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The Incidence of U.S. Climate Policy

Alternative Uses of Revenues from a Cap-and-Trade Auction

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RESOURCES FOR THE FUTURE

The Incidence of U.S. Climate Policy: Alternative Uses of Revenues from a Cap-and-Trade Auction

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Abstract

Federal policies intended to slow global warming would impose potentially significant costs on households, and the costs would vary depending on the policy approach used. This paper evaluates the effects of a carbon dioxide (CO_2) cap-and-trade program on households in each of 11 regions of the country and sorted into annual income deciles. We find important variation in the incidence (the distribution of cost) of the policy. The most important feature that affects households is how the policy distributes the value created by placing a price on CO_2 emissions. We evaluate five policy alternatives that yield results ranging from moderately progressive (expansion of the Earned Income Tax Credit and cap-and-dividend approaches) to moderately regressive (reduced income taxes and reduction in the payroll tax). To varying degrees, the allocation of the value of emissions allowances amplifies or mitigates the distributional impacts of placing a price on CO_2.

Key Words: cap-and-trade, allocation, distributional effects, cost burden, equity

JEL Classification Numbers: H22, H23, Q52, Q54

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Executive Summary

Federal climate policy would impose potentially significant costs on households, costs that would vary depending on the policy enacted. Cap-and-trade remains a leading candidate for climate policy because it is expected to be effective in identifying low-cost emissions reductions, thereby substantially reducing the overall costs to the economy. Nonetheless, the distribution of those costs could have serious consequences. Because a cap-and-trade policy will put a price on carbon dioxide (CO_2) emissions, it may impose costs on households that are many times greater than the resource costs associated with achieving emissions reductions.

The effect on households can be separated into two components. First, the introduction of a price on CO_2 would be fairly regressive, meaning it would disproportionately affect lower-income households because they spend a larger portion of their income on energy expenditures. The second part would depend on how the policy distributes the value from the CO_2 price—both the value of emissions allowances, if allocated for free, and the government revenue collected under an allowance auction.

This paper evaluates the effects of a cap-and-trade program on households in each of 11 regions of the country and sorted into annual income deciles, corresponding to effects that would occur in 2015 from policies enacted in 2009. We examine five alternative policies, all involving use of revenues from a government auction, and find tremendous variation in their incidence (distributional effect).

Three types of policies are progressive, including expansion of the Earned Income Tax Credit and a cap-and-dividend program that directly returns revenue to households as either taxable or nontaxable income. In contrast, reducing the income or payroll tax appears regressive. These policies may have important efficiency advantages: many public finance economists have argued the merits of using revenues from auctioned allowances or emissions fees to reduce other distortionary taxes. Our results suggest that this efficiency advantage may come at a distributional cost, since low-income households appear to bear a large burden in these scenarios.

We also assess the distributional burden across regions of the country. Although the case for equity across income groups is straightforward, interregional equity is more complicated because of differences in preexisting policies, energy prices, resources, and lifestyle choices.

Nonetheless, important differences emerge, and the biggest regional differences affect poor households. We find that households in the lowest two deciles incur a welfare loss as high as 4.5 percent of their income in some regions or a gain up to 7.4 percent in others, depending on how revenues are distributed. Low-income households in the Northeast and Ohio Valley are consistently among the most harmed, while Texas and California households come out ahead of their regional counterparts. Although climate change is a long-run problem, it has an important short-run political dynamic, and the local and regional effects of policy may be fundamentally important to building the political coalition necessary to enact climate policy.

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Dallas Burtraw, Richard Sweeney, and Margaret Walls *

1 Introduction

Federal policies intended to slow global warming will impose potentially significant costs on the economy. The overall costs and their distribution across households will vary depending on the policy approach used. One criterion to be considered in designing a program is the extent to which it disproportionately burdens any one segment of the population, especially low-income households. Another criterion to consider is regional differences in the cost of the policy, especially because this can have important political implications.

This paper provides evidence for how climate policy may affect different types of households and guidance for how those effects can be modified. Several policy scenarios are analyzed in each of 11 regions of the country and for households sorted into annual income deciles. The model is calibrated to roughly correspond to effects that would occur in 2015 from policies enacted in 2009. Our policy scenarios consider not only the costs of placing a price on carbon dioxide (CO_2) emissions but also the benefits associated with redistributing the associated revenue raised. We consider both direct and indirect (through consumption of goods and services) energy expenditures, and we focus on a cap-and-trade program, the approach most likely to be adopted at the U.S. federal level and already the focus of the Regional Greenhouse Gas Initiative (RGGI) in the northeastern states and schemes in California and the European Union. We introduce a price on CO_2 emissions of $20.87 per metric ton of CO_2 ($mtCO_2$), which is the resulting 2015 permit price under the cap in Lieberman-Warner (S. 2191), according to the Energy Information Administration.[1]

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[1] All monetary values are in 2006 dollars. Data are available from the supplementary spreadsheets for EIA 2008a (National Energy Modeling System run S2191.D031708A). Economy-wide accounting for expected demographic changes, EIA estimates that this CO_2 price corresponds to a 11.7 percent reduction in emissions from 2006 levels and 16.5 percent from business-as-usual emissions in 2015.

An incentive-based approach such as cap-and-trade or an emissions fee seems well suited to addressing climate change externalities because CO_2, the primary greenhouse gas leading to global warming, is a uniformly mixing pollutant in the atmosphere, and its damage is not related importantly to the location or timing of those emissions. Furthermore, there is tremendous variation in the cost of emissions reductions among agents in the economy, and indeed among nations, and incentive-based regulation is expected to yield emissions reductions where they are least expensive (Newell and Stavins 2003). But a cap-and-trade policy can have serious distributional consequences. This effect has two components. One part depends on how the introduction of a price on CO_2 changes expenditures and ultimately consumer surplus throughout the economy. The second part depends on how the policy distributes the value from the CO_2 price—both the value of emissions allowances if allocated for free and the government revenue collected under an allowance auction (Dinan and Rogers 2002; Parry et al. 2007; Boyce and Riddle 2007; Shammin and Bullard 2009).

Existing literature on this topic has analyzed the distributional impacts, mostly by income group, of cap-and-trade and CO_2 taxes with redistribution of auction or tax revenues in a lump sum manner ("cap-and-dividend" or "tax-and-dividend") and in the form of reductions in income and other taxes. Some of these studies, which we review below, have also considered free allocation of allowances ("grandfathering"). We analyze two forms of the cap-and-dividend option—taxable and nontaxable dividends—as well as expansion of the Earned Income Tax Credit, which benefits low-income households, and reduction in the income tax or the payroll tax. All of the scenarios evaluated in this paper have the same price ($20.87 mt$CO_2$) and level of emission reductions, and thus they have the same total costs in 2015. This allows a comprehensive assessment of a range of CO_2 tax policies using a consistent framework and set of assumptions. We provide the first study to assess the impacts of these policy options by both income group and region.

We find that putting a price on CO_2 emissions can distribute costs unevenly across income groups and regions, and that revenue allocation decisions can either temper or exacerbate these distributional effects. The introduction of a price on CO_2 is regressive in that it imposes a greater cost as a share of household income on lower-income households. In three policy scenarios we examine—caps with taxable or nontaxable dividends and expansion of the Earned Income Tax Credit—the allocation of revenue reverses this outcome, leading to progressive distributions of incidence. However, the assignment of revenues to reduce the income tax or payroll tax would amplify the regressivity of climate policy.

