetting effects cause additional annual revenue to be roughly constant over time.[6]

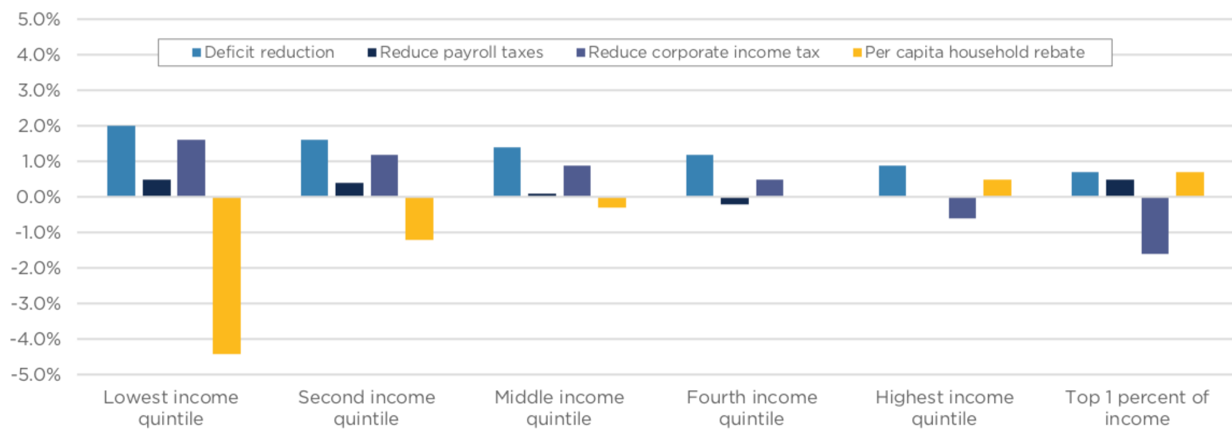
How to use the additional revenue is subject to wide debate. Our analysis focuses on three revenue uses: payroll tax reductions, equal rebate checks, and deficit reductions. The table below also describes two additional potential revenue uses: corporate income tax reductions and increases in government spending. In each case, we assume all revenues are used for a single purpose. In reality, legislators may choose to split the revenue, including directing portions of revenue to address adverse effects of the tax—for example, to ensure low-income households do not experience increases in energy prices they cannot afford or to invest in regions of the country that are most dependent on coal.

	Revenue Use Options				
	Reduce payroll taxes[7]	**Send rebate checks**	**Reduce deficits**	**Reduce corporate taxes**	**Increase governemnt spending**
Purpose of using the revenue in this way	Returns carbon tax payments to taxpayers; targets the middle class; spurs growth by adding incentive to work/hire	Returns carbon tax payments to taxpayers in a highly progressive and visible way	Reduces the federal debt, which may have a range of positive economic effects[8]	Returns carbon tax payments to taxpayers; spurs economic growth by adding incentives to invest	Impacts vary based on expenditure (e.g., clean energy, infrastructure, climate adaptation)
Impact of revenues from $50/ ton Scenario	Reduction in payroll taxes between 2 and 3 percentage points	Each individual receives roughly $1,000 per year in rebates	Reduces debt-to-GDP ratio from 45% to 31% and interest rates by 0.5 percentage points	Reduces corporate income tax rate from 21% to 10%	Adds roughly $180 billion per year in additional expenditures

THE TAX BURDEN ACROSS THE INCOME DISTRIBUTION

- How the carbon tax revenue is used is the major differentiating factor in distributional outcomes.
- A carbon tax policy can be progressive, regressive, or neither.

Change in Tax Burden as a Percent on Pre-Tax Income in 2025: $50/Ton Scenario



A carbon tax is often referred to as regressive because low-income households spend relatively large shares of their total consumption on energy-intensive goods such as electricity, home heating fuels, and gasoline. This is just one of many important distributional consequences. Energy price increases also reduce the revenues of businesses; this impact is likely to disproportionately affect wealthier households.[9] Also, many low-income households (particularly retirees) are shielded from energy price increases because payments they receive from Social Security and other government assistance programs increase with the price level.[10]

In fact, the most important driver of differing impacts of a carbon tax across the income distribution is the use of the revenue. Under a $50/ton carbon tax scenario, we see the following distributional outcomes:[11]

