WHO PAYS FOR CLIMATE POLICY? NEW ESTIMATES OF THE HOUSEHOLD BURDEN AND ECONOMIC IMPACT OF A U.S. CAP-AND-TRADE SYSTEM

by

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ABSTRACT

Many U.S. lawmakers view cap and trade as a politically superior non-tax approach to climate policy. However, cap and trade imposes identical economic burdens on households to a similarly designed carbon tax. Using the newly-released 2002 input-output accounts we present new estimates of the distributional impact of a typical cap-and-trade system by income, age, U.S. region and family type. In total, households would face an annual burden of roughly $144.8 billion per year with costs disproportionately borne by low-income households, those under age 25 and over 75 years, those in Southern states, and single parents with dependent children. Using RIMS II multipliers we estimate the broader economic impact of cap and trade. Depending on how the system is structured, cap and trade could reduce U.S. employment by 965,000 jobs, household earnings by $37.8 billion, and economic output by $136 billion per year or roughly $1,145 per household. Lawmakers weighing the costs and benefits of climate policy should be aware that cap and trade would impose a significant and regressive annual burden on U.S. households, and would not represent a "tax free" way to reduce greenhouse gas emissions.

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I. INTRODUCTION

Climate change legislation has become a top Congressional priority in recent months. In June 2008 the Lieberman-Warner cap-and-trade bill (S. 2191) was brought to debate in the U.S. Senate, and during the recent presidential campaign both President Obama and Sen. McCain placed climate change at the center of their domestic policy agendas.[1] With the inclusion of a cap-and-trade proposal in the President's Fiscal Year 2010 budget, it is likely that the new administration will pursue federal climate legislation in the coming months.[2]

Lawmakers face two basic options for climate policy: a federal carbon tax, or a U.S. cap-and-trade system. Both policies have a similar goal of cutting greenhouse gas emissions. However, cap and trade is often viewed as more politically attractive because of lawmakers' unwillingness to be associated with explicit tax increases. A cap-and-trade system offer lawmakers a way to curb greenhouse gas emissions through regulations rather than tax increases—a less visible approach that enjoys the popular perception of being less burdensome to households.

Contrary to this perception, economic theory teaches that cap and trade and carbon taxes impose nearly identical economic burdens on households.[3] Both policies increase consumer prices for carbon-intensive products and lower real household income in an economically equivalent way. The popular view that cap and trade offers a "tax free" way to address climate change is therefore based on a misconception of how the economic burdens of climate policy—both cap and trade and carbon taxes—will ultimately be borne by American households.

The goal of this study is to clarify the equivalence of cap and trade and carbon taxes from the standpoint of household burdens and illustrate the annual cost of a typical cap-and-trade system to U.S. households. Using an input-output model of the U.S. economy, we illustrate the distributional impact of a cap-and-trade system that cuts greenhouse gas emissions by 15 percent compared to 2006 levels by income group, age, U.S. region and type of family. Additionally, using RIMS II multipliers from the U.S. Bureau of Economic Analysis we illustrate the likely economic impact of a U.S. cap-and-trade system on employment, household earnings and total economic output.

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[1] The complete Lieberman-Warner cap-and-trade bill is available as Senate bill 2191, "America's Climate Security Act of 2007." Available online at http://thomas.loc.gov/cgi-bin/bdquery/z?d110:S.2191:.

[2] See *Budget of the United States Government: Fiscal Year 2010*, available at www.whitehouse.gov/omb/budget/.

[3] See Weitzman (1974) for a review of conditions under which the theoretical equivalency of carbon taxes and cap and trade may not hold. For example, if there is uncertainty about the size of the economic costs of a strict carbon limit, a more flexible carbon tax may be preferred. By contrast, if there is uncertainty about the economic costs of allowing carbon emissions to exceed some limit, or uncertainty about firms' elasticities with respect to carbon taxes, a cap-and-trade system may be preferred.

The findings suggest a federal cap-and-trade system would impose a significant annual burden on households, and that this burden is economically equivalent to a similarly designed federal carbon tax. Contrary to popular perception, cap and trade does not represent a less costly way to address climate change than a carbon tax from the standpoint of household burdens. As lawmakers weigh the costs and benefits of curbing greenhouse gas emissions, they should be cognizant of these costs to U.S. households—particularly low- and middle families least able to bear them.

II. ECONOMIC THEORY OF CLIMATE POLICY

Cap-and-trade systems are often viewed as regulations rather than taxes. However, economic theory shows that cap and trade imposes an identical annual burden on households to a similarly designed carbon tax. Regardless of which approach lawmakers choose, both policies impose equivalent costs from the standpoint of U.S. households.

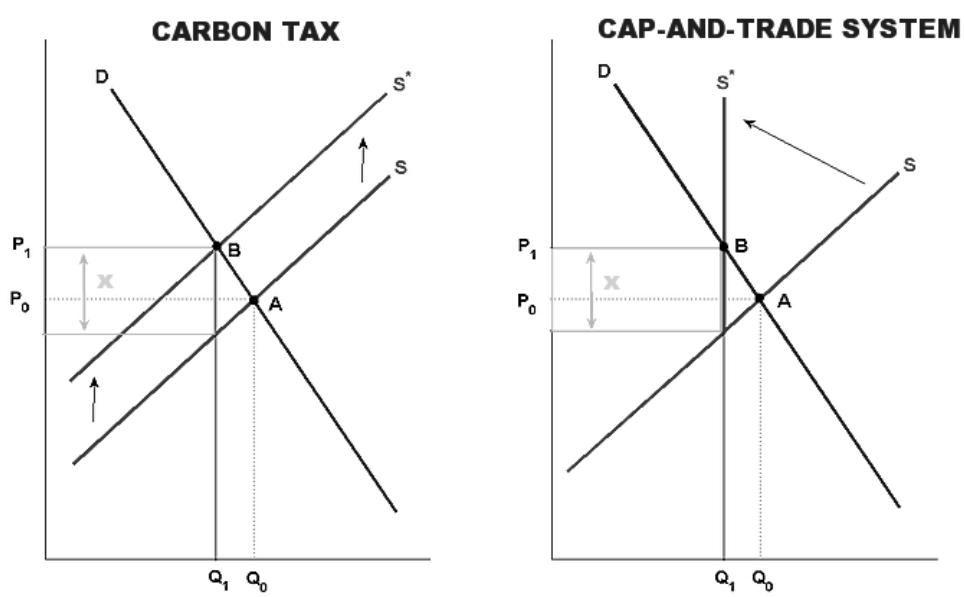
In this section we provide an overview of the economic theory of climate policy, illustrating the basic equivalence of cap and trade and carbon taxes on annual household burdens.

A. HOW CLIMATE POLICY AFFECTS MARKETS

The central goal of climate policy is to cut U.S. greenhouse gas emissions. Both carbon taxes and cap and trade achieve this by placing controls on suppliers throughout the economy. In the language of supply and demand, both policies shift the supply curve for carbon-intensive products upward, forcing up consumer prices for these products. Carbon taxes achieve this with a simple per-unit tax, while cap and trade achieves it with a regulatory quantity restriction. But from the standpoint of consumers bearing the ultimate burden, both policies have exactly the same impact.

The easiest way to see the equivalence of carbon taxes and cap and trade is through a simple supply and demand diagram. In Figure 1 we illustrate the impact of both policies. The left panel shows a carbon tax and the right panel shows a cap-and-trade system.

FIGURE 1. PARTIAL EQUILIBRIUM IMPACT OF CARBON TAX AND CAP-AND-TRADE SYSTEM



Source: Tax Foundation.

In the figure, before federal carbon policy the economy operates at the point labeled *A* in both panels. At this point, the price of carbon-intensive products is labeled P_0 and the economy produces Q_0 units of carbon-heavy products per year. This corresponds to the current U.S. economy without federal climate policy.

Imagine Congress aims to cut carbon emissions to some lower level associated with Q_1 in the figure. In the left-hand panel they do so with a carbon tax, which is designed to discourage carbon emissions indirectly by affecting prices. In the right panel they do so with a cap-and-trade system, which is designed to reduce emissions by directly limiting the quantity of carbon emitted in the economy.

In the left panel, the carbon tax raises production costs for companies that produce carbon-intensive products by the amount of the tax per ton. This shifts the supply curve upward by the amount of the tax. In the figure, lawmakers impose a tax of *x* dollars which moves the supply curve upward to the line labeled *S**. After the tax, the economy moves to the point labeled *B*. Prices rise to P_1 as carbon tax burdens are passed on to consumers and carbon emissions fall to the targeted level of Q_1.

In the right-hand panel, lawmakers instead reduce carbon emissions with a U.S. cap-and-trade system. Under cap and trade, lawmakers simply "cap" total carbon emissions at some predetermined level. In the figure, the capped quantity is the emissions target associated with Q_1. Tradable permits or "allowances" are then distributed to companies with each allowance granting the right to emit one unit of carbon per year.

Cap and trade operates like a quantity restriction that transforms the supply curve in the right panel into a vertical line labeled *S** at the emissions target set by lawmakers. Under the cap the economy moves to the new point labeled B. Since cap and trade essentially rotates the supply curve to the left, it reduces output and raises prices just like a carbon tax. Once the cap is in place, prices for carbon-intensive products rise to P_1—the exact level as under a similarly designed carbon tax in the left-hand panel—as cap and trade burdens are passed on to consumers throughout the economy.

As is clear from the figure, the economic impact of carbon taxes and cap and trade are essentially the same. Both cut the economy's carbon emissions to the same level and both raise prices for carbon-intensive products by the same amount. Regardless of the policy lawmakers choose, U.S. households will ultimately bear an equivalent economic burden from either approach to federal climate policy.[4]

Impact on Government Revenue

While both policies have an identical impact on households, they have dramatically different impacts on government revenue. Under a carbon tax government collects tax

[4] While the supply curve in Figure 1 is presented as upward-sloping for the purposes of illustration, the modeling in this study is based on the assumption of a horizontal or perfectly elastic long-run supply curve for carbon-intensive products. See note 22 and accompanying text for a detailed explanation.

revenue from companies that emit carbon. In Figure 1, this revenue corresponds to the light-grey rectangle in the left-hand panel, which is equal to the tax rate *x* times the quantity of carbon emitted Q_1. Once this tax revenue is collected the federal government can then spend it in a variety of ways—cutting corporate or personal income taxes, refunding it as a lump-sum transfer to households, or simply increasing other federal spending.

By contrast, under a cap-and-trade system the revenue to government depends on how the initial allowances are distributed. If allowances are sold through an auction government will collect revenue from the sale of allowances. In Figure 1, this auction revenue corresponds to the light gray rectangle in the right panel, which is equal to the market-determined allowance price of *x* times the quantity of allowances sold Q_1.[5] Government can then dispose of this revenue just as with the tax revenue from a federal carbon tax.

However, government can also freely distribute allowances to companies, or offer them at a discounted price. This was the "grandfathering" approach largely followed by the European Union Emission Trading System (EU ETS) currently in place throughout Europe.[6] Under freely distributed permits the revenue impact is more complicated. A cap-and-trade system essentially forces large sectors of the economy to operate as a cartel, restricting carbon output and raising prices. As with any cartel, the cartelization of carbon emissions has the potential to create large economic rents for companies lucky enough to obtain allowances for free. For example, a company receiving free initial allowances can immediately resell them on the open trading market for a potentially large one-time profit. In this way, free allocation of allowances would create large one-time windfall profits for U.S. companies that receive allowances that are roughly equal in the aggregate to the total market value of the allowances distributed by government.