Some earlier literature has concluded that regional differences from CO_2 pricing policies are likely to be relatively small (Hassett et al. 2009). We find that the range of impacts on an average household can be as high as $231. For example, we find that a CO_2 price of $20.87 implemented with revenues returned to households as taxable dividends yields a loss in consumer surplus of $234 per year for the average household in the Northeast, but the average household in Texas loses only $3 per year. The loss in consumer surplus for the average household on a national basis would be $86. When expressed as a fraction of income, these differences are quite small. Where we do find significant differences across regions is for poorer households, where the range of consumer surplus losses can be quite high, especially as a percentage of income. Again using cap-and-dividend as an example, average households in the lowest two deciles may enjoy a consumer surplus gain of as much as 5.4 percent of income (in Texas) or of just 1.9 percent of income (in the Northeast).

The costs we report are partial equilibrium measures and do not account for hidden costs that accrue through the general economy from changes in factor markets. These additional costs could be substantial. A more complete analysis would assess the efficiency impacts of the policies, accounting for the impacts on factor markets of using CO_2 revenue to reduce preexisting distortionary taxes through expansion of the Earned Income Tax Credit or reduction of the income and payroll taxes. Many public finance economists have argued the merits on efficiency grounds of using “green” taxes or auctioned allowances to reduce other distortionary taxes (Goulder et al. 1999; Parry et al. 1999). Assessing the resulting general equilibrium impacts on households by region and by income decile is beyond our scope in this paper. Our findings indicate, however, that there may be trade-offs between efficiency and equity that should be more fully explored in a general equilibrium setting.

In summary, our results suggest that policymakers may be able to find options that can further reduce the burden on low-income households and lessen the difference in regional effects through the distribution of CO_2 allowance value while preserving the advantages of incentive-based options, such as cap-and-trade or an emissions fee.

2 Defining and Measuring Regressivity

One way to measure the distributional impact of a policy is to look at the absolute measure of cost borne by different types of households. However, most analyses focus on the cost of a policy relative to some measure of ability to pay. A person’s ability to pay might be measured on the basis of her “lifetime income” or “permanent income”—that is, the discounted stream of earnings over her lifetime. However, such measures can be constructed only based on panel data, which are difficult to come by.[2] Some authors have constructed proxies for lifetime

[2] See Fullerton and Rogers (1993) for an example of this kind of exercise.

income based on age, education, and other factors (Rogers 1993; Caspersen and Metcalf 1994; Bull et al. 1994; Hassett and Metcalf 1994; Walls and Hanson 1999; Hassett et al. 2009). Others have relied on annual consumption expenditures as a proxy for lifetime income on the basis of the permanent income hypothesis—that annual consumption is a relatively constant proportion of lifetime income (Poterba 1989; West 2004). It is well known that most taxes look more regressive if annual income rather than lifetime income is used (Fullerton and Rogers 1993), and although this should be kept in mind when viewing our results, some experts see merit in using annual income. Barthold (1993) argues that it is politically impractical to talk about lifetime income both because of the inherent uncertainty in measuring it and because of the short time horizons of elected officials and the voting public. Empirical evidence about whether the permanent, or lifetime, income hypothesis is observed in household behavior is mixed (Shapiro and Slemrod 1994). We use annual income, net of taxes and transfers, as the basis to assess households' ability to pay as reported in the Consumer Expenditure Survey (CEX) for 2004–2006. At the end of the paper, we compare annual income with annual expenditures to illustrate the potential consequence of this decision.

Most incidence studies calculate tax expenditures based on pretax consumption levels relative to income (or some other measure of ability to pay) and report averages for income deciles or quintiles. We go beyond the expenditure calculation by allowing for partial equilibrium demand responses to higher CO_2 prices and calculating changes in consumer surplus.[3] We assume that almost all of the price effects are passed forward to consumers, and we account for the following:

- changes in direct fuel and energy costs;
- changes in indirect costs from embodied energy in consumer goods and services; and
- redistribution of allowance auction revenues (as dictated by the different scenarios we analyze).

The only instance in which the CO_2 pricing policy does not fully pass through to consumers is in the case of the electricity sector, where we use a detailed model to account for the long-lived nature of plants and equipment. We discuss this approach more carefully in Section 4.1. Although we allow for some behavioral responses to higher CO_2 prices, our analysis reflects only changes that could be expected by 2015. We use estimated short-run demand elasticities and do not assume large changes in capital stock in response to the CO_2 policy. In the

[3] West (2004) also calculates consumer surplus changes in an analysis of taxes on vehicles and miles traveled.

long run, consumers and investors would have the opportunity to make greater changes in response to price changes.

We do not account for ancillary effects from changes in employment and income. Climate policy will likely shift economic activity away from relatively energy-intensive sectors of the economy to those that are less energy intensive. This shift could lead to unemployment for displaced workers and may force some workers to accept jobs with lower wages. To the extent that lower-wage workers are employed by energy-intensive industries or in regions of the country that experience a reduction in economic activity, these employment and income impacts could be regressive.

It is also worth mentioning that like almost every other study in the literature, we are focusing on only the costs of climate policy and not the benefits. Parry et al. (2007), in a review of studies of the incidence of pollution control policies, found only two studies that had integrated benefits and costs to look at the net incidence of policies, Gianessi et al. (1975) and Dorfman (1977). None of the recent studies have attempted to take on such an analysis. For climate policies, it would be extremely difficult, since one would need an estimate of the benefits of CO_2 emissions reductions.

3 Literature on Distributional Impacts of Climate Policies

Many studies of the incidence of CO_2 taxes and cap-and-trade policies have been published in recent years.[4] Dinan and Rogers (2002) analyze the efficiency and distributional impacts of a cap-and-trade program aimed to reduce emissions by 15 percent. They incorporate behavioral responses (assumed to be uniform across households) and indexing of transfer payments (e.g., Social Security), and they allocate to households additional burdens from the effect of higher product prices on real factor returns and compounding efficiency costs of preexisting factor tax distortions. They find that distributional effects hinge crucially on whether allowances are grandfathered or auctioned and whether revenues from allowance auctions, or from indirect taxation of allowance rents, are used to cut payroll taxes or corporate taxes or provide lump-sum transfers. For example, they estimate that households in the lowest-income quintile would be worse off by around $500 per year under grandfathered allowances; if instead the allowances were auctioned with revenues returned in equal lump-sum rebates for all households, low-income households would, on net, be better off by around $300.

[4] We focus here only on studies that look at CO_2 taxes and cap-and-trade systems. See Parry et al. (2007) for a review of the broader literature on the incidence of environmental policies.

Dinan and Rogers (2002) also highlight the trade-offs between efficiency and distributional concerns. They find that programs that auction allowances and reduce corporate income taxes have the greatest potential for efficiency gains, whereas programs that implement lump-sum revenue recycling would realize little to no increase in economic efficiency.