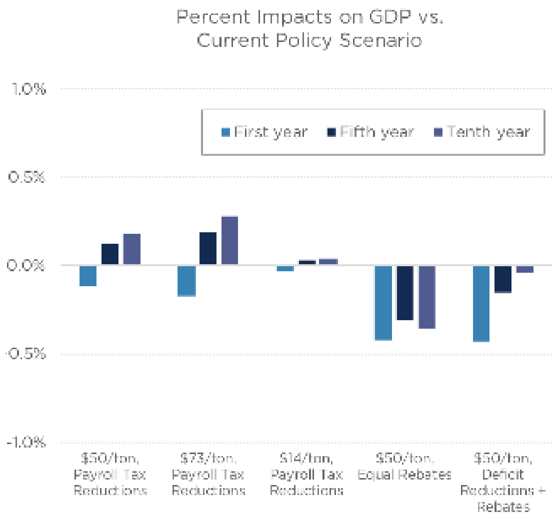
- When all revenues are used for ***deficit reductions***, the policy is initially regressive, with the tax burden of lowest-income and highest-income households increasing by over 2 percent and less than 1 percent, respectively, as a percent of pre-tax incomes.[12] In the long run, however, lower debt will enable lower taxes and/or increased government spending, which can be structured in ways that are progressive, regressive, or neither;
- When all revenues are used for ***equal rebates***, the policy is progressive, with lower income households receiving far more in rebates than they pay in additional taxes. The tax burden for low-income households (bottom 20 percent) decreases by 4–5 percent of pre-tax income, middle-income households come out slightly ahead, and high-income households (top 20 percent) pay 0.4– 0.6 percent more in taxes; or
- When all revenues are used for ***payroll tax reductions***, middle and upper-middle income households fare best and see little change to their overall tax burden.[13] Low-income households (bottom 20 percent) and very rich households (top 1 percent) both see increased tax burdens of about 0.5 percent of pre-tax income.[14]

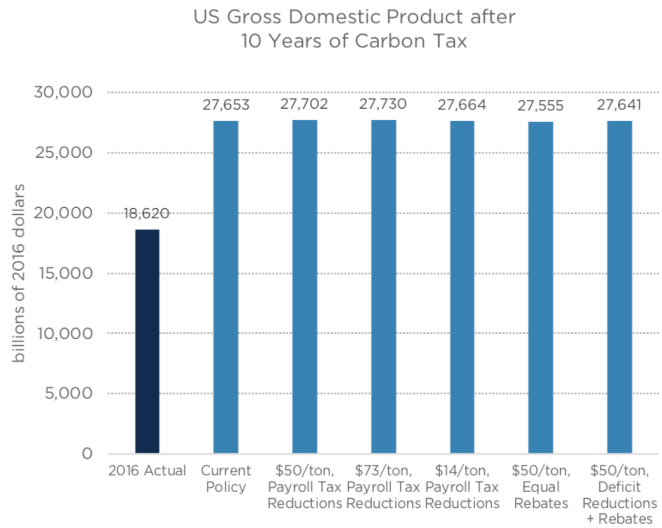
A carbon tax policy can be designed to ensure that low-income households receive as much in government rebates as they pay in higher prices, and studies have shown that roughly 10 percent of carbon tax revenues might be needed to accomplish this goal.[15]

Certain important distributional consequences are not captured in our (or comparable) studies. For example, low-income households may disproportionately benefit from reductions in air pollution caused by the carbon tax.[16] Also, a carbon tax may replace other federal and state policies that have important distributional consequences (e.g., high-income households have benefited disproportionately from clean energy tax credits and subsidies[17]).

MACROECONOMIC EFFECTS[18]

- How the carbon tax revenue is used is the major differentiating factor in macroeconomic outcomes.
- Models show that effects of a carbon tax on near-term economic growth are small and typically negative.
- Accounting for the economic effects of lower air pollution or avoided regulations would improve outcomes.





We find annual effects of a carbon tax on US gross domestic product (GDP) of less than 0.6 percent per year across all scenarios and years; these effects could be positive or negative. The economic drag caused by higher prices is roughly offset by the positive effects of revenue use. In scenarios where all carbon tax revenue is used to reduce payroll taxes (which provides additional incentives to hire and work), the carbon tax increases GDP after 5 and 10 years (by less than 0.3 percent). In contrast, in the scenarios where all revenues are used to reduce the debt or provide rebates, the negative factors outweigh the positive over the first decade.[19] Effects on GDP do not increase over time.