Because of the various federal, state and local corporate income taxes, governments would recapture somewhere on the order of 40 percent of these extra profits created by free initial allowances.[7] The remaining 60 percent would ultimately accrue to shareholders throughout the economy. In this way, government would receive significant revenue from cap and trade even if initial allowances are freely distributed. In effect, free distribution of initial allowances is equivalent selling initial allowance via auction and

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[5] If a carbon tax and cap and trade have the same emissions-reduction goal, the equilibrium price of allowances will equal the per-unit carbon tax. To see why, consider the right-hand panel of Figure 1. At the capped quantity of Q_1 companies holding allowances can sell output at a price of P_1 but can produce it for the lower price given by the height of the supply curve at Q_1. The vertical distance between the two—labeled *x* in the figure—represents the pure economic profit companies can earn by holding an allowance. Companies will therefore bid up allowance prices to *x* dollars, which is also equal to the carbon tax rate that would achieve a similar emissions cut.

[6] See European Commission, "Questions and Answers on Emissions Trading and National Allocation Plans for 2008 to 2012." Available online at www.ec.europa.eu/environment/climat/pdf/m06_452_en.pdf.

[7] The Congressional Budget Office assumes governments recapture 45 percent of economic rents from free allowances. According to the Organization for Economic Cooperation and Development (OECD), the combined U.S. top marginal corporate tax rate is closer to 40 percent, which is the figure used in this study.

then distributing the auction proceeds directly back to carbon-emitting companies in the form of a one-time profit. These profits would then be divided 60-40 between shareholders and federal, state and local government treasuries.

The basic lesson from the above discussion is that lawmakers' choices about the structure of a cap-and-trade system—and the way they dispose of the revenue generated—can have enormous distributional consequences throughout the economy. While supply and demand will determine who ultimately bears the burden of cap and trade, government has the power to create large winners and losers in the economy by controlling who receives the value of allowances. In Section III of this study we explore these large distributional impacts of cap and trade on U.S. households in detail.

B. IMPACT ON THE BROADER U.S. ECONOMY

In addition to raising prices throughout the economy, cap and trade has broader impacts on household income, employment and economic growth. Economists call these the "general equilibrium" effects of carbon policy. As noted above a cap-and-trade system restricts output and raises prices for carbon-intensive products. This in turn affects the broader economy in three distinct ways: (1) it permanently increases relative prices for carbon-intensive products; (2) it lowers real earnings for workers and owners of capital; and (3) it leads to potentially large adjustment costs to workers and companies currently operating in carbon-intensive industries.

Permanent Price Impacts

In the long run, cap and trade causes prices throughout the economy to rise by an amount roughly equal to the value of outstanding carbon allowances. If the federal government issues $150 billion in allowances, prices for carbon-intensive products will rise by approximately $150 billion in the aggregate. This occurs regardless of whether initial allowances are auctioned or distributed freely. The intuition behind this effect is that cap and trade introduces artificial scarcity in the market for carbon-intensive products, which is reflected in the price of tradable allowances. Requiring companies to hold these carbon allowances permanently raises their costs of production. As firms adjust to these cost increases, the burden of holding the allowances is ultimately passed forward to consumers in the form of higher prices throughout the economy.

Reduced Returns to Labor and Capital

Because cap and trade raises prices for carbon-intensive products throughout the economy, it has a secondary effect of lowering real returns to U.S. capital and labor. In effect, the price increases caused by cap and trade allow workers to buy fewer things with the same dollar amount of wages, lowering their income in real terms. Similarly, investors are able to buy less with the same dollar amount of capital income, lowering real returns to capital. These poorer returns reduce the supply of capital and labor throughout the economy, lowering household earnings, employment and economic output. This indirect economic impact of cap and trade is known as the "tax interaction" effect of carbon policy.[8]

Adjustment Costs to Workers and Companies

As the economy adjusts to lower carbon emissions many workers and companies will face large adjustment costs. For example, workers in coal mining and petroleum extraction industries have highly specialized skills and earn high wages. Under cap and trade, many of these workers will face unemployment and lower wages as they move into other fields. Similarly, owners of capital in carbon-intensive industries will face temporary losses as returns are depressed. While the costs to capital owners will tend to be highly diffused throughout the economy, as most investors hold diversified portfolios of assets, the transition costs to workers will be highly concentrated in just a few industries and geographic regions throughout the country.[9]

These broader economic impacts of climate policy are explored in detail in Section IV of this study, in which we illustrate how the impact of a typical cap-and-trade system on U.S. gross domestic product will in turn affect employment, household earnings and total economic output.

[8] For a thorough exploration of the theory and estimates of the "tax interaction" effect of climate policy, see Parry, Williams and Goulder (1999).

[9] It should be noted that these cost are transitional only. In the long run capital and labor will tend to migrate away from carbon-intensive industries and into other industries, returning wages and capital returns in carbon-intensive industries to their long-run levels.

III. DISTRIBUTIONAL IMPACT OF A CAP-AND-TRADE SYSTEM

Because a cap-and-trade system restricts carbon emissions and raises prices, it imposes household burdens that are equivalent to a similarly designed carbon tax. In this section we present new estimates of the distributional impact of these burdens by income group, age, U.S. region and type of family. These estimates help illustrate which Americans would bear the ultimate cost of federal policy aimed at curbing greenhouse gas emissions.

A basic lesson from the economics of taxation is that all taxes are ultimately borne by individuals rather than companies. Similarly, although cap and trade requires companies in the petroleum, coal and natural gas industries to bear the initial cost of tradable allowances, economists agree that the real economic burden is likely to be passed forward to households in the form of an invisible tax built into the price of consumer products throughout the economy.

In this study we model the impact of a cap-and-trade system designed to cut U.S. carbon emissions by 15 percent compared to 2006 levels. This is a typical emissions-reduction goal for a wide range of climate change proposals, and is the one modeled by most U.S. Congressional Budget Office studies of cap and trade.[10] The system is an "upstream" one; that is, only companies in coal mining and petroleum and natural gas extraction industries are required to hold carbon allowances.

According to U.S. Congressional Budget Office estimates, a cap-and-trade system that cuts emissions by 15 percent corresponds to an allowance price of roughly $100 per metric ton of carbon.[11] In Figure 1 this corresponds to the value labeled *x* in light gray in the right-hand panel which represents the increased production costs borne by companies producing carbon-intensive products. Using a standard input-output model we trace the burden of this cost increase down to the level of households.

BOX 1. CARBON OR CARBON DIOXIDE?

Some climate policies limit carbon, while others limit carbon dioxide equivalent (CO_2). The relationship between them is that one metric ton of CO_2 contains 12/44 tons of carbon.

To convert from CO_2 units to carbon, simply multiply by 12/44. For example, an allowance price of $100 per ton of carbon is equivalent to (12/44) x $100 or $27.27 per ton of CO_2.

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[10] See for example "Containing the Cost of a Cap-and-Trade Program for Carbon Dioxide Emissions," CBO Testimony (May 20, 2008); "Trade-Offs in Allocating Allowances for CO2 Emissions," CBO Economic and Budget Issue Brief (April 25, 2007); and "Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs," CBO Study (June 2000).

[11] See "Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs," CBO Study (June 2000) and Lasky (2003). $100 per ton of carbon allowance price is based on a literature estimate for the price elasticity of carbon emissions of -0.57 and a pre-policy carbon price of $307 per ton.

Table 1 summarizes the cap-and-trade system modeled in this study. In 2006, fossil-fuel carbon emissions in the U.S. were roughly 1.7 billion metric tons.[12] A cap-and-trade system designed to cut emissions by 15 percent would restrict annual carbon emissions to 1.45 billion tons. At an assumed allowance price of $100 per ton the total cap-and-trade burden to U.S. consumers would therefore be approximately $144.8 billion per year or $1,218 per household. This is the overall cap-and-trade burden estimate used throughout this study.

TABLE 1. OVERVIEW OF THE CAP-AND-TRADE SYSTEM MODELED IN THIS STUDY

Emissions Target (Reduction from 2006 Levels)	15 percent
Allowance Price ($ per metric ton of carbon)	$100
Pre-Policy U.S. Carbon Emissions (Metric Tons)	1,703,181,818
Post-Policy U.S. Carbon Emissions (Metric Tons)	1,447,704,545
Total Value of Allowances Issued	$144,770,454,545

Source: Tax Foundation; U.S. Congressional Budget Office;
U.S. Environmental Protection Agency.

In this analysis we focus primarily on the burden of cap and trade to households in the form of higher consumer prices. As noted above, cap and trade also generates government revenue that may be disposed of by lawmakers in various ways that may affect these household burdens. Because of uncertainty about how lawmakers may or may not dispose of future cap-and-trade revenue, we present only household burdens from higher consumer prices throughout the body of the study. This is the approach followed by the U.S. Congressional Budget Office when presenting the household impact of higher prices from cap and trade, and we follow that convention in this study.[13]

However, the distribution of government revenue from cap and trade can have a large impact on the net distribution impact of climate policy. To illustrate this impact, in Box 2 we present an example of how the results of this study would change if both the burden and spending sides of climate policy are taken into account. The box illustrates the net fiscal incidence of a cap-and-trade system under a scenario in which initial allowances are freely distributed to companies and lawmakers return the extra corporate tax revenue generated from companies' one-time profits in the form of an across-the-board revenue-neutral corporate tax cut.[14]

[12] See U.S. Environmental Protection Agency (2008), Figure 2-6, "2006 U.S. Fossil Carbon Flows." Note that all units of CO_2 are converted to carbon for this study.

[13] See for example U.S. Congressional Budget Office (2008), Table 1, page 14.

[14] Note that other net distributional scenarios (such as lump-sum rebates of cap-and-trade auction revenue to households) can easily be derived from the tables in this study. Various scenarios of how lawmakers may dispose of revenue to households can simply be subtracted from this study's tables of household burdens. Many previous studies have explored these options; see for example Dinan and Rogers (2002),

BOX 2. HOW FEDERAL SPENDING AFFECTS CAP-AND-TRADE BURDENS

In this study, we focus on the initial household burden of cap and trade. However, implementing such a system would also generate government revenue that—depending on how lawmakers spend it—can have a dramatic impact on net household burdens from climate policy.

For example, if government sells initial allowances via auction with the proceeds distributed as lump-sum transfers to U.S. households a household's annual burden would be partly or totally offset by the subsequent transfer payment. The combined impact of household burdens and government spending benefits is known as the "net fiscal incidence" of climate policy.

As an illustration, the table below presents the net fiscal incidence of a cap-and-trade system with freely distributed initial allowances. As noted in Section II of this study, free initial allowances create large one-time profits for companies that receive them. Governments recapture approximately 40 percent of these profits through federal, state and local corporate taxes, and the remaining 60 percent accrue to shareholders throughout the economy. In the table below we assume government returns these higher corporate tax collections to taxpayers in the form of an across-the-board corporate income tax cut.

The table illustrates the impact of three factors on households: (1) the initial household cost of cap and trade, (2) minus the increased stock returns to shareholders, (3) minus the tax savings from a revenue-neutral corporate tax cut. The first line presents the household cap-and-trade burden from Section III of this study. The second line shows the impact of higher stock returns to shareholders, and the third line shows households' tax savings from the corporate tax cut.