Several studies look at CO_2 taxes and other kinds of energy taxes. Bull et al. (1994) use input-output tables to trace through the indirect component of energy taxes. They compare a tax based on energy content (i.e., a Btu tax) with a tax based on carbon content. They assess the incidence of these taxes on the basis of annual income, annual consumption expenditures, and a measure of lifetime income that they construct by using data on age and education. Their results suggest that the direct components of Btu and CO_2 taxes look quite regressive on an annual income basis, but the indirect components are less regressive. On the basis of lifetime income, the direct component remains regressive, but the indirect component becomes mildly progressive; overall, the taxes look much less regressive on a lifetime income basis than on an annual income basis. This finding is consistent with studies of other kinds of taxes (Lyon and Schwab 1995).

Metcalf (1999), using similar data, analyzes a revenue-neutral package of environmental taxes, including a CO_2 tax, an increase in motor fuel taxes, taxes on various stationary source emissions, and a virgin materials tax. Prices of energy—electricity, natural gas, fuel oil, and gasoline—increase substantially under these measures while prices of all other consumer goods increase by less than 5 percent. Although the taxes disproportionately hit low-income groups, Metcalf shows that the overall package can be made distributionally neutral (under a range of different income measures) through careful targeting of income and payroll tax reductions.

Parry (2004) estimates a simple, calibrated, analytical model with household income proxied by consumption to examine the incidence of emissions allowances, among other control instruments, to control power plant emissions of CO_2, sulfur dioxide (SO_2), and nitrogen oxide (NO_x). He finds that using grandfathered emissions allowances to reduce CO_2 emissions by 10 percent and NO_x emissions by 30 percent can be highly regressive; the top income quintile is made better off while the bottom income quintile is made much worse off. The SO_2 cap imposed by the Clean Air Act Amendments of 1990, which has reduced emissions by roughly 45 percent, is also found to be regressive but much less so than the CO_2 and NO_x policies.

A recent study adopts the methodology of Bull et al. (1994) and Metcalf (1999)—that is, the use of input-output tables to calculate the indirect effect of the tax and the construction of a measure of lifetime income based on age and education—and analyzes the effects of a CO_2 tax (Hassett et al. 2009). The authors also add a regional focus. They use CEX data for 1987, 1997, and 2003 and assess the impacts of the tax if it were enacted in each of those years. Similar to the earlier studies, they find that the direct component of the tax is significantly more regressive than the indirect component and that the regressivity is muted when lifetime income is used rather than annual income. The authors find only small differences in the incidence of the tax across regions. They do not, however, look at the distribution of costs across income deciles within regions.[5]

Holak et al. (2008) assess the overall impacts of three recent CO_2 tax bills introduced in the U.S. Congress. As part of their study, the authors calculate the tax expenditures as a fraction of income and report the results by annual income decile, under the assumption that revenues are returned in a lump-sum manner. They look at three scenarios: one in which the burden of the tax is fully passed forward to consumers in the form of higher energy and product prices, and two scenarios in which a share of the burden is borne by producers—that is, shareholders of firms.[6] The tax alone, assuming full forward shifting, is highly regressive, but returning revenues lump sum makes it progressive; households in deciles 1 through 6 are actually better off with the policy, and only the two highest-income deciles experience a net loss. Shifting the burden back to shareholders also reduces the regressivity of the tax, since shareholders are predominantly in the higher-income groups.

Metcalf (2009) assesses the impact of a carbon tax “swap”—a CO_2 tax coupled with a reduction in payroll taxes. Specifically, he gives each worker in a household a tax credit equal to the first $560 of payroll taxes; this would be equivalent to exempting from the payroll tax the first $3,660 of wages per worker. Metcalf finds that this option leads to an outcome that is approximately distributionally neutral. He then analyzes an option that couples this rebate with an adjustment to Social Security payments that benefits the lowest-income households. This makes the CO_2 policy more progressive. Finally, he compares these options with a lump-sum redistribution of the CO_2 tax revenues and finds that this option is the most progressive of all.

In summary, the literature indicates that it is important to look at both the direct effects of climate policies (i.e., the increase in the price of energy consumed by households) and the indirect effects (i.e., the increase in the costs of products and services for which energy is an input). The two effects have different impacts on regressivity. Studies also find that the way in

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[5] Batz et al. (2007) find differences in the regional impact of climate policy to be an important consideration, but they do not look at income differences. They consider only direct energy use, and they use kernal regression to estimate effects at a local scale, thereby accounting for rural versus urban differences in consumption.

[6] The backward shifting analysis is informed by runs from the MIT Emissions Prediction and Policy Analysis model. See Paltsev et al. (2007) for a description of the model.

which revenues from a CO_2 tax or auctioned allowances are returned to households is critically important in determining the incidence of the policy. Although one study finds little difference in impacts on the mean household across regions, we provide a more detailed regional analysis that accounts for the income distribution across regions. We also develop a more careful representation of the electricity sector and the new transportation policy, which have regional implications. Also, given the importance of revenue redistribution to the overall incidence measures and the wide range of suggestions in the policy arena for exactly what to do with revenues, we look at five alternative scenarios for redistributing revenues and reducing the impacts of CO_2 pricing. We find these extensions have regional and distributional consequences that are likely to be important because political issues loom large when there are substantial impacts on particular states and regions.

4 Data and Methodology

Our estimation of the effect of climate policy on household expenditures depends on the emissions intensity of economic activity. The component related to direct energy use is relatively easy to measure; the indirect component is measured with significantly less precision.

4.1 Estimating CO_2 Content of Direct Energy Expenditures

The building blocks for the analysis are expenditures at the household level as reported in the CEX for 2004–2006. We use these data to anticipate the incidence of climate policy in the year 2015, with attention to variation across 11 regions and 10 income categories. A variety of technological, economic, and demographic changes can be expected by 2015. However, we account for changes only in the transportation and electricity sectors. Transportation-related changes are expected to result from new corporate average fuel efficiency (CAFE) standards that are likely to take effect on the basis of recent legislation and proposed regulations. We also account for changes in equilibria in electricity markets, including incremental but important changes in investment in supply-and-demand technologies that occur in both the baseline and under climate policy by 2015. Beyond these changes, we assume that expenditure and income patterns in 2004–2006 are a proxy for the patterns that would be in effect in 2015 without climate policy.

The population sampled in the survey includes 97,519 observations for 39,839 households; an observation equals one household in one quarter (Table 1).[7] The Bureau of Labor Statistics (BLS) builds a national sample, and we use their data to construct national after-tax income deciles, also shown in Table 1.[8] Since we are interested in a finer level of geographic detail, we examine the data with state-level indicators. Because BLS cannot preserve the confidentiality of its respondents when samples get small, 15,486 observations (6,605) households have missing state identifiers. This top-coding causes five states—Iowa, New Mexico, North Dakota, Vermont, and Wyoming—to fall out of the data entirely. Consequently, for the regional component of our analysis, we have 82,033 observations for 33,234 households in 43 states plus the District of Columbia.[9] We aggregate the observations into 11 regions. Observations with missing state identifiers are still used in our calculations at the national level.

The data for some expenditure categories appear missing or are reported as zero for a few households. Most problematic are reported zeros for electricity expenditures, because although it is feasible that households do not pay a separate bill, in those cases they inevitably receive services bundled with their housing. Therefore our estimates may underestimate electricity expenditure. On the other hand, zero expenditure for gasoline for personal transportation is plausible but also could reflect errors in data. We interpret the data as a conservative (lower-bound) estimate of energy use and associated CO_2 emissions in these categories.