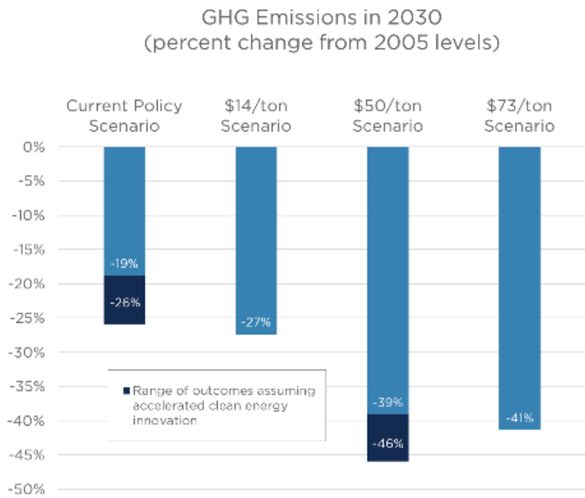
Other macroeconomic indicators, such as effects on consumption, investment, and employment, generally follow similar trends over the first ten years after reform, with small positive impacts for payroll tax reductions and small negative impacts for the other revenue uses compared to the current policy scenario. An exception is the effect on economy-wide investment when revenue is used to reduce the federal debt, which is about 2 percent higher after 10 years under the carbon tax, due to lower interest rates.

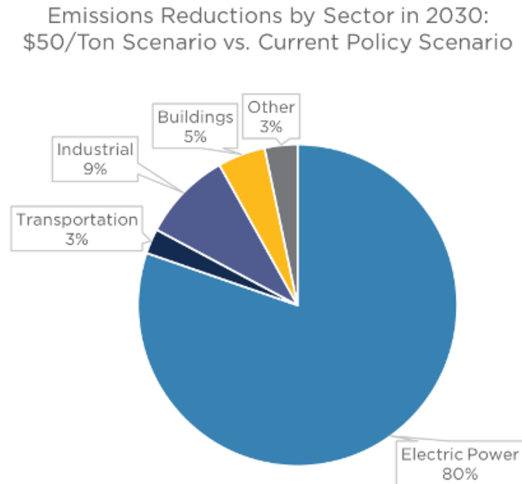
Comparable carbon tax studies have shown similarly small impacts on macroeconomic outcomes. However, whether the tax increases GDP when all revenue is used to reduce other taxes (as we show) is highly model dependent.[20] Major factors omitted from our (and similar) analysis include the economic benefits of avoided regulations and reduced air pollution,[21] as well as any changes in technological progress stimulated by the tax. While not all omitted factors point in the same direction, on balance, omitted factors suggest that economic outcomes are likely to be better than suggested by current economic models.

Nationwide results mask subnational variation, primarily caused by regional differences in energy production and consumption. While the western and northeastern regions of the country fare relatively well under a carbon tax, the economic effects of a carbon tax tend to be worse in the more carbon- and energy-intensive southern and middle parts of the country, where, according to one recent study, the carbon tax causes gross regional product to fall by as much as 0.6 percent compared to the baseline scenario in 2030.[22] Carbon tax revenues can be used to mitigate such regional disparities.

EMISSIONS IMPACTS[23]

- In the $50/ton scenario, GHG emissions fall by about 40 percent below 2005 levels and 25 percent below current policy scenario levels by 2030.
- Over three-quarters of the emissions reductions are achieved in the power sector.
- Emissions impacts are influenced by assumptions about expected technological progress.





Reducing GHG emissions is the primary reason to implement a carbon tax. Our research shows that in the 2020s, US GHG emissions decline by 0.4 percent per year in the current policy scenario. Under the carbon tax, emissions fall far more rapidly: by 1.2 percent, 3.2 percent, and 3.5 percent per year in the $14/ton, $50/ton, and $73/ton scenarios, respectively.

By 2030, under the $50/ton scenario, US emissions fall to 39–46 percent below 2005 levels, depending on assumptions related to technological progress.[24] Such emissions reductions outpace the pathway described in the United States Nationally Determined Contribution to the Paris climate agreement (26 to 28 percent reductions in net GHG emissions by 2025) by a considerable margin, whereas the $14/ton scenario falls short of this marker.

Roughly 80 percent of the emissions reductions caused by the carbon tax are in the power sector, where competitive markets, a relatively small number of corporate actors, and an array of clean energy technologies facilitate deep and immediate emissions reductions.