NET FISCAL INCIDENCE OF A CAP AND TRADE SYSTEM WITH FREE INITIAL ALLOWANCES AND A REVENUE-NEUTRAL CORPORATE TAX CUT

	Quintiles of Cash Income Before Taxes (2006)				
	Lowest 20 Percent	Second 20 Percent	Third 20 Percent	Fourth 20 Percent	Highest 20 Percent
Household Cap-and-Trade Burden	$617	$863	$1,100	$1,418	$2,091
Less: Higher Stock Returns from One-Time Profits	($42)	($139)	($307)	($664)	($2,499)
Less: Tax Savings from Revenue-Neutral Corp. Tax Cut	($48)	($175)	($357)	($571)	($1,496)
Net Household Burden	$528	$548	$436	$182	($1,904)

Note: Assumes shareholders earn 60 percent of one-time corporate profits, while governments recapture 40 percent through corporate income taxes. Higher stock returns are distributed to households on the basis of dividend income. Reduced corporate tax burdens are assumed to fall 70 percent on labor income and 30 percent on capital income based on Randolph (2006).
Source: Tax Foundation; 2007 Current Population Survey (March Supplement); 2006 Consumer Expenditure Survey (CEX).

As is clear from the table, how lawmakers choose to dispose of revenue from a cap-and-trade system can have a dramatic impact on the fiscal incidence of climate policy. In this example, households in the top quintile actually profit by $1,904 per year on a net basis from cap and trade while households in the bottom four quintiles pay a net burden ranging from $182 to $548 per year. In total, such a policy would redistribute roughly $145 billion from the lowest-earning 80 percent of U.S. households to the nation's highest-earning one-fifth.

As is clear from this illustration, implementing a U.S. cap-and-trade system would transfer enormous power to federal lawmakers who choose how to dispose of the revenue generated from the system. In turn, these choices will have a dramatic impact on which Americans bear the ultimate cost of policy aimed at reducing U.S. greenhouse gas emissions.

A. BURDENS BY INCOME GROUP

A well-known aspect of climate policy is that costs are regressively distributed across households. That is, lower-income households tend to spend a larger fraction of their income on carbon-intensive products like fuel and electricity than higher-income households. As a result, cap and trade tends to impose the heaviest relative burdens on households least able to bear them. This study confirms that finding.

Table 2 presents the basic distribution of cap-and-trade burdens by income quintile. The quintiles contain equal numbers of households and all figures are for calendar year 2006, the most recent year for which data are available.[15] As is clear from the table, higher-income groups bear the largest dollar burden from cap and trade while lower-income groups bear the largest burden as a percentage of income.

Households in the highest-earning quintile—those earning over $88,774 in cash income—bear an annual cap-and-trade burden of $2,091 per year or 1.4 percent of income. Households in the middle quintile earning between $35,095 and $56,222 pay an annual burden of $1,100 or 2.4 percent of income. And households in the lowest-earning quintile—those earning less than $18,370 per year—pay $612 per year or a substantial 6.2 percent of income.

TABLE 2. ANNUAL BURDEN OF A U.S. CAP-AND-TRADE SYSTEM BY INCOME QUINTILE

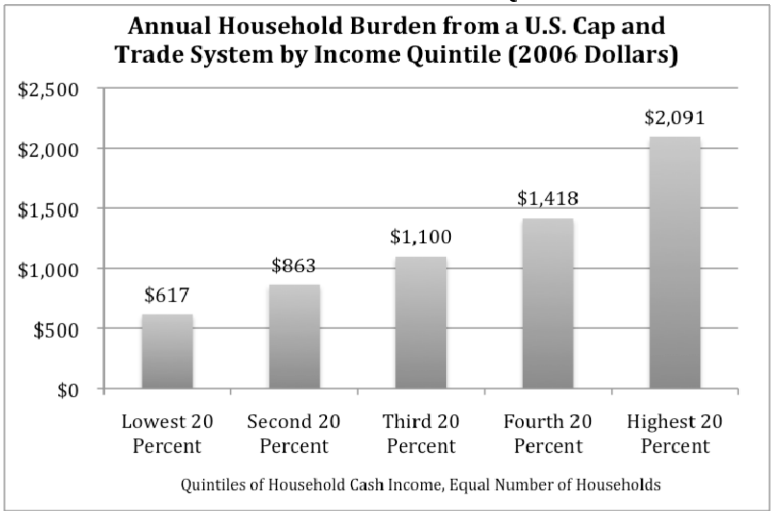
		Quintiles of Cash Income Before Taxes, Equal Number of Households				
	All Households	Lowest 20 Percent	Second 20 Percent	Third 20 Percent	Fourth 20 Percent	Highest 20 Percent
Lower Bound of Household Income	n/a	n/a	$18,370	$35,095	$56,222	$88,774
Average Annual Household Burden	$1,218	$617	$863	$1,100	$1,418	$2,091
Household Burden as a % of Income	2.0%	6.2%	3.2%	2.4%	2.0%	1.4%
Aggregate Burden ($ billion)	$144.8	$14.6	$20.5	$26.1	$33.7	$49.8

Note: Assumes a 15 percent emissions reduction and an allowance price of $100 per ton of carbon.
Source: Tax Foundation Input-Output Model; U.S. Bureau of Labor Statistics.

Figures 2 and 3 present the figures from Table 2 graphically. Figure 2 illustrates the annual household dollar burden from cap and trade by income quintile, and Figure 3 presents annual burdens as a percentage of household cash income. As expected, as income and therefore consumption rises households bear a larger dollar burden from a cap-and-trade system. However, as a fraction of income the lowest-earning households in the nation bear the heaviest price for policy aimed at reducing greenhouse gas emissions.

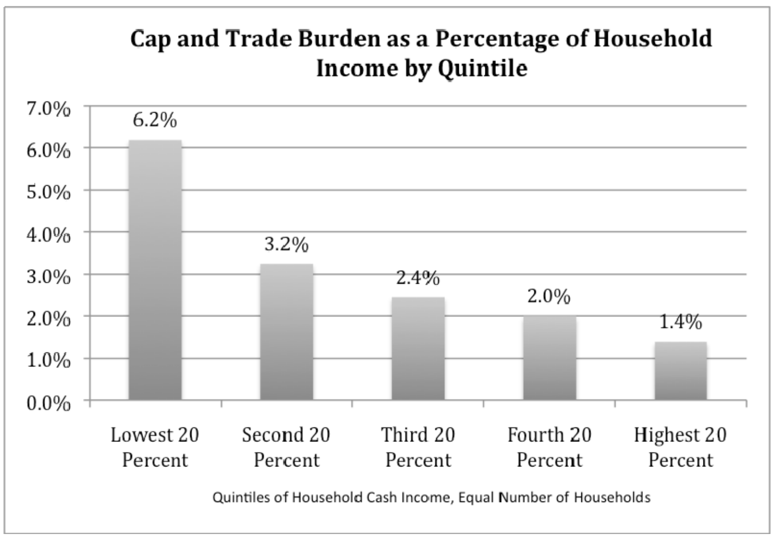
[15] The household income concept employed is cash income before taxes as defined by the U.S. Bureau of Labor Statistics' Consumer Expenditure Survey (CEX). It consists of wages and salaries; self-employment income; Social Security, private and government retirement; interest, dividends, rental income, and other property income; unemployment, workers' compensation and veteran's benefits; public assistance, supplemental security income, and food stamps; alimony and child support; and other cash income including scholarships, and stipends. See www.bls.gov/bls/glossary.htm.

FIGURE 2. ANNUAL HOUSEHOLD BURDEN FROM A U.S. CAP-AND-TRADE SYSTEM BY CASH INCOME QUINTILE



Source: Tax Foundation Input-Output Model.

FIGURE 3. ANNUAL CAP-AND-TRADE BURDEN AS A PERCENTAGE OF HOUSEHOLD CASH INCOME



Source: Tax Foundation Input-Output Model.

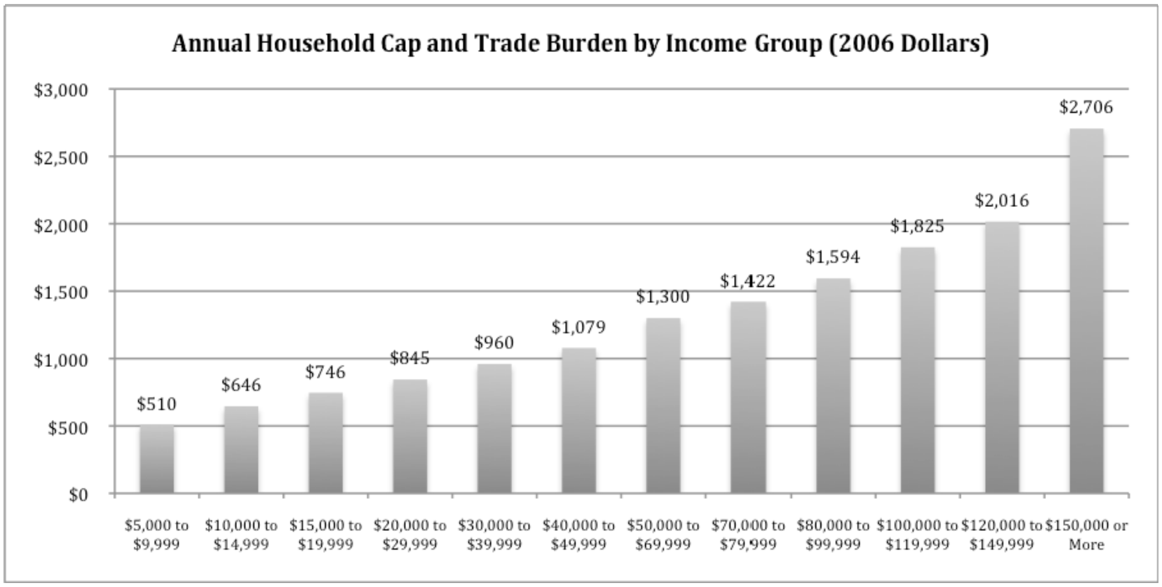
Dollar Income Groups

One drawback of the quintile presentations in Figures 2 and 3 is that they mask considerable variation in cap-and-trade burdens between households within the same income quintile. In Figures 4 and 5 we present a more detailed view of cap-and-trade burdens by dividing U.S. households into twelve groups based on household cash income.[16]

[16] Due to significant under-reporting of income among low-income households, we do not present results for households reporting cash incomes of less than $5,000 per year.

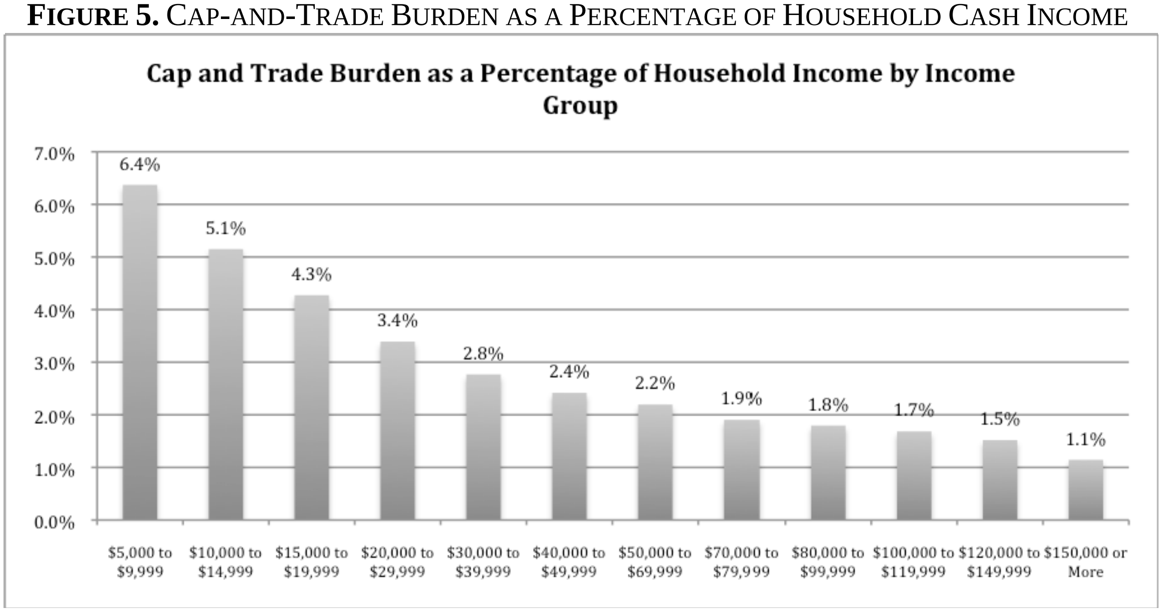
As is clear from Figures 4 and 5, there are large differences in burdens within quintiles. For example, annual burdens in the top quintile range from $1,825 for those earning between $100,000 and $120,000 per year to more than $2,700 for those earning $150,000 per year or more. Figure 5 further emphasizes the regressive nature of cap and trade which consumes 6.4 percent of income for households earning between $5,000 and $10,000 per year compared to just 1.1 percent for those earning over $150,000 per year.