As noted above, the transportation sector is given special consideration because of the new CAFE standards proposed by the Department of Transportation's National Highway Traffic Safety Administration in April 2008 in response to the Energy Security and Independence Act passed in December 2007. These standards would bring the fuel economy standard for cars to 35.7 miles per gallon (mpg) and trucks to 28.6 mpg by the 2015 model year (see Appendix F).

[7] These numbers exclude observations in Hawaii and Alaska. Although households can remain in the data for up to four quarters, each quarter's sample is designed to be independently representative. Analysis has shown that richer, older, homeowning households are disproportianately likely to complete all four quarters of the survey. For both of these reasons, we treat each individual quarter as an observation, which we annualize, as opposed to only taking observations that contain four quarters' worth of data. All observations are unweighted, and straight averages are calculated at for each region and income decile. Though we have a large number of observations, BLS does not guarantee the statistiscal representativeness of its data at the state level.

[8] We distribute regional observations based on the CEX data into these national income deciles. These income "buckets" do not necessarily accurately represent regional income deciles; rather, they are constructed as deciles at the national level.

[9] BLS refers to observations as "consumer units," which we loosely interpret as households. Compared with the population as a whole, the missing observations are unevenly distributed toward the lower end of the income distribution.

Table 1. Observations by Region and After-Tax Income Decile

		Decile										
Region	**States**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Southeast	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	1327	1423	1434	1354	1371	1189	1230	1156	1315	1189	12988
CA	CA	577	792	796	905	904	1001	962	1002	1196	1457	9592
TX	TX	462	501	602	617	631	624	541	608	520	594	5700
FL	FL	438	578	571	611	536	634	546	568	469	401	5352
Ohio Valley	IL, IN, KY, MI, MO, OH, WV, WI	1247	1476	1764	1716	1567	1722	1754	1805	1814	1644	16509
Mid-Atlantic	DE, MD, NJ, PA	593	840	961	966	926	889	1069	1061	1052	1268	9625
Northeast	CT, ME, MA, NH, RI	261	312	387	314	350	464	389	476	579	579	4111
Northwest	ID, MT, OR, UT, WA	454	443	469	534	587	584	697	591	573	590	5522
NY	NY	405	443	345	391	444	407	456	465	531	599	4486
Plains	KS, MN, NE, OK, SD	218	254	304	346	319	398	401	439	327	368	3374
Mountains	AZ, CO, NV	350	434	485	509	574	486	495	503	481	457	4774
National		9751	9752	9752	9752	9752	9752	9752	9752	9752	9752	97519

The new regulations affect our baseline 2015 expenditure calculations in two ways. First, new vehicles are more costly than they would otherwise be and more costly than in the 2006 CEX data, all else equal. We rely on estimates in Fischer et al. (2007) to obtain our higher vehicle price.[10] In 2015, a new car will cost $149 more than it would in 2006, all else equal; and a new truck will cost $246 more. We use data from Bureau of Transportation Statistics to calculate the percentage of new cars on the road as a fraction of all cars. [11] Second, gasoline expenditures, all else equal, are lower than they would be without the new standards (and lower than in 2006). We estimate that in 2015, the average on-road fuel efficiency for cars will be 26.3 mpg, and the average for trucks will be 21.9 mpg. These are improvements of 17 percent and 22 percent, respectively, over the fleetwide average for cars and trucks in 2006.[12] When fuel economy increases, there is a "rebound effect" on driving—that is, in response to the drop in the per mile cost of driving, people drive more (Small and Van Dender 2007; U.S. Department of Transportation 2008). Accounting for the increased fuel efficiency and the rebound effect and the gradual replacement of new vehicles for old ones, we estimate that average gasoline expenditures per household in 2015 are 15 percent lower than the 2006 levels.

Figure 1 illustrates the direct annual expenditures as a percentage of reported annual income by expenditure category at the national level. The 10 vertical bars represent income deciles, and the amount of expenditure in various categories, as a percentage of income, is displayed for the average household within each decile. The four reported categories represent direct purchases by the average household of electricity, gasoline, natural gas, and heating oil. Their consumption leads directly to CO_2 emissions, and climate policy would directly increase their cost.

At the national level, direct expenditure on energy represents 24 percent of annual income among the households in the lowest-income category, which is the greatest percentage of any group.[13] For the highest-income households, it is 3.6 percent. On average across all income

[10] Fischer et al. (2007) rely on the National Academy of Sciences (2002) study of fuel economy technologies for estimates of the costs of meeting higher CAFE requirements.

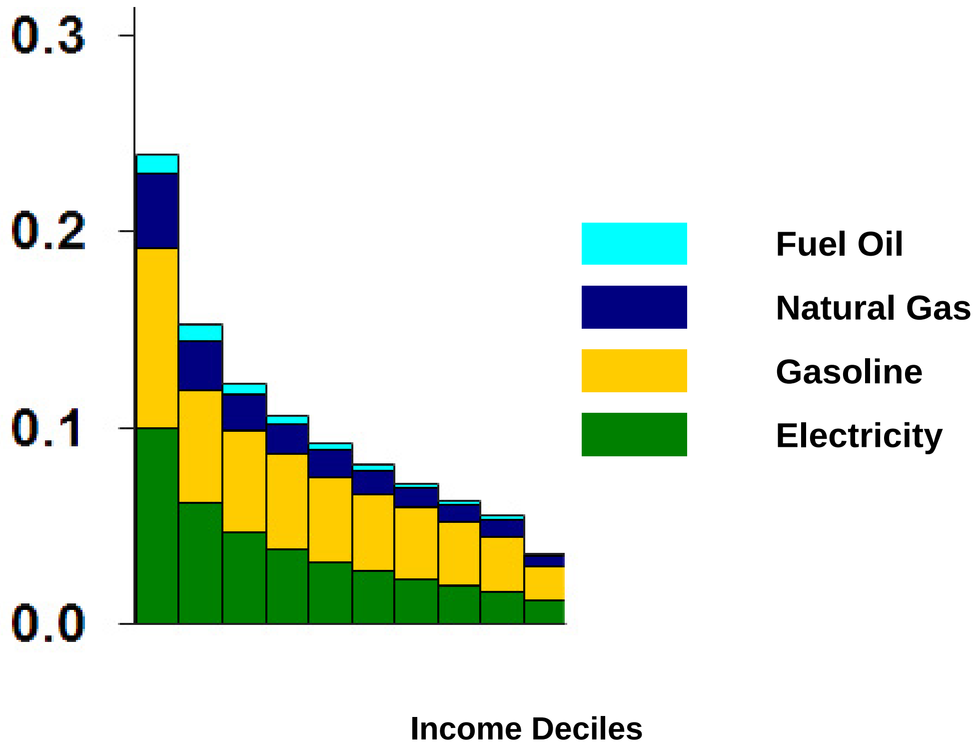
[11] See http://www.bts.gov/publications/national_transportation_statistics/.

[12] On-road average fuel efficiency is available from the Bureau of Transportation Statistics. See http://www.bts.gov/publications/national_transportation_statistics/.

[13] Information about households in the lowest-income category is complicated by the fact that some households may be in this category on a temporary basis, including for example students or seniors drawing on savings, and consumption is likely to exceed income for these populations. Further, some authors have noted the possibility of measurement error at the bottom of the income distribution.

groups, the share of expenditure on energy is 6.7 percent of annual income.