Emissions reductions outside the power sector are small, due to fewer cost-effective clean alternatives and weak responses to price changes, among other factors. For example, transportation sector emissions are only 2 percent lower in 2030 in the central tax scenario compared to the current policy scenario. If the carbon tax causes an acceleration in innovation in low-carbon technologies (such as electric vehicles)[25] or if the consumers' response to a carbon tax is stronger than to day-to-day price changes, as some evidence suggests,[26] then studies like ours may underestimate emissions reductions in these sectors (and economy wide).

While our analysis focuses on the United States, climate change is a global phenomenon, so it is important to consider the effects a US carbon tax could have on global GHG emissions. For example, changes in production, consumption, and investment in the United States would have spillover effects elsewhere, and a carbon tax on imports would encourage trading partners to implement similar policies. Perhaps most importantly, a federal carbon tax could change the landscape of international climate negotiations and enable the United States to ask other countries to take stronger actions to reduce emissions.

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NOTES

1. Detailed results can be found in the Rhodium Group study released alongside this report.
2. In this report, "dollars per ton" is shorthand for dollars per metric ton of carbon dioxide or carbon dioxide-equivalent emissions of other greenhouse gases.
3. A carbon tax is likely to increase innovation in low-carbon technologies, but the magnitude of this effect is not well understood. One recent study finds that to reduce emissions by 30 percent in 20 years, the carbon tax rate needed is nearly 20 percent lower in a scenario that accounts for the innovation induced by the carbon tax (Fried 2018).
4. Under the $50/ton scenario, in 2030, the demand for gasoline, distillate, and electricity are only about 3 percent lower than under the current policy scenario.
5. Studies of the effects of carbon taxes in British Columbia and Sweden both found that the carbon tax caused a decrease in gasoline consumption that was roughly three times larger than the expected effect of an equivalent change in the price of gasoline (Lawley and Thiverge 2018; Anderson 2017).
6. In the $50/ton scenario, annual revenues increase by less than 2 percent per year in nominal terms (including inflation) and decrease by less than 1 percent per year in real terms (excluding inflation).
7. This option would return carbon tax revenues by reducing the employee's share of the Social Security payroll tax. Currently the Old-Age, Survivors, and Disability Insurance (OASDI) payroll tax rate is 12.4 percent (6.2 is imposed on the employer and 6.2 on the employee), and it applies to earnings up to a maximum of $128,400 (in 2018).
8. Benefits of reduced federal debt may include lower interest rates, reduced probabilities of fiscal emergencies, and greater fiscal flexibility when unexpected events arise, among others.
9. Carbon taxes reduce "real incomes" by reducing the ratio of wages of workers and profits of business owners to average prices that consumers must pay for goods and services. Empirical estimates suggest that these impacts of the carbon tax on real incomes are disproportionately felt by higher-income households. For further details, see the Tax Policy Center and Baker Institute reports released alongside this report.
10. Fullerton et al (2012).
11. Two studies released alongside this report, by the Urban-Brookings Tax Policy Center (TPC) and the Baker Institute for Public Policy at Rice University, provide estimates of the distributional outcomes associated with the three carbon tax scenarios, as well as various revenue uses. TPC estimates tax burden on US households of different income levels using its large-scale microsimulation model, which is a similar model to those used by the Congressional Budget Office, the Joint Committee on Taxation, and the Treasury's Office of Tax Analysis. The Baker Institute estimates the "equivalent variation" (a measure of lifetime welfare) of US households across income levels using its Diamond-Zodrow dynamic overlapping generations computable general equilibrium model.
12. All quantitative results on distributional outcomes referenced on this page are from the TPC study released alongside this report. TPC's methodology is intended to reflect the effects of a "fully phased-in" policy that assumes, for example, that Social Security payments adjust for the reduction in inflation-adjusted wage rates caused by the carbon tax.
13. Specifically, the TPC results show households in the fourth income quintile (60th to 80th percentile of income) see their tax burden decrease by 0.3 percent of pre-tax income, while households in the second and third income quintiles (20th to 40th percentiles and 40th to 60th percentiles) see their tax burdens increase by 0.4 and 0.1 percent, respectively.
14. Middle-income households benefit disproportionately from payroll tax reductions because a large portion of income for many high-income households is either from investments or from income above the earnings cap on the payroll tax of $128,400, and low-income households that are out of the workforce do not pay payroll taxes.
15. The Stanford Energy Modeling Forum 32 exercise involved various energy/economic modeling teams analyzing similar carbon tax scenarios in the United States. With a $25/ton carbon tax increasing at 5 percent per year, two modeling teams estimated the minimum percent of carbon tax revenues that need to be