FIGURE 4. ANNUAL CAP-AND-TRADE BURDEN BY HOUSEHOLD CASH INCOME GROUP



Source: Tax Foundation Input-Output Model.

FIGURE 5. CAP-AND-TRADE BURDEN AS A PERCENTAGE OF HOUSEHOLD CASH INCOME



Source: Tax Foundation Input-Output Model.

B. BURDENS BY AGE GROUP

An often-overlooked aspect of climate policy is how cap-and-trade burdens would be borne by different age groups. Consumption patterns vary widely as households move from youth through working years and ultimately into retirement. These shifting consumption patterns in turn influence the degree to which households purchase carbon-intensive products which determines their household burden from climate policy.

Household income and consumption generally follow a mound-shaped distribution across the life cycle. Income and consumption begin at relatively low levels, rising throughout the working years until reaching a peak just before retirement. In old age, income and consumption tend to return to lower levels as households retire from the labor market. Because households on average save some portion of their income, as income expands consumption for most items tends to grow more slowly. The result is that consumption as a percentage of household income tends to be highest in youth and old age, and lowest in the prime earning years of 45-64.[17]

These demographic patterns are clear in Table 3, which presents the basic distribution of cap-and-trade burdens by age group. In general, the lowest dollar burdens from cap and trade are borne by the youngest and oldest households in the nation while the highest dollar burdens are borne by middle-aged households in their prime earning years. Households under 25 years bear an annual burden of $696 which rises to $1,430 per year for households between 45 and 54 years and then declines to $830 per year for retired households aged 75 and older.

TABLE 3. ANNUAL BURDEN OF A U.S. CAP-AND-TRADE SYSTEM BY AGE GROUP

		Age of Household Head						
	All Households	Under 25 Years	25-34 Years	35-44 Years	45-54 Years	55-64 Years	65-74 Years	75 Years and Older
Annual Household Burden	$1,218	$696	$1,130	$1,389	$1,430	$1,329	$1,130	$830
Household Burden as a % of Income	2.0%	2.4%	2.0%	1.8%	1.9%	2.1%	2.5%	2.8%
Aggregate Burden ($ billions)	$144.8	$5.7	$22.7	$33.3	$35.3	$25.2	$13.3	$9.3

Source: Tax Foundation Input-Output Model.

As a percentage of income, cap-and-trade burdens by age group reflect the underlying regressive nature of climate policy. When incomes are lowest in youth and old age cap and trade imposes the heaviest relative burden on households. Households over age 75 bear the heaviest burden at 2.8 percent of income followed by households aged 65-75 at 2.5 percent and the youngest households under age 25 at 2.4 percent.

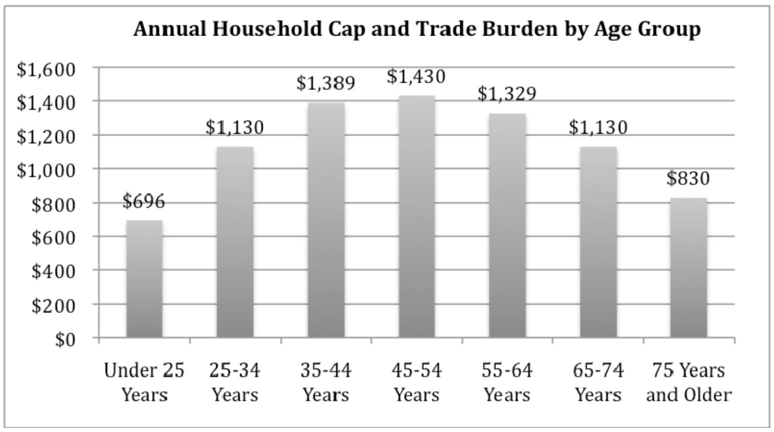
By contrast, cap-and-trade burdens comprise just 1.8 percent of income for higher-earning households aged 35-44 and 1.9 percent of income for the highest-earning households between 45 and 54 years. In terms of aggregate burden, working-age

[17] For a comprehensive review of household income and tax burdens by U.S. age group, see Chamberlain and Prante (2007b).

households aged 35 to 54 bear an annual burden for cap and trade of roughly $69 billion per year—47 percent of the total U.S. burden.

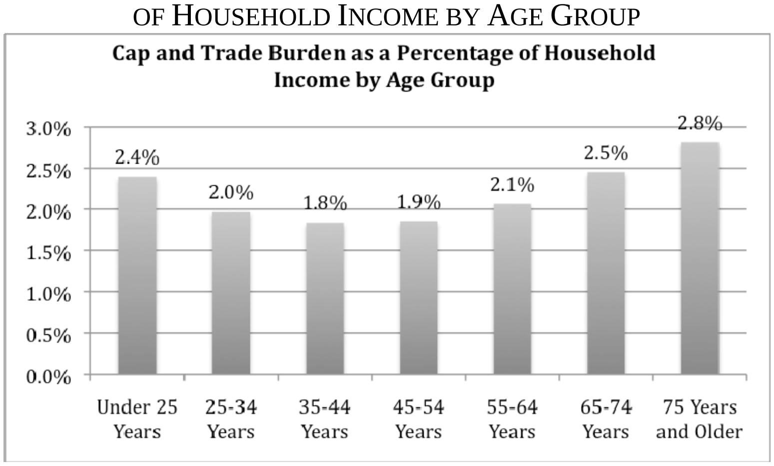
Figures 6 and 7 present the figures from Table 3 graphically. Figure 6 shows the annual dollar amount of cap-and-trade burden by age group and Figure 7 presents cap-and-trade burdens as a percentage of household cash income. As noted above, the figures are essentially mirror images of each other. Households pay low dollar burdens and high burdens as a percentage of income in youth and old age, and pay large dollar burdens and low burdens as a percentage of income in their prime working years of age 35 to 64.

FIGURE 6. ANNUAL HOUSEHOLD BURDEN FROM A U.S. CAP-AND-TRADE SYSTEM BY AGE OF HOUSEHOLD HEAD



Source: Tax Foundation Input-Output Model.

FIGURE 7. ANNUAL CAP-AND-TRADE BURDEN AS A PERCENTAGE OF HOUSEHOLD INCOME BY AGE GROUP



Source: Tax Foundation Input-Output Model.

C. BURDENS BY U.S. REGION

As with all federal policy, cap-and-trade burdens do not fall equally on the cities, states and regions that comprise the geographic landscape of the United States. In this section we briefly explore the geographic burden of a typical federal cap-and-trade system.

To the extent that consumption of carbon-intensive products varies among U.S. regions household cap and trade burdens will vary as well. For example, households in the South spend on average 4.2 percent of household income on carbon-intensive gasoline and motor oil compared to 3 percent for households in the Northeast. Similarly, southern households spend on average 2.8 percent of income on electricity—another carbon-heavy expenditure—compared to 1.6 percent for households in the west. These differences in purchasing patterns help drive geographic differences in cap-and-trade burdens.

Table 4 presents the basic distribution of cap-and-trade burdens by U.S. region.[18] Overall, the results are more tightly clustered around the national average than burdens by income or age group. This clustering is largely the result having organized the nation's roughly 120 million households into just four regional categories. However, important regional differences are still apparent even from this highly aggregated view.

TABLE 4. ANNUAL BURDEN OF A U.S. CAP-AND-TRADE SYSTEM BY U.S. REGION

	All Households	U.S. Region			
		Northeast	Midwest	South	West
Annual Household Burden	$1,218	$1,292	$1,156	$1,157	$1,318
Household Burden as a % of Income	2.01%	2.01%	1.99%	2.06%	1.97%
Aggregate Burden ($ billions)	$144.8	$29.4	$31.4	$49.1	$34.8

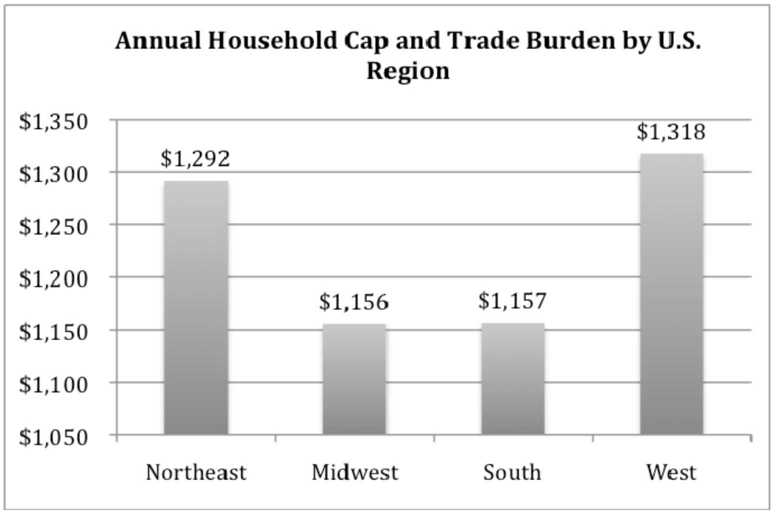
Source: Tax Foundation Input-Output Model.

In terms of dollar amounts residents in the West—a region dominated by the State of California—bear the largest annual cap-and-trade burden of $1,318 per year. Households in the Midwest and South are essentially tied for having the smallest average dollar burden at $1,156 and $1,157 per year, respectively. In terms of burdens as a percentage of income, residents in the South bear the heaviest burden at 2.06 percent of income. This finding is consistent with the regressive impact of cap and trade discussed above, as Southern households have the lowest average incomes in the nation. The lowest burdens as a percentage of income are borne by the nation's highest-income households in the West.