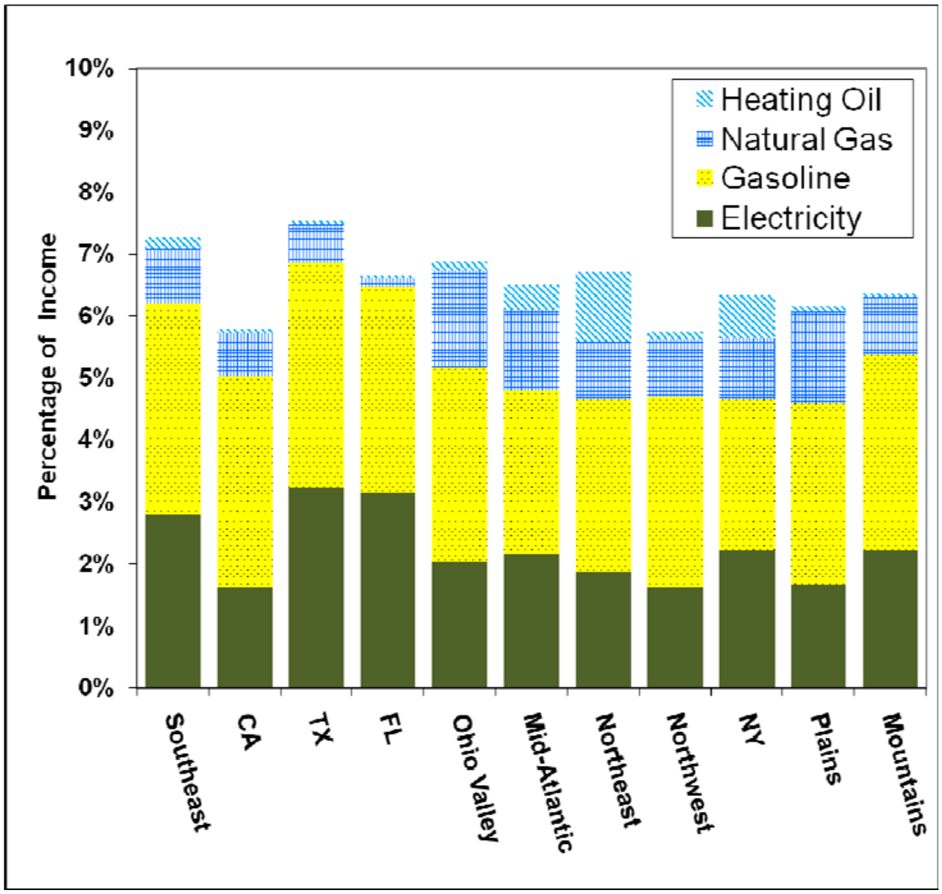
Figure 1. National Direct Energy Expenditures as Fraction of Income



The nation is divided into 11 regions in our analysis. Figure 2 shows the average direct energy expenditures as a percentage of income in each region and for each fuel type. The average expenditure ranges from a low of 5.8 percent in California and Nevada and the Northwest to a high of 7.5 percent in Texas. In dollars, average annual expenditures range from $3,547 in the Northwest to $4,676 in the Northeast.

These overall average direct expenditures do not show a great deal of variation across regions. However, greater regional differences show up for lower-income households. For instance, the lowest decile has direct expenditures equal to 22 percent of income in California and Nevada and 38 percent in the Northeast states. Low-income households in California and Nevada pay 7.7 times as much as those in the highest decile, as a percentage of income. In the Southeast, the figure is 11.5 times as much.

Figure 2. Average Household Expenditures on Direct Fuel Purchases as Percentage of Income, by Region



The categories of expenditure also vary considerably across regions. Since the CO_2 content of each type of expenditure varies, there would be variable effects on overall expenditures across regions. In the Northeast and the Mid-Atlantic, home heating contributes importantly to expenditures, but not so in the South. In contrast, electricity expenditures are substantially greater as a percentage of income in the South than for other regions on average. Gasoline expenditures are also greatest in the South. The Midwest has intermediate levels of expenditures in all categories. New York would also achieve levels as high as the other regions except for lower gasoline expenditures. In the West, overall expenditure tends to be lower, but gasoline expenditure is relatively high, especially compared with the Northeast. These variations are amplified when comparing regional differences for the lowest-income groups.

To understand how household expenditures would be affected by climate policy, we calculate the quantities of fuels purchased by households in each group by taking expenditures from BLS and dividing by fuel-specific, state-specific energy prices from the Energy

Information Administration (EIA). With information about the quantities of fuels purchased, we can calculate the embodied CO_2 content of expenditures and the incremental change in expenditures that would result from a price on CO_2 emissions. For natural gas, fuel oil, and gasoline, the carbon content and resulting CO_2 emissions are fixed numbers. For electricity, the effect of climate policy is more complicated. The CO_2 content of electricity depends on the fuel used for generation, which varies over seasonal and diurnal periods in different regions. Changes in electricity price also depend on the way that price is determined in electricity markets, which varies across regions. This pattern is identified by Haiku, the electricity market model built and maintained by Resources for the Future.[14] The Haiku model solves for market equilibria accounting for price-sensitive demand and changes in electricity supply, including changes in capacity investment and retirement over a 25-year horizon and system operation for three seasons of the year (spring and fall are combined) and four times of day. The model solves for 21 regions of the country, which are mapped into the 11 regions in this analysis. The model indicates that changes in electricity prices and expenditures differ importantly by region, but they do not directly reflect where the greatest emissions occur (see Appendix G).

4.2 Estimating Indirect CO_2 Content of Other Expenditures

The second category we incorporate in the analysis is spending on energy embodied indirectly in food, durable goods, and other goods and services. CO_2 emissions resulting from indirect energy consumption are calculated on the basis of data in Hassett et al. (2009), who provide information on the emissions intensity of goods aggregated into 38 indirect expenditure categories by updating methods developed by Metcalf (1999).[15]

The estimates of direct fuel use and the implied CO_2 emissions based on the CEX data correspond well to data collected by EIA (2007) (Batz et al. 2007). However, the total emissions we calculate fall short of economy-wide EIA estimates, which are 20.2 $mtCO_2$ in 2006.[16] At least some of the missing emissions are from the public sector—that is, from direct and indirect energy consumption by federal, state, and local government agencies. Assuming that government directly accounts for 14 percent of total emissions, we would expect the CEX data to yield per

[14] Haiku models regions with either regulated (cost-of-service) or market-based prices (see Paul et al. 2008 for a description of the model).

[15] Metcalf (1999) has been the basis for similar calculations elsewhere in the literature (Dinan and Rogers 2002; Boyce and Riddle 2007).