transferred to households in the bottom income quintile (20 percent) so that these households receive as much in transfers as they pay in carbon taxes. The studies found that targeting roughly 10 percent of carbon tax revenues is sufficient to accomplish this objective (Caron et al. 2018). In 2015, the Center on Budget and Policy Priorities (CBPP) proposed an approach whereby nearly all low-income households in the country would receive rebates using existing government transfer programs, including via income tax credits, payments from state human service agencies through the electronic benefit transfer system used to deliver food stamp benefits, and supplemental payments to beneficiaries of Social Security and other federally administered programs (Stone 2015).

16. Reduced air pollution is likely to improve health outcomes disproportionately in low-income communities where pollution mortality and morbidity rates are highest (Hendryx and Ahem 2009).

17. A 2015 study shows the bottom three income quintiles have received about 10 percent of all clean energy tax credits, while the top quintile has received about 60 percent. Electric vehicles are a particularly extreme example, where the top income quintile has received about 90 percent of all electric vehicle credits (Borenstein and David 2015).

18. Detailed results can be found in the Baker Institute for Public Policy study released alongside this report.

19. While this summary report focuses on the first decade of implementation of the carbon tax (the 2020s), the analysis of the Baker Institute report takes a longer-term view. For the scenario in which revenues are used to reduce federal debt levels, while near-term effects on GDP are negative, the long-term effects are positive (starting around 2040) once the benefits of reduced federal debt on the economy begin to accrue.

20. The macroeconomic impacts of a carbon tax were estimated using the Baker Institute's Diamond-Zodrow (DZ) dynamic overlapping generations computable general equilibrium (CGE) model, designed to estimate the short- and long-run macroeconomic and distributional effects of tax reforms in the United States. Various unique aspects of this model influence its estimates of the macroeconomic effects of a carbon tax, including the model's sectoral aggregation and its ability to differentiate effects on individuals by age. Please see the Baker Institute study released alongside this report for additional details.

21. The primary intent of a carbon tax is to reduce carbon dioxide emissions, but it would also significantly reduce the emissions of particulate matter and other conventional air pollutants with detrimental effects on human health (primarily due to the reduction in coal production caused by the carbon tax). For a carbon tax starting at $25 per ton and increasing 5 percent per year, Woollacott (2018) estimates both the costs and cobenefits at the national level and finds that the marginal cobenefit offsets over half of the marginal welfare costs to households from the tax.

22. Ross (2018) estimates the effects on GDP in 2030 of 10 US regions for a carbon tax that starts at $25 per ton and increases at 5 percent per year. The analysis considers three different revenue uses. Effects on GDP are most negative when revenues are used for "lump sum recycling" (i.e., household rebates). In this scenario 2030 regional GDPs decline between 0.0 and 0.6 percent below the baseline scenario, with the East North Central, West North Central, and Mountain regions faring worst.

23. Detailed results can be found in the Rhodium Group study released alongside this report.

24. For two scenarios (current policy and $50/ton), the Rhodium Group analysis examined a "high innovation" scenario in addition to its base technology assumption. However, any single estimates provided in this report refer to the base technology assumptions and not the "high innovation" scenario.

25. A carbon tax is likely to increase innovation in low-carbon technologies, but the magnitude of this effect is not well understood. One recent study finds that to reduce emissions by 30 percent in 20 years, the carbon tax rate needed is nearly 20 percent lower in a scenario that accounts for the innovation induced by the carbon tax (Fried 2018).

26. Lawley and Thiverge 2018; Anderson 2017.

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ACKNOWLEDGMENT

The authors would like to thank the authors of three studies on which this report is based: John Larsen, Shashank Mohan, Peter Marsters and Whitney Herndon of the Rhodium Group; Joseph Rosenberg, Eric Toder, and Chenxi Lu of the Urban-Brookings Tax Policy Center; and John Diamond and George Zodrow of Rice University. The authors would also like to acknowledge the contributions of Jason Bordoff, Ron Minsk, Jesse McCormick, Mathew Robinson, Edwin Saliba and Anna Gossett.

The opinions expressed in this report should no be construed as reflecting the views of the Columbia SIPA Center on Global Energy Policy or any other entity.

This work was made possible by support from the Center on Global Energy Policy. More information is available at: https://energypolicy.columbia.edu/about/mission.

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