[18] The regional classifications are drawn from the U.S. Bureau of Labor Statistics' Consumer Expenditure Survey (CEX). "Midwest" includes Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; "Northeast" includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; "South" includes Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; and "West" includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

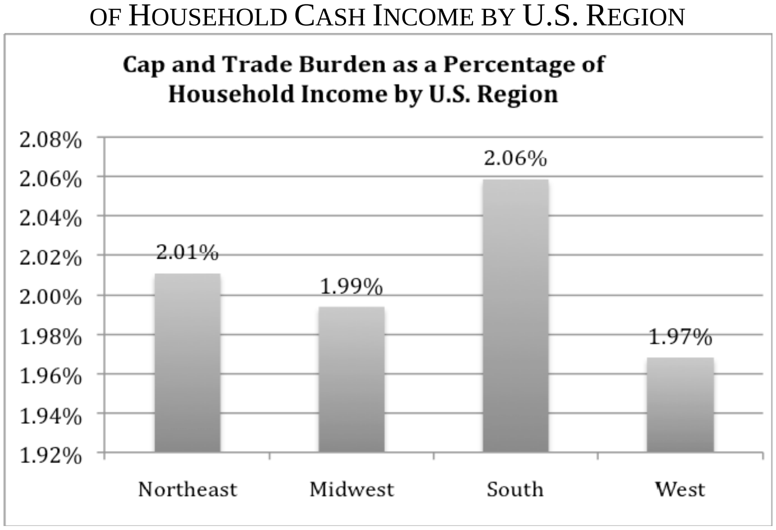
Figures 8 and 9 present the figures from Table 4 graphically. As is clear from the figures, the regressive nature of cap and trade is apparent even at this broad regional level as the heaviest burdens as a percentage of income are borne by low-income households in the South, while the nation's highest-income households in the West bear the lightest relative burden.[19]

FIGURE 8. ANNUAL HOUSEHOLD BURDEN FROM A U.S. CAP-AND-TRADE SYSTEM BY U.S. REGION



Source: Tax Foundation Input-Output Model.

FIGURE 9. ANNUAL CAP-AND-TRADE BURDEN AS A PERCENTAGE OF HOUSEHOLD CASH INCOME BY U.S. REGION



Source: Tax Foundation Input-Output Model.

[19] In addition to the cap-and-trade burden from higher consumer prices measured here, it should be noted that cap-and-trade results in potentially large adjustment costs to workers and companies in carbon-intensive industries such as coal and oil extraction, many of whom are concentrated in particular states and regions. While this study does not estimate these burdens, it should be noted that including those costs will tend to amplify the regional differences in cap-and-trade burdens presented in Figures 8 and 9.

D. BURDENS BY TYPE OF FAMILY

Household income and consumption in the United States tend to be correlated with other household characteristics such as marital status and the presence of children. As a result, the regressive impact of cap and trade has the unanticipated side effect of imposing a disproportionate annual burden on some types of U.S. families over others.

On average, the nation's highest earning households are married couples with children aged 18 years or older. The average age for these head-of-households is 52 years, placing them squarely in what are typically the peak earning years for most families. In 2006 these households earned an average of roughly $94,000 per year—55 percent higher than the U.S. national average.

By contrast, the nation's lowest-earning households are single parents with at least one child aged 18 years or less. The average age for these head-of-households is just 38, a full decade younger than the U.S. national average. These households earned an average household cash income of $34,850 in 2006, just 58 percent of the nation's average.

These patterns in household income are apparent in Table 5, which presents estimates of annual household cap-and-trade burdens for various types of U.S. families. Overall, there are significant differences in cap-and-trade burdens by family type, a finding that largely mirrors existing differences in household income and the consumption of carbon-intensive products.

TABLE 5. ANNUAL BURDEN OF A U.S. CAP-AND-TRADE SYSTEM BY TYPE OF FAMILY

			Husband and Wife with Children					
	All Households	Husband and Wife Only	Husband and Wife with Children: Oldest Child Under 6	Husband and Wife with Children: Oldest Child 6 to 17	Husband and Wife with Children: Oldest Child 18 or Older	Other Husband and Wife	One Parent, at Least One Child Under 18	Single Person and Others
Annual Household Burden	$1,218	$1,410	$1,428	$1,669	$1,785	$1,701	$950	$873
Household Burden as a % of Income	2.0%	1.9%	1.8%	1.9%	1.9%	2.0%	2.7%	2.2%
Aggregate Burden ($ billions)	$144.8	$35.7	$8.2	$25.3	$15.1	$8.1	$6.9	$45.5

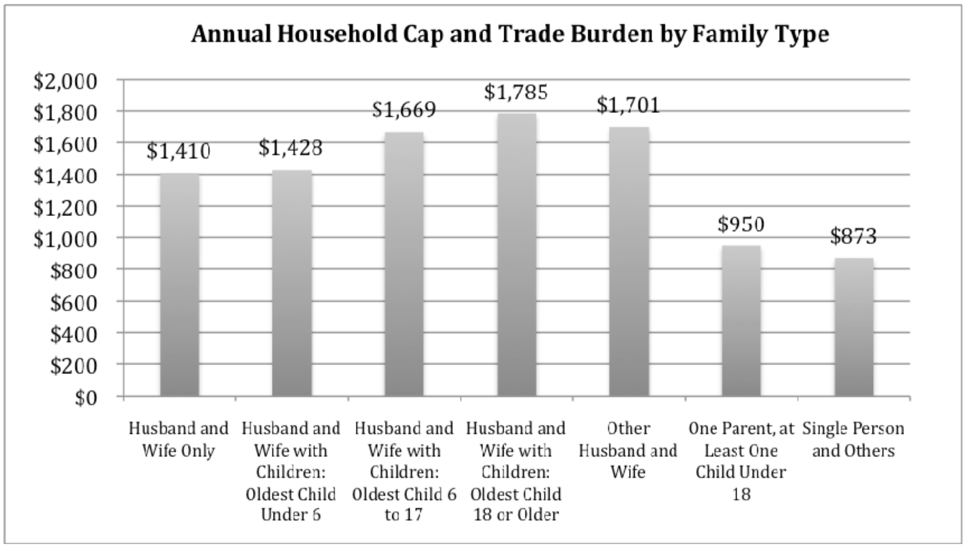
Source: Tax Foundation Input-Output Model.

The largest dollar burden from cap and trade is borne by the nation's highest earning and highest consuming household type: married couples with at least one child aged 18 or older. These households bear an annual burden of $1,785 per year. The smallest dollar burdens are borne by single households with no children at $873 per year followed by single parents with at least one child under age 18 at $950.

In terms of burden as a percentage of income, single parents with young children bear the heaviest burden from climate policy at 2.7 percent of income. By contrast, married couples with children under age 6 bear the lightest relative burden at just 1.8 percent of household cash income.

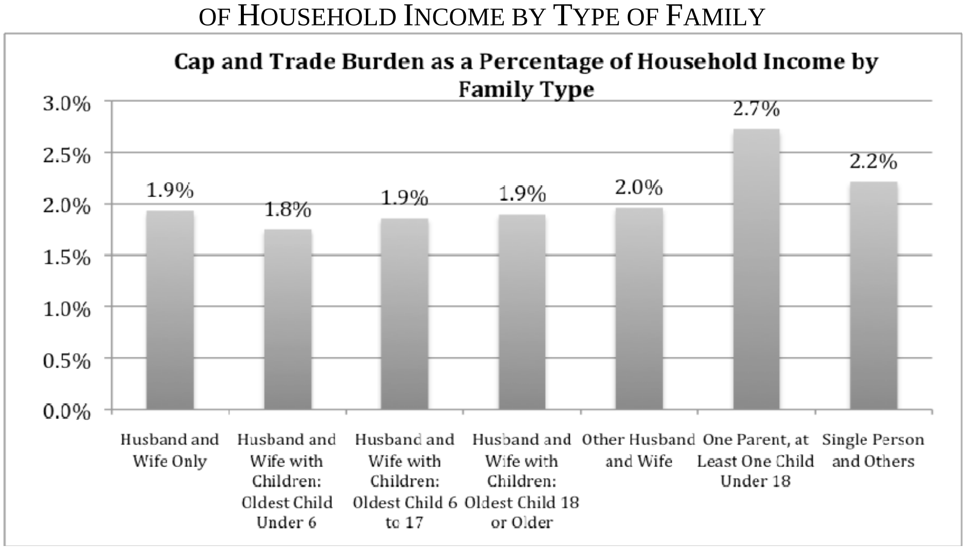
In Figures 10 and 11 we present the figures from Table 5 graphically. These images further underscore a theme that runs throughout the findings of this study: the burden of a U.S. cap-and-trade system would represent a significant annual cost to most household budgets, and the burdens would tend to fall most heavily on American families with relatively low cash incomes who are least able to bear it.

FIGURE 10. ANNUAL HOUSEHOLD BURDEN FROM A U.S. CAP-AND-TRADE SYSTEM BY TYPE OF FAMILY



Source: Tax Foundation Input-Output Model.

FIGURE 11. ANNUAL CAP-AND-TRADE BURDEN AS A PERCENTAGE OF HOUSEHOLD INCOME BY TYPE OF FAMILY



Source: Tax Foundation Input-Output Model.

E. COMPARING CAP-AND-TRADE BURDENS TO OTHER HOUSEHOLD TAX BURDENS

The previous sections present household cap-and-trade burdens by income, age, region and family type. In this section we place those burdens in a broader context by comparing them to the annual cost of other federal, state and local taxes borne by U.S. households.

Table 6 presents a comparison of annual cap-and-trade burdens to the burden of other existing federal and state-local taxes. The household tax burden estimates by income quintile are derived from a comprehensive 2007 study of U.S. tax burdens from the Tax Foundation,[20] which are inflation-adjusted to 2006 dollars. As is clear from the table, annual cap-and-trade burdens are broadly comparable to other tax burdens.

TABLE 6. ANNUAL CAP-AND-TRADE BURDENS COMPARED TO OTHER EXISTING TAXES PAID BY U.S. HOUSEHOLDS

	Quintiles of Cash Income Before Taxes, Equal Number of Households				
	Bottom 20 Percent	Second 20 Percent	Third 20 Percent	Fourth 20 Percent	Top 20 Percent
Annual Cap and Trade Burden	$617	$863	$1,100	$1,418	$2,091
Federal Tax Burdens					
Income	$71	$947	$2,817	$6,737	$27,066
Payroll	$656	$2,829	$5,835	$9,951	$18,405
Corporate Income	$183	$817	$1,514	$2,609	$6,361
Gasoline	$61	$123	$187	$273	$493
Alcoholic Beverages	$33	$45	$70	$95	$151
Tobacco	$50	$66	$79	$76	$63
Diesel Fuel	$7	$31	$57	$98	$239
Air Transport	$17	$46	$70	$120	$316
Other Excise	$40	$62	$83	$115	$189
Customs, Duties, etc.	$90	$138	$187	$257	$422
Estate & Gift	$0	$0	$0	$0	$1,155
State-Local Tax Burdens					
Income	$35	$389	$1,071	$2,274	$6,803
Corporate Income	$32	$144	$267	$460	$1,121
Personal Property	$12	$33	$47	$61	$115
Motor Vehicle License	$60	$100	$133	$160	$186
Other Personal Taxes	$7	$17	$28	$45	$96
General Sales	$753	$1,371	$1,953	$2,952	$4,910
Gasoline	$85	$171	$262	$381	$688
Alcoholic Beverages	$18	$25	$38	$52	$82
Tobacco	$86	$115	$136	$131	$109
Public Utilities	$119	$164	$199	$234	$298
Insurance Receipts	$59	$102	$129	$158	$237
Other Selective Sales	$113	$174	$235	$323	$531
Motor Vehicle (Business)	$6	$25	$47	$81	$198
Severance	$20	$37	$53	$75	$139
Property	$876	$1,609	$2,373	$3,512	$7,120
Special Assessments	$17	$32	$47	$69	$140
Other Production Taxes	$36	$161	$298	$514	$1,254
Estate & Gift	$0	$0	$0	$0	$268

Note: All figures in 2006 inflation-adjusted dollars.

Source: Author's calculations based on Chamberlain and Prante (2007a).

[20] See Chamberlain and Prante (2007a). While figures in the published study present tax burdens in quintiles with equal numbers of individuals, the underlying microdata model allows the presentation of tax burdens in quintiles with equal numbers of households. These unpublished figures in quintiles with equal numbers of households serve as the basis for the figures in Table 6.