[16] The estimate is based on the U.S. population in 2006.

capita emissions of 17.32 $mtCO_2$. Instead, our analysis of the CEX data accounts for per capita emissions of 15.24 $mtCO_2$.[17]

Table 2. Per Capita Emissions and Elasticities, by Category

	Baseline (mtCO2)	%	Post-Cap (mtCO2)	%	Elasticity	Source
Direct						
Electricity	2.19	10.9%	1.59	8.5%	-0.38	Haiku*
Natural Gas	1.09	5.4%	1.07	5.7%	-0.20	Dahl (1993)
Gasoline	4.60	22.8%	3.88	20.7%	-0.10	Hughes et al. (2008)
Fuel Oil	0.43	2.2%	0.42	2.2%	-0.20	Dahl (1993)
Indirect						
Food	1.56	7.7%	1.55	8.3%	-0.63	Tellis (1988)
Services	1.78	8.8%	1.77	9.4%	-1.00	Boyce and Riddle (2008)
Air Travel	0.23	1.1%	0.23	1.2%	-0.25	Boyce and Riddle (2008)
Industrial Goods	1.03	5.1%	1.02	5.4%	-1.23	Tellis (1988)
Auto	2.68	13.3%	2.64	14.1%	-1.30	Boyce and Riddle (2008)
Other Transportation	0.05	0.3%	0.05	0.3%	-0.25	Boyce and Riddle (2008)
Other Indirect	1.68	8.3%	1.68	9.0%	0.00	Assumption
Government (Implied)	2.83	14.0%	2.83	15.1%	0.00	Assumption
Total	20.2		18.7			

Note: For the electricity sector, this elasticity represents the equilibrium percent change in quantities for a percent change in equilibrium prices.

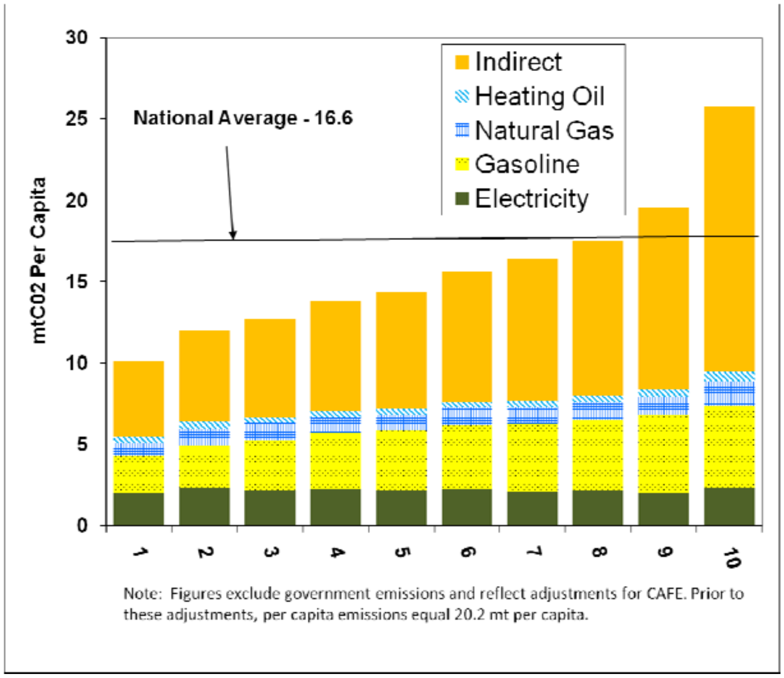
The literature reveals a variety of approaches to deal with inconsistencies between the CEX data and other sources. Batz et al. (2007) correct for oversampling in their demographic model. Dinan and Rogers (2002) scale the CEX data so that they align with expenditures reported in the National Income Product Accounts, which implicitly scale emissions from fossil fuel use at the national level. Boyce and Riddle (2007) do not scale and appear to account for only 13.46 $mtCO_2$ per capita in their data. On the other hand, Hassett et al. (2009) appear to account for emissions of 24.4 $mtCO_2$ per capita, well above the EIA estimate.

[17] Batz et al. (2007) mention several potential explanations for discrepancies between CEX data and other sources, including oversampling of urban areas in the CEX data. Another discrepancy is nonfossil fuel sources of CO_2, including cement and limestone, which account for nearly 2 percent in the EIA data. Also, errors in mapping CEX data into expenditure categories and exclusion of exports (and imports) could be other discrepancies.

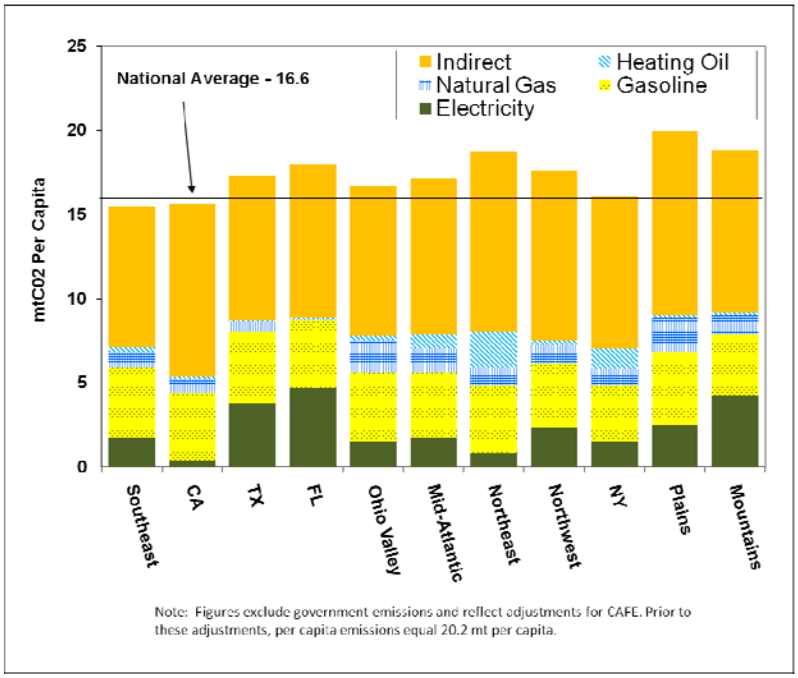
To measure the effects on households in a way that more closely resembles the EIA data, we scale the emissions intensity of indirect expenditures in the CEX data so that the total emissions correspond with EIA estimates, increasing indirect expenditures by 30 percent (2.7 $mtCO_2$ per capita) to achieve overall EIA emissions levels of 20.2 $mtCO_2$. Table 2 organizes emissions into direct and indirect expenditure on energy. The baseline indicates the shares in the absence of climate policy, with government emissions represented in the indirect category and prior to accounting for the CAFE adjustment. The policy case indicates how those shares change as per capita emissions fall to 18.7 $mtCO_2$ under the CAFE adjustment (which accounts for 47 percent of the change) and the cap-and-trade policy (which accounts for 53 percent of the change).

Figure 3. Emissions ($mtCO_2$) per Capita, by Alternative Measures

Panel A. Income Decile



Panel B. Region

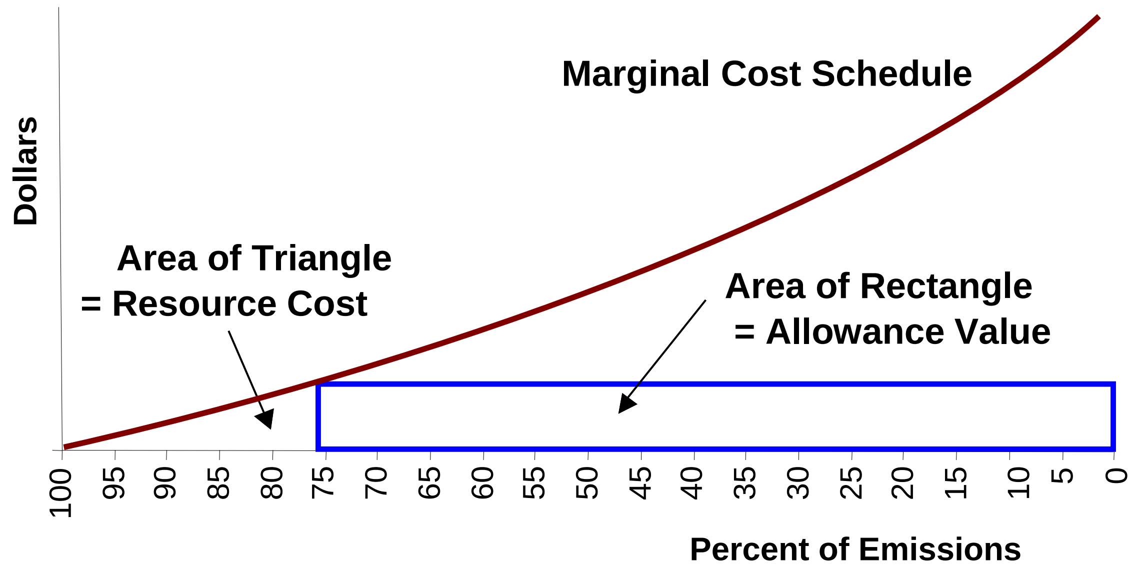


Panel A in Figure 3 illustrates the CO_2 content of expenditures for direct and indirect fuel purchases for the average household in each income group at the national level. The expenditures for direct fuel purchases are distributed fairly evenly across income groups. The big difference emerges in the indirect expenditure category, where high-income households spend significantly more than low-income households. We assume the emissions intensity per dollar of expenditure for indirect consumption of fuels is uniform throughout the country; consequently, actual emissions vary directly with expenditure. However, panel B in Figure 3 shows significant differences across regions in the types of direct expenditures for fuels. The variation in emissions from the electricity sector is particularly noteworthy.

5 Effects of Pricing CO_2

Figure 4 illustrates the mechanism of placing a price on CO_2 emissions through the introduction of a cap-and-trade policy. The horizontal axis in the graph is the reduction in emissions (moving to the right implies lower emissions), and the upward-sloping curve is the incremental resource cost of a schedule of measures to reduce emissions; thus, it sketches out the marginal abatement cost curve. The hypothetical emissions cap in the figure is set at about 75 percent of baseline emissions. According to most experts, for the next couple of decades at least, the value of emissions allowances under a cap-and-trade program should be substantially larger than the value of the resources actually used to achieve emissions reductions. This relationship is illustrated in Figure 4, where the allowance value rectangle—the height of the rectangle equals the allowance price and the width is the number of emissions allowances—is much larger than the triangle-shaped abatement costs. Moreover, the value of the allowances (the rectangle) grows faster than the cost of emissions reductions (the triangle) as the emissions cap is tightened until reductions of about one-third are reached. The figure highlights the important role played by the allocation of emissions allowances in determining the distributional consequences of climate policy under an incentive-based policy such as cap-and-trade or a CO_2 tax.

Figure 4. Resource Cost and Allowance Value in CO_2 Cap-and-Trade Program



As noted previously, we benchmark the stringency of the policy to a price of $20.87 per ton of CO_2. We assume that the policy is announced in 2009 and takes effect in 2012, and we consider the effect on households in 2015. This time frame allows for some technological evolution in transportation and electricity; otherwise, expenditure patterns of households are assumed to match those in the CEX data.

The CAFE adjustment leads to emissions reductions of 0.68 mtCO_2 per capita. To calculate the additional change in emissions due to the CO_2 price, we multiply the CO_2 price by the CO_2 content of expenditures in each category except electricity and add this to the product price to calculate new levels of product prices. Although demand is relatively inelastic in the short run, the change in product prices is expected to lead to a change in consumer expenditures, which we calculate using elasticity estimates specific to each fuel. The elasticities used in the model are reported in Table 2. To model the change in residential electricity demand, we use the Haiku model, which has elasticities embedded in it. The change in emissions results from a change in generation technologies, prices, and demand, all of which vary by region (see Appendix G). These estimates, coupled with the model results for the electricity sector, allow us to calculate the changes in expenditure based on partial equilibrium changes in price and quantity. The CO_2 price yields emissions reductions of 0.76 $mtCO_2$ in addition to the reductions accounted for by the CAFE adjustment.

This approach implicitly assumes that all changes in costs are fully passed through to consumers in every industry except electricity. In the long run, production technology is usually characterized as constant returns to scale, which implies that consumers bear the cost of policy. In the short run, there is more likely to be a sharing of lost economic surplus with producers because of changes in the value of in-place capital, but this will dissipate over time. The electricity sector is an exception because of the long-lived nature of capital in the sector, which means that the loss to producers will dissipate more slowly. Nonetheless, even in this sector consumers are expected to bear eight times the cost borne by producers (Burtraw and Palmer 2008). The degree to which the burden of any tax is shared between consumers and producers has been the focus of previous studies but is outside our scope here. As explained in the literature review above, Holak et al. (2008) assess the distributional impacts of a carbon tax under alternative assumptions about the share of burden borne by consumers and producers.

5.1 How to Interpret Incidence and Alternative Policy Remedies

Most existing distributional studies look at expenditures as a fraction of income, assuming no behavioral adjustments or demand response. We show these calculations for our study in column 3 of Table 3. However, the goal of climate policy is to spur adjustments in behavior that result in emissions reductions, and therefore we consider it essential to account for demand responses in our analysis. Expenditures changes, assuming these demand responses, are shown in column 1 of the table. This calculation also is problematic, since it fails to account for the welfare effects of the demand adjustment. In fact, the change in expenditure can differ importantly from the change in consumer surplus. For example, a price increase in an expenditure category with own-price elasticity of demand equal to –1 would lead to a reduction in quantity and consumer surplus, but there would be no change in expenditure. Simply equating expenditure change with well-being therefore would underestimate the cost of constraining CO_2 emissions; all other things equal, consumers are clearly harmed if they are forced to consume less.[18] The numbers in column 2 indicate that accounting for the welfare loss is important, as they are significantly larger for all income groups than the numbers in column 1.

Table 3. Alternative Measures of Cost of Pricing CO_2

Decile	Change In Expenditure with Demand Response	Change In Consumer Surplus With Demand Response	Change in Expenditure Without Demand Response
1	$253	$350	$379
2	$336	$487	$519
3	$399	$598	$631
4	$456	$712	$747
5	$504	$803	$846
6	$553	$910	$952
7	$611	$1,039	$1,079
8	$681	$1,162	$1,209
9	$790	$1,381	$1,442
10	$994	$1,841	$1,912
Average	$558	$928	$972

Our consumer surplus loss estimates end up close to the expenditure estimates assuming no demand response, the numbers in column 3. Although this may indicate that expenditures are a close proxy for the welfare loss, we hasten to point out that this may not be the case with more elastic demand curves or a tighter cap on emissions and thus a higher CO_2 price. In addition, our scenarios all have the same CO_2 price, but for policy scenarios that might lead to different prices for the same emissions target, this difference would be important. The initial average costs of pricing CO_2 for each region and decile are reported in Appendix H.