For households in the lowest-earning quintile, the $617 cap-and-trade burden represents a significant annual cost. Among federal taxes, cap-and-trade burdens would exceed every tax for these households except the federal payroll tax, which costs an average of $656 per year. In essence, the household burden from cap-and-trade would be equivalent to a 94 percent increase in the federal payroll tax paid by these households. Similarly, cap-and-trade burdens are equivalent to an 82 percent increase in state-local sales taxes, a 70 percent increase in property taxes, or a four-fold increase in the combined federal and state-local gas tax paid by these households.

For households with middle- and upper-incomes cap-and-trade burdens are less dramatic but still represent a significant annual cost. For households in the middle 20 percent of earners the $1,100 annual cost of cap and trade is approximately equal to the average amount of state and local personal income taxes paid per year of $1,071. Cap-and-trade burdens for the middle quintile are comparable to a 46 percent increase in state and local property taxes, a 39 percent increase in federal personal income taxes, or a roughly doubling of the combined federal and state-local gas tax paid by these households.

For households in the highest-earning quintile, the $2,091 annual cap-and-trade burden appears modest in comparison to the existing large federal, state and local tax burdens currently paid by these households. Cap-and-trade burdens for this group are equivalent to an 8 percent increase in federal personal income taxes, a 29 percent increase in state and local property taxes, or a 43 percent increase in state and local sales taxes borne by these households. One interesting finding is that the annual cap-and-trade burden to the nation's highest-earning households would exceed the $1,423 average burden of the highly controversial state and federal estate taxes by more than $600 per year.

F. IMPACT ON CONSUMER PRICES

The basic mechanism by which the economic costs of climate policy are transferred from carbon-emitting firms to carbon-consuming households is through higher consumer prices. In general, carbon-intensive products that rely heavily on coal, petroleum and natural gas as productive inputs will face the largest price increases. However, a key finding from previous studies is that because nearly all industries make some use of fossil fuels cap-and-trade burdens tend to be highly diffused throughout prices across the economy with nearly every product facing some degree of price increase.

Table 7 presents the basic commodity-level price impacts from a typical cap-and-trade system with a $100 per ton allowance price. As expected, the largest price increases are for fossil-fuel products. Petroleum and coal products rise 18.2 percent; natural gas rises 17.6 percent; electric power rises 15.1 percent; and coal mining rises 14.7 percent. However, a wide range of chemicals, metals, services and household products also face significant price increases. This diffused nature of cap-and-trade burdens largely masks the overall cost of climate policy to consumers. Unlike a federal carbon tax, cap and trade does not produce official tax revenue figures that can be easily monitored by the public—likely the source of cap-and-trade's persistent political appeal to U.S. lawmakers.

TABLE 7. IMPACT ON CONSUMER PRICES FROM A $100/TON CARBON ALLOWANCE PRICE

Commodity	Percentage Price Increase	Distribution of Cap and Trade Burden	Percentage of Total Burden
Petroleum and coal products	18.2%	$28,094,623,659	19.4%
Natural gas distribution	17.6%	$7,841,922,604	5.4%
Electric power generation, transmission, and distribution	15.1%	$18,068,994,987	12.5%
Coal mining	14.7%	$1,435,031,376	1.0%
Primary ferrous metal products	7.7%	$2,455,297,517	1.7%
Basic chemicals	7.5%	$4,121,138,684	2.8%
State and local government enterprises	7.1%	$1,757,639,490	1.2%
Pipeline transportation	7.0%	$745,605,695	0.5%
Water, sewage and other systems	6.5%	$1,352,321,999	0.9%
Resins, rubber, and artificial fibers	4.9%	$1,527,606,437	1.1%
Agricultural chemicals	3.8%	$409,365,832	0.3%
Metal ores mining	3.5%	$135,256,536	0.1%
Air transportation	3.4%	$1,669,936,336	1.2%
Paints, coatings, and adhesives	3.1%	$418,511,216	0.3%
Other chemical products	3.0%	$527,699,270	0.4%
Transit and ground passenger transportation	2.9%	$561,589,933	0.4%
Nonmetallic mineral mining and quarrying	2.9%	$263,794,649	0.2%
Pulp, paper, and paperboard	2.8%	$1,077,476,678	0.7%
Courier and messenger services	2.5%	$741,982,519	0.5%
Primary nonferrous metal products	2.5%	$587,134,568	0.4%
Forgings and stampings	2.5%	$256,295,583	0.2%
Nonmetallic mineral products	2.4%	$1,170,736,245	0.8%
Animal products	2.4%	$1,177,707,336	0.8%
Yarn, fabrics, and other textile mill products	2.4%	$449,183,173	0.3%
Truck transportation	2.3%	$2,339,302,920	1.6%
Crop products	2.1%	$1,512,591,166	1.0%
Oil and gas extraction	2.0%	$867,557,436	0.6%
Boilers, tanks, and shipping containers	2.0%	$211,957,099	0.1%
Foundry products	2.0%	$243,163,291	0.2%
Fish and other nonfarm animals	2.0%	$71,509,347	0.0%
Plastics and rubber products	2.0%	$1,817,584,791	1.3%
Mining support services	1.9%	$311,268,156	0.2%
Architectural and structural metal products	1.9%	$514,041,661	0.4%
Scenic and sightseeing transportation and support activities	1.8%	$468,382,793	0.3%
Converted paper products	1.8%	$727,317,557	0.5%
Amusements, gambling, and recreation	1.6%	$861,155,520	0.6%
Soaps, cleaning compounds, and toiletries	1.5%	$690,739,520	0.5%
Other fabricated metal products	1.5%	$889,868,839	0.6%
Food products	1.5%	$4,350,986,398	3.0%
New nonresidential construction	1.5%	$3,224,180,497	2.2%
Support activities for agriculture and forestry	1.4%	$107,821,300	0.1%
Nonapparel textile products	1.4%	$361,708,973	0.2%
All other administrative and support services	1.4%	$1,854,353,984	1.3%
Rail transportation	1.4%	$279,860,605	0.2%
Motor vehicle bodies, trailers, and parts	1.4%	$1,530,257,652	1.1%
Other electrical equipment and components	1.4%	$247,665,538	0.2%
Agriculture, construction, and mining machinery	1.3%	$290,370,551	0.2%
New residential construction	1.3%	$2,667,202,832	1.8%
Maintenance and repair construction	1.2%	$867,332,717	0.6%
Other general purpose machinery	1.2%	$328,947,491	0.2%
Metalworking machinery	1.2%	$145,202,768	0.1%
HVAC and commercial refrigeration equipment	1.2%	$187,210,849	0.1%
Commercial and service industry machinery	1.1%	$127,662,639	0.1%
Wood products	1.1%	$500,909,665	0.3%
Industrial machinery	1.1%	$165,496,716	0.1%
Electrical equipment	1.1%	$159,932,490	0.1%
Cutlery and handtools	1.1%	$86,127,589	0.1%
Printed products	1.1%	$395,417,981	0.3%
Household appliances	1.1%	$176,798,954	0.1%
General state and local government services	1.0%	$5,200,971,378	3.6%
Beverage products	1.0%	$661,762,473	0.5%
Motor vehicles	1.0%	$1,462,441,385	1.0%
Turbine and power transmission equipment	1.0%	$178,368,838	0.1%
Educational services	1.0%	$966,838,853	0.7%
Magnetic media products	1.0%	$37,754,877	0.0%
Electric lighting equipment	1.0%	$75,647,411	0.1%
Semiconductors and electronic components	1.0%	$528,587,963	0.4%
Furniture and related products	1.0%	$529,193,686	0.4%
Warehousing and storage	1.0%	$196,288,121	0.1%
Forestry and logging products	1.0%	$161,866,933	0.1%
All other industries (64 industries)	<1.0%	$28,341,992,020	19.6%
Total	n/a	$144,770,454,545	100.0%

Note: Complete table of 134 commodity-level price impacts is available from the author upon request. Distribution of cap-and-trade burden is determined by weighting price impacts by total commodity output.
Source: Tax Foundation Input-Output Model.

IV. ECONOMIC IMPACT OF A CAP-AND-TRADE SYSTEM

Because cap and trade raises prices for consumer products it has the effect of lowering real returns to labor and capital throughout the economy. This in turn reduces the supply of these productive inputs, lowering overall U.S. economic output. In this section we make use of RIMS II multipliers from the U.S. Bureau of Economic Analysis to explore the likely impact of this "tax interaction" effect on jobs, household earnings and total output for the U.S. economy.

A. IMPACT ON EMPLOYMENT, HOUSEHOLD EARNINGS AND ECONOMIC OUTPUT

Previous studies from the U.S. Congressional Budget Office and others have estimated the impact of various cap-and-trade proposals on U.S. gross domestic product. Table 8 presents two typical estimates. Both estimates assume initial cap-and-trade allowances are distributed by auction. In the first scenario, auction revenue is returned to taxpayers in the form of a revenue-neutral corporate or payroll tax cut. In the second scenario auction proceeds are returned directly to households in the form of an equal lump-sum government transfer payment.

TABLE 8. CBO ESTIMATES OF REDUCED GDP FROM A TYPICAL CAP-AND-TRADE SYSTEM

	Reduced U.S. GDP	
Policy	Percentage	Dollars (2008)
Revenue from Allowance Sales Used to Cut Corporate or Payroll Taxes	0.13%	$18,757,960,000
Revenue from Allowance Sales Used to Provide Equal Lump-Sum Rebates to Households	0.34%	$49,059,280,000

Source: U.S. Congressional Budget Office based on Dinan and Rogers (2002).

According to CBO estimates, cap and trade with auctioned allowances and a corporate or payroll tax cut will reduce annual GDP by $18.8 billion in 2008 dollars or 0.13 percent from the current baseline in the long run. By contrast, a system with auctioned allowances and a lump-sum transfer payment to households will cut annual GDP by $49.1 billion or 0.34 percent in the long run. These estimates represent the range of likely impacts from cap and trade on the broader U.S. economy.[21]

Using input-output analysis it is possible to illustrate how these initial changes in GDP from cap and trade will likely affect output, employment and earnings in the overall economy. Input-output analysis relies on an accounting framework that divides the U.S. economy into distinct industries. Each industry buys inputs from itself and other industries, combines them with value added, and sells the resulting products as intermediate inputs to other industries or as final demand to consumers, governments and

[21] It should be noted that GDP only measures the value of final goods and services produced, and therefore is not a true measure of overall welfare. Leisure, household production, environmental quality and other factors that influence welfare are not captured by GDP. These limitations should be kept in mind when interpreting the economic impact estimates in Section IV of this study.

the rest of the world. These economic linkages are typically summarized in an input-output or "Leontief" table after the 1973 Nobel Laureate economist Wassily Leontief.

One of the most common uses of input-output analysis is to estimate the regional "multiplier effect" from a policy change that affects GDP. For example, the impact of closing a $100 million per year military base is larger than $100 million dollars for the affected region. The reason is that military bases purchase large amounts of food, fuel and other supplies from companies in the area. Closing the base cuts jobs, earnings and output in these supplying industries as well. The total economic impact of the policy therefore should include the direct impact of the base closing as well as the indirect or "induced" impact felt by other local industries.

The most widely used regional input-output multipliers are from the U.S. Bureau of Economic Analysis' "Regional Impact Modeling System" (RIMS II).[22] RIMS II multipliers are derived from the official U.S. national input-out tables, and allow users to estimate the order-of-magnitude impacts of any initial change in household earnings, employment or final demand on the broader economy.

Table 9 provides estimates of the economic impact of a typical cap-and-trade system on jobs, household earnings and total U.S. output. The figures are based on the CBO's second cap-and-trade scenario from Table 8, which corresponds to a 0.34 percent initial reduction in GDP. As a result, these figures represent upper-bound estimates of cap-and-trade's likely economic impact.

As the price increases from cap and trade lower returns to labor and capital, discouraging their supply in various industries, those industries suffer initial reductions in output. This initial decline in output in turn leads to declining revenue in complementary industries, job losses, reductions in household earnings, and ultimately to lower overall economic output for the economy.

Overall, a cap-and-trade system that reduces annual GDP by 0.34 percent per year can be expected to reduce U.S. employment by roughly 964,900 jobs per year, reduce household earnings by $37.8 billion, and reduce total U.S. economic output by $136.1 billion. Because overall usage of labor and capital inputs by industries is highly correlated with industry output, these estimates assume initial GDP reductions from cap-and-trade's "tax interaction" effect are distributed across industries on the basis of GDP by industry.

To the extent that GDP losses from climate policy are more heavily concentrated in particular industries, these overall impacts by industry will also differ. Due to uncertainty in the underlying data and the many assumptions involved in such a calculation, the economic impacts presented in Table 9 should be considered illustrative order-of-magnitude estimates rather than precise figures.

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[22] See Bureau of Economic Analysis, "Regional Input-Output Modeling System (RIMS II)." Available online at www.bea.gov/regional/rims/.

TABLE 9. ECONOMIC IMPACT OF A CAP-AND-TRADE SYSTEM THAT REDUCES GDP 0.34 PERCENT (AUCTIONED INITIAL ALLOWANCES, LUMP-SUM REBATE TO HOUSEHOLDS)

	Economic Impact of GDP Losses from a U.S. Cap-and-Trade System			
RIMS II Industry	Initial Reduction in U.S. GDP	Reduced Total Economic Output	Reduced Household Earnings	Reduced Employment (Job Losses)
Farms	$418,372,935	$1,257,545,369	$267,884,190	10,141
Forestry, fishing, and related activities	$129,219,778	$423,168,931	$121,918,861	4,268
Oil and gas extraction	$691,122,243	$1,654,408,424	$422,206,578	7,198
Mining, except oil and gas	$191,188,759	$477,704,233	$125,955,154	2,466
Support activities for mining	$257,221,315	$663,630,993	$156,982,169	3,271
Utilities	$1,070,649,617	$2,370,739,447	$496,246,097	9,051
Construction	$2,925,762,152	$9,460,744,495	$2,936,294,896	73,309
Wood products	$160,848,153	$521,212,355	$133,069,677	3,713
Nonmetallic mineral products	$236,405,821	$702,007,085	$180,992,297	4,052
Primary metals	$286,529,083	$764,774,776	$167,533,555	3,568
Fabricated metal products	$572,090,919	$1,698,537,938	$439,937,917	10,091
Machinery	$527,278,771	$1,570,921,644	$406,373,749	8,748
Computer and electronic products	$582,691,722	$1,821,261,246	$527,918,700	10,415
Electrical equipment and appliances	$193,069,032	$570,789,286	$144,454,250	3,130
Motor vehicles, bodies and trailers, and parts	$418,448,146	$1,381,297,330	$318,606,418	6,867
Other transportation equipment	$395,364,518	$1,140,784,781	$325,384,999	6,396
Furniture and related products	$132,158,689	$419,114,849	$110,630,038	2,866
Miscellaneous manufacturing	$290,955,595	$900,129,324	$262,121,896	5,481
Food and beverage and tobacco products	$714,980,718	$2,465,325,013	$548,461,709	14,280
Textile mills and textile product mills	$82,641,924	$276,271,951	$66,997,808	1,661
Apparel and leather and allied products	$67,963,990	$210,688,368	$62,642,409	1,707
Paper products	$227,042,937	$699,610,106	$163,720,662	3,724
Printing and related support activities	$196,742,123	$618,439,189	$177,736,834	4,177
Petroleum and coal products	$383,025,994	$875,597,421	$173,932,104	3,042
Chemical products	$871,925,774	$2,596,769,340	$579,133,099	11,567
Plastics and rubber products	$304,933,018	$938,156,923	$216,929,349	4,957
Wholesale trade	$3,456,545,665	$9,185,424,449	$2,767,656,114	60,975
Retail trade	$3,580,348,508	$9,867,440,489	$2,943,762,544	94,979
Air transportation	$217,754,390	$625,651,912	$161,813,287	3,650
Rail transportation	$150,273,149	$386,532,594	$99,480,825	2,084
Water transportation	$42,942,806	$130,700,726	$31,588,728	713
Truck transportation	$541,437,225	$1,685,277,508	$487,889,084	12,261
Transit and ground passenger transportation	$78,413,059	$248,875,208	$77,534,833	2,879
Pipeline transportation	$62,920,049	$173,256,646	$37,330,465	751
Other transportation and support activities	$423,534,503	$1,167,388,150	$422,941,554	9,826
Warehousing and storage	$170,739,262	$465,554,746	$164,695,092	4,515
Publishing industries (includes software)	$607,312,801	$1,737,764,848	$474,372,029	10,461
Motion picture and sound recording	$187,410,723	$577,749,776	$151,634,016	3,674
Broadcasting and telecommunications	$1,408,114,852	$3,972,010,375	$882,888,012	19,185
Information and data processing services	$298,887,722	$874,276,477	$227,304,113	5,256
Federal Reserve banks, credit intermediation	$2,384,505,958	$5,336,285,883	$1,473,624,682	31,520
Securities, commodities and investments	$944,512,174	$3,148,531,332	$1,068,432,171	20,685
Insurance carriers and related activities	$1,211,997,155	$3,830,153,408	$1,066,557,496	22,786
Funds, trusts, and other financial vehicles	$110,613,823	$431,648,323	$126,553,275	2,439
Real estate	$6,787,312,012	$13,205,394,251	$2,214,699,910	66,153
Rental and leasing services	$640,524,540	$1,886,985,293	$458,551,518	11,519
Miscellaneous prof., sci. and tech. services	$2,561,098,990	$7,795,985,325	$2,630,248,663	57,644
Management of companies and enterprises	$1,034,671,253	$3,113,118,867	$990,387,324	19,240
Administrative and support services	$1,549,496,934	$4,572,255,554	$1,473,261,685	47,608
Waste management and remediation	$148,418,675	$431,824,136	$115,855,618	2,726
Educational services	$491,486,686	$1,533,880,798	$507,607,449	16,119
Ambulatory health care services	$2,012,919,456	$5,993,668,973	$2,059,417,896	47,726
Hospitals and nursing	$1,533,986,870	$4,935,909,553	$1,615,441,573	41,802
Social assistance	$338,965,518	$1,043,200,278	$342,829,725	14,145
Performing arts, spectator sports, museums	$250,067,096	$741,223,879	$257,444,075	8,927
Amusements, gambling, and recreation	$335,187,919	$911,074,282	$265,435,313	9,816
Accommodation	$332,977,505	$907,929,763	$258,323,948	7,779
Food services and drinking places	$1,211,327,253	$3,697,091,909	$992,682,684	41,052
Other services, except government	$1,623,941,743	$4,977,543,838	$1,442,222,662	43,868
Total	$49,059,280,000	$136,071,240,365	$37,824,533,775	964,907

Note: Initial reductions in GDP are assumed to be proportional to total economic output by industry.
Source: Tax Foundation; U.S. Bureau of Economic Analysis "Regional Input-Output Modeling System, 2006 (Region: United States).

B. IMPACT ON EQUITY PRICES

As noted in Section II of this study, cap and trade imposes potentially large transition costs on owners of capital in carbon-heavy fossil fuel industries as the quantity of their products demanded falls in response to price increases. Another way of viewing the impact of cap and trade is by exploring the likely impact on stock prices for these carbon-intensive U.S. industries.

The impact of cap-and-trade on stock prices is an important policy consideration for two reasons. First, because investors typically hold diversified portfolios of assets through mutual funds and other investment vehicles deterioration in equity prices for carbon-intensive industries could affect retirement savings and household wealth a large number of U.S. households, labor unions, and private sector retirement funds. Second, to the extent that equity losses are concentrated in particular industries the impact on stock prices is a measure of the economic incentive these industries have to oppose climate policy through lobbying and the broader political process.

Table 10 presents estimates of the impact of cap and trade on stock prices and after-tax profits for various U.S. industry sectors. The figures are drawn from a comprehensive 2002 study from Resources for the Future using a computable general equilibrium model of the U.S. economy and a cap-and-trade system that reduces carbon emissions by roughly 23 percent. Although the assumed emissions reduction is larger than the 15 percent reduction modeled in this study, the likely impact on equity prices is of a similar order of magnitude.

TABLE 10. IMPACT OF A TYPICAL CAP-AND-TRADE SYSTEM ON EQUITY PRICES AND PROFITS (ASSUMES 23 PERCENT REDUCTION IN U.S. CARBON EMISSIONS)

Industry	Percentage Impact on Equity Prices	Percentage Impact on After-Tax Profits
Coal Mining	-54.6%	-40.0%
Oil and Gas Extraction	-20.0%	-5.5%
Electric Utilities	-4.2%	-6.2%
Petroleum Refining	-2.1%	-9.1%
Metals and Machinery	-0.9%	-3.5%

Source: Goulder (2002).

Overall, a U.S. cap-and-trade system could reduce equity prices by 54.6 percent for coal mining companies, 20 percent for oil and natural gas extraction companies, and 4.2 percent for electric utilities. In terms of reduced after-tax profits, cap-and-trade could result in a 40 percent reduction in profits for coal mining companies, a 9.1 percent reduction for petroleum refiners, and a 6.2 percent reduction for the nation’s electric utilities. For U.S. shareholders, these stock-price declines represent a significant indirect cost of implementing a national cap-and-trade system.

V. Methodology and Data Sources

The distributional and economic impact results in this study are based on standard input-output models using the latest available data from the U.S. Bureau of Economic Analysis. This section explains the methodology and data sources used.

A. Distributional Analysis

The distributional estimates presented in Section III are based on a Leontief input-output model. Because this approach captures flows between industries, it can be used to model the way cap and trade burdens are pushed forward through the network of inter-industry transactions into the final prices of consumer goods.

i. Theory of Input-Output

The economist's input-output framework is based on two relationships. First, the total value of each industry's output equals the amount they spend on inputs plus any value they add in the production process. Second, each industry's total output must equal the amount other industries buy from them as inputs plus the amount they sell as final output to consumers, governments and the rest of the world.[23]

For industry one, we can write these two relationships as follows:

(1) $$Y_1 = p_1 \cdot x_{11} + p_2 \cdot x_{12} + ... + p_n \cdot x_{1n} + V_1$$

Where:

Y_1 = Total value of output from industry one;

$p_1, p_2, ..., p_n =$ Price of intermediate inputs purchased by industry one from other industries one through *n*;

$x_{11}, x_{12}, ..., x_{1n} =$ Quantity of intermediate inputs purchased by industry one from other industries one through *n*; and

V_1 = Value added by industry one.

(2) $$Y_1 = p_1 \cdot x_{11} + p_1 \cdot x_{21} + ... + p_1 \cdot x_{n1} + p_1 \cdot D_1$$

Where:

Y_1 = Total value of output from industry one;

p_1 = Price of output from industry one;

$x_{11}, x_{21}, ..., x_{n1} =$ Quantity of output from industry one purchased as intermediate inputs by other industries one through *n*; and

[23] For earlier presentations of the input-output theory underlying distributional analysis of climate policy, see Fullerton (1995) and Metcalf (1999).

D_1 = Quantity of industry one's output sold as final demand to consumers, government and the rest of the world.

These relationships can be summarized as a standard input-output table. In table (3) below, summing down the columns corresponds to equation (1) while summing across the rows corresponds to equation (2):

$$(3)\qquad \begin{array}{ccccc} p_1 \cdot x_{11} & p_1 \cdot x_{21} & \cdots & p_1 \cdot x_{n1} & p_1 \cdot D_1 \\ p_2 \cdot x_{12} & p_2 \cdot x_{22} & \cdots & p_2 \cdot x_{n2} & p_2 \cdot D_2 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ p_n \cdot x_{1n} & p_n \cdot x_{2n} & \cdots & p_n \cdot x_{nn} & p_n \cdot D_n \\ V_1 & V_2 & \cdots & V_n & \end{array}$$

Table (3) can be manipulated into a Leontief input-output model as follows. Reading down the first column of the table, the sum of inputs purchased by column industry one plus their value added is equal to total output for that industry. Put differently,

$$(4)\qquad Y_1 = \sum_{j=1}^{n} p_j \cdot x_{1j} + V_1$$

To simplify the algebra we define a new number a_{ij}. Let a_{ij} equal the share of each row industry *j*'s total quantity of output purchased from them as an intermediate input by each column industry *i*. That is, let:

$$(5)\qquad a_{ij} = \frac{p_j \cdot x_{ij}}{Y_j}$$

This is known as the "input coefficient" between industries *i* and *j*, and will generally be a fraction between zero and one. If the value of row industry *j*'s total output represents a pie, a_{ij} represents the slice purchased from them by column industry *i* as an input. For example, if a_{12} = 0.2, column industry one buys 20 percent of row industry two's output.

Define a new matrix *A* that collects the a_{ij} coefficients for all industries into an *n x n* matrix. To calculate *A*, we divide each $p_j \cdot x_{ij}$ entry in the input-output table (3) by its row sum. The result is the following:

$$(6)\qquad A = \begin{bmatrix} a_{11} & a_{21} & \cdots & a_{n1} \\ a_{12} & a_{22} & \cdots & a_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1n} & a_{2n} & \cdots & a_{nn} \end{bmatrix}$$

We can now substitute a_{ij} into equation (4) and rewrite it as follows:

(7) $$Y_1 = \sum_{j=1}^{n} a_{1j} \cdot Y_j + V_1$$

By dividing both sides of equation (7) by the quantity of column industry one's total output x_1, we can convert this relationship into one between the price of industry one's output—which is equal to the value of total output divided by the quantity of output—and its various inputs and value added. That is,

(8) $$\frac{Y_1}{x_1} = \sum_{j=1}^{n} a_{1j} \cdot \left(\frac{Y_j}{x_1}\right) + \frac{V_1}{x_1} = p_1$$

This equation only shows the relationship between inputs and output prices for column industry one. To generalize it for all *n* industries we can express equation (8) in matrix notation as follows:

(9) $$\begin{bmatrix} Y_1/x_1 \\ Y_2/x_2 \\ \vdots \\ Y_n/x_n \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \cdot \begin{bmatrix} Y_1/x_1 \\ Y_2/x_2 \\ \vdots \\ Y_n/x_n \end{bmatrix} + \begin{bmatrix} V_1/x_1 \\ V_2/x_2 \\ \vdots \\ V_n/x_n \end{bmatrix}$$

In equation (9), the *n* x *n* matrix of *a*'s on the right-hand side is simply the transpose of the *A* matrix defined above. Label this *A'*. Also, by labeling the *n x 1* price vector of (Y/x)'s as *P*, and the *n x 1* value-added vector of (V/x)'s as *V*, we can rewrite equation (9) more simply as:

(10) $$P = A' \cdot P + V$$

Solving for the price vector *P*, we get:[24]

$$P - A' \cdot P = V$$
$$(I - A') \cdot P = V$$
(11) $$P = (I - A')^{-1} \cdot V$$

Equation (11) is the basic input-output model of the economy relating the price of industry economic output to the input coefficients and value added. This is a variant of the standard "Leontief" model named after economist Wassily Leontief.

[24] In equation (11), *I* represents an *n* x *n* identity matrix with 1's along the diagonal and zeros elsewhere.

The price vector *P* in equation (11) represents prices throughout the economy before cap and trade. Next we develop an alternative model that includes the impact of cap and trade. Comparing the price vectors in the two models provides the estimate of the impact of cap and trade on prices.

In modeling cap and trade, we follow the standard assumption that industry burdens are forward-shifted in the form of higher prices.[25] As with a federal carbon tax, cap-and-trade burdens are passed from carbon-emitting industries to the industries that purchase intermediate inputs from them. In turn, these burdens are ultimately passed forward to households in the form of higher prices for final products throughout the economy.

Let t_j represent the total dollar value of carbon allowances that must be held by industry *j* as a percentage of that industry's total intermediate output. That is, if industry one's carbon emissions are 1,000 tons per year, allowance prices are $100 per ton and intermediate output for industry one is $500,000, t_1 will equal ($100,000)/($500,000) = 0.20. This represents the cap-and-trade "tax" that will be passed forward from industry one to other industries and consumers.

Since cap-and-trade burdens are forward shifted, the impact is equivalent to multiplying the intermediate inputs portion of equation (7) by $(1+t_j)$. Under a cap-and-trade system equation (7) then becomes:

(12) $$\hat{Y}_1 = \sum_{j=1}^{n} a_{1j} \cdot Y_j \cdot (1+t_j) + V_1$$

In equation (12) the value of industry output *Y* has been relabeled $\hat{Y}$ to denote that it includes the embedded cap-and-trade burden. To finish the model, define matrix *T* as an *n x n* matrix with (1 + industry effective cap-and-trade burden *t*) along the diagonal and zeros elsewhere:

(13) $$T = \begin{bmatrix} (1+t_1) & 0 & \cdots & 0 \\ 0 & (1+t_2) & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & (1+t_n) \end{bmatrix}$$

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[25] Fullerton (1995) and Metcalf (1999) refer to this as the "Armington" assumption after Armington (1969). Specifically, it assumes U.S. products are sufficiently different from foreign substitutes to allow the demand curve for domestic products to be downward-sloping. Combined with the assumption that the long-run supply of carbon-intensive products is perfectly elastic, the result is full forward-shifting of cap-and-trade burdens; that is, $\eta_s/(\eta_s - \eta_d)$ = 1 where η_s and η_d are the price elasticities of supply and demand for carbon-intensive products, respectively.

Using the simplified notation from equation (10), we can rewrite equation (12) more generally for the impact of cap and trade for all *n* industries as the following:

(14) $\hat{P} = A' \cdot T \cdot \hat{P} + V$

Solving for the price vector under cap and trade $\hat{P}$, we get:

$$\hat{P} - A' \cdot T \cdot \hat{P} = V$$

$$(I - A' \cdot T) \cdot \hat{P} = V$$

(15) $\hat{P} = (I - A' \cdot T)^{-1} \cdot V$

Equation (15) provides an input-output model that includes the burden of cap and trade on industry-level prices. The two price vectors from equations (11) and (15) can then be compared to isolate the impact of cap and trade on prices at the industry level:

(11) No Cap and Trade (Industry Level): $P = (I - A')^{-1} \cdot V$

(15) With Cap and Trade (Industry Level): $\hat{P} = (I - A' \cdot T)^{-1} \cdot V$

One complication is that is the price vectors in (11) and (15) are for industry-level prices. That is, they assume each of the *n* industries in the economy produces only one type of commodity. In reality industries may produce a variety of commodities making it necessary to convert industry-level price impacts into commodity-level price impacts.

This can be accomplished through the use of a price-transformation matrix as follows. Let *Z* be an *n x m* matrix of *n* industries (corresponding to rows) and *m* commodities (corresponding to columns). Let each entry represent the fraction of column commodity *i* that is produced by row industry *j*, with each column summing to one. Commodity-level price impacts are then given by,

(16) No Cap and Trade (Commodity Level): $P_c = Z' \cdot (I - A')^{-1} \cdot V$

(17) With Cap and Trade (Commodity Level): $\hat{P}_c = Z' \cdot (I - A' \cdot T)^{-1} \cdot V$

ii. Data Sources

The data for the input-output model are drawn from the 2002 benchmark input-output accounts from the U.S. Bureau of Economic Analysis (BEA), released in September 2007.[26] Starting with the rectangular Make and Use tables at the summary level, we combine them into a *133 x 133* square input-output (I-O) table as follows.

[26] See U.S. Bureau of Economic Analysis, "2002 Standard Make and Use Tables at the summary level" available online at bea.gov/industry/io_benchmark.htm.

First we construct the intermediate-uses portion of the I-O table. Starting with the Make table, let *M* be a *133 x 134* matrix where each element is equal to the corresponding Make table element divided by the column total. In the Use table, remove the rows labeled "noncomparable imports" and "ROW adjustment" and label the *134 x 133* intermediate-uses portion of the table *U*. Let *S* be a *133 x 133* matrix equal to *M x U*. This represents the intermediate-uses portion of the I-O table.

Next we construct the final demands portion of the I-O table. Beginning with the Use table, we label the *133 x 13* final demands portion of the table *D*. Let *K* be a *133 x 13* matrix equal to *M x D*. This represents the final demands portion of the I-O table. To complete the table we reconcile the sum of each industry's column output to their row output using the "gross operating surplus" component of column-industry value added as a balancing item.[27] This results in a *133 x 133* I-O table for the U.S. economy for 2002.

The analysis in this study is based on emissions and consumer expenditure data for calendar year 2006. The 2002 I-O table is therefore inflated to 2006 based on the growth rate of nominal U.S. GDP between 2002 and 2006. This 2006 table serves as the basis for the input-output model outlined above.

The *Z* price-transformation matrix is constructed as follows. We begin with the 2002 benchmark Make table at the summary level. The table is reported in producer's prices paid by firms rather than purchaser's prices faced by household consumers. To adjust the table to purchaser's prices, we use data from the BEA's 2002 bridge tables to Personal Consumption Expenditures (PCE) to add each commodity's transportation costs and retail and wholesale margins to the table. Using this Make table in purchaser's prices we then create the *133 x 134 Z* matrix by dividing each element in the Make table by its column sum.

Once the *P* vector of commodity-level price impacts is estimated, the percentage price changes are weighted by each commodity's total output from the Make table. The aggregate cap-and-trade burden is then distributed to the 134 I-O commodities based on this weighted distribution. Once burdens have been distributed to commodities we use the BEA's 2002 bridge tables to distribute burdens to the 230 PCE categories in the National Income and Product Accounts (NIPA). Once burdens are distributed to PCE categories we construct a final crosswalk from PCE categories to the 98 household expenditure categories in the 2006 Consumer Expenditure Survey (CEX) from the U.S. Bureau of Labor Statistics.[28] Using public use data from the CEX we distribute cap-and-trade burdens to households by income quintiles, income groups, age groups, U.S. regions, and type of household.

[27] A complete 2002 U.S. input-output table is available from the author upon request.

[28] A crosswalk from PCE categories to CEX categories is available from the author upon request.

B. Economic Impact Analysis

The economic impact estimates presented in Section IV are based on 2006 RIMS II multipliers from the U.S. Bureau of Economic Analysis. The multipliers are “Type II” multipliers that account for the impact of both industry and household purchases. Once the CBO estimate of a 0.34 percent reduction in GDP is distributed to industries these initial changes in GDP by industry are multiplied by the final-demand multipliers for employment, household earnings, and total economic output for each industry.

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