One way to represent the distribution of costs in a quantitative manner is the Suits Index, which is the tax analog to the better-known Gini coefficient that serves as an index measuring income inequality. A curve is constructed by plotting the relationship between cumulative tax paid and cumulative income earned.[19] The area under this curve is then compared with the area

[18] West (2004) showed that when demand elasticities vary by income group, using consumer surplus rather than expenditures can lead to quite different distributional findings. She estimates a more elastic demand for gasoline (and miles traveled) in lower-income groups than higher ones, leading those groups to reduce gasoline expenditures more in response to a gasoline tax (and other vehicle-related taxes). This behavioral adjustment will mute the regressivity of the tax when regressivity is measured on the basis of expenditures. However, the consumer surplus effect, because it adds a welfare loss triangle to the expenditure rectangle, indicates a greater harm to lower-income households. Although we calculate a consumer surplus effect, we do not allow elasticities to vary by income.

[19] This curve is similar to a Lorenz curve, which graphically represents the cumulative distribution of income relative to the cumulative distribution of the population.

under a proportional line to calculate the Suits Index. If all tax collections are nonnegative, the index is bounded by –1 and 1, with values less than zero connoting regressivity, and values greater than zero, progressivity; a proportional tax has a Suits Index of zero (Suits 1977). The Suits Index provides a simple metric with which to compare the distributional impacts of alternative policies. At the national level, not accounting for the revenue that may be collected or the allocation of emissions allowances, the Suits Index for the CO_2 price of $20.87 is –0.18. We also consider the distribution of the benefits associated with distributing the revenue raised from cap-and-trade. In this case, the analysis is the same, but the sign interpretation is reversed, with negative values indicating progressivity. However, although both numbers are informative individually, they are not additive. We discuss the Suits Index results further in our alternative policy scenarios below.

We also look at regional incidence. Figure 2 above and the accompanying discussion foreshadow some of those regional results—namely, large regional differences do not show up for average households but do exist for lower-income households. Hassett et al. (2009) find it "quite remarkable how small" the differences are across regions, but they do not look across income groups. Batz et al. (2007) also look only at average households. Although they consider only direct energy use, they do so with much greater geographic detail than previous researchers by examining county-level data, and they account for differences in the emissions intensity of electricity generation across the country. They reach a different conclusion from Hassett et al. (2009), finding "substantial variation in the incidence of a CO_2 emissions tax" across regions, which they say is due to variation in energy use as well as differences in the CO_2 intensity of electricity generation. Our analysis does not have the detail at the county level, but it does have similar estimates of electricity generation, taken from an updated version of the model they use, and it includes indirect expenditures. Neither Hassett et al. (2009) nor Batz et al. (2007) look at the allocation of CO_2 revenue; they assess only the regional incidence of pricing CO_2.

6 Results for Alternative Policy Scenarios

The price on CO_2 emissions creates a sum of revenue of significant value. The way this value is allocated to different groups in the economy greatly affects the costs and distributional burden of the CO_2 policy. We group our revenue scenarios into two categories, cap-and-dividend options and changes to preexisting taxes. In the first group, we consider two cap-and-dividend options—one in which the dividend is subject to income taxes and one in which it is not. In the second group, we consider a reduction in income taxes, a reduction in payroll taxes, and an expansion of the Earned Income Tax Credit. In each of the options, the revenues generated from the allowances used to cover all nongovernment emissions (recall from Section 4.2 above that we do not address the government sector) are returned to households according to the individual policy prescription. The one exception is the Earned Income Tax Credit; in this option, we assume the credit is increased by 50 percent above its current level, which leads to “leftover” revenue that is returned in a lump-sum manner as in the (taxable) cap-and-dividend case. The average net effects of each policy for each region and decile are reported in Appendix I.

6.1 Cap-and-Dividend (Lump-Sum Transfers)

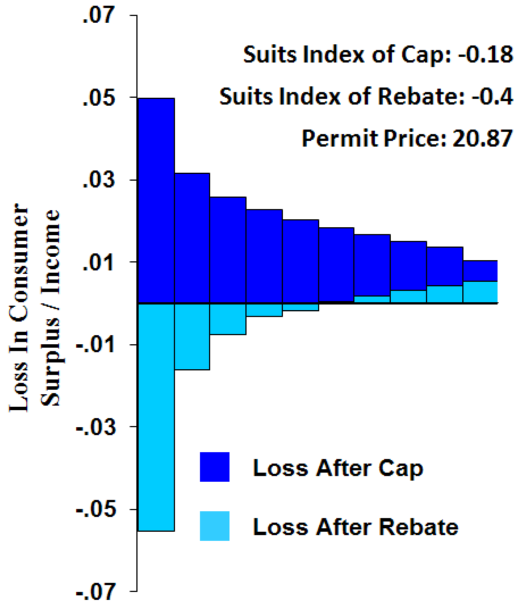
One straightforward remedy to alleviate the regressivity of the CO_2 policy would be to return the CO_2 revenue to households on a per capita basis. This approach recently has been referred to as cap-and-dividend (Boyce and Riddle 2007) and previously was known as “sky trust” (Kopp et al. 1999; Barnes 2001). In principle, the government would auction the emissions allowances and return the auction revenues in a lump-sum manner to each person. Using information from the CEX, we identify the number of persons per household in each income group in each region and calculate a per capita dividend payment to redistribute to each household. In our first scenario, people are assumed to pay personal income taxes on the dividends. In the next scenario, discussed in Section 6.1.2 below, we consider a dividend that is not taxed. [20]

6.1.1 Taxed Dividends

The net effect of the cap-and-taxable dividend policy, by region and nationally, is shown in Figure 5. The bar graph illustrates the incidence of the policy, in consumer surplus loss as a fraction of annual income, on the average household in each income group; the table portion of the figure shows the impacts for the average household in each region and for households earning less than $19,208, which corresponds to the lowest two income deciles on a national basis. The Suits Indexes and the CO_2 allowance price are also listed.

[20] Since our results are derived in a partial equilibrium setting, we do not consider any effects that this lump-sum payment would have on household expenditures. However, recent evidence from the behavioral economics literature suggests that consumers are unlikely to factor the expectation of such payments into their short-run energy consumption decisions (Sunstein and Thaler 2008).

Figure 5. Cap-and-Dividend (Taxable)



	Average Welfare Loss for Households in the Bottom Two Deciles Nationally		Average Welfare Loss for All Households	
	$	%	$	%
Southeast	-$284	-3.13%	$85	0.15%
CA	-$459	-4.70%	$29	0.04%
TX	-$516	-5.39%	$3	0.00%
FL	-$240	-2.56%	$42	0.08%
Ohio Valley	-$198	-2.22%	$210	0.35%
Mid-Atlantic	-$217	-2.36%	$198	0.30%
Northeast	-$164	-1.87%	$234	0.34%
Northwest	-$314	-3.54%	$78	0.13%
NY	-$308	-3.53%	$56	0.08%
Plains	-$236	-2.74%	$285	0.45%
Mountains	-$320	-3.59%	$134	0.23%
National	-$317	-3.56%	$86	0.15%

Note: Negative numbers in the table reflect gains in welfare. A negative Suits Index number represents regressive taxation and positive rebates. The bottom two deciles nationally consist of households earning less than $19,208 in annual income after taxes and transfers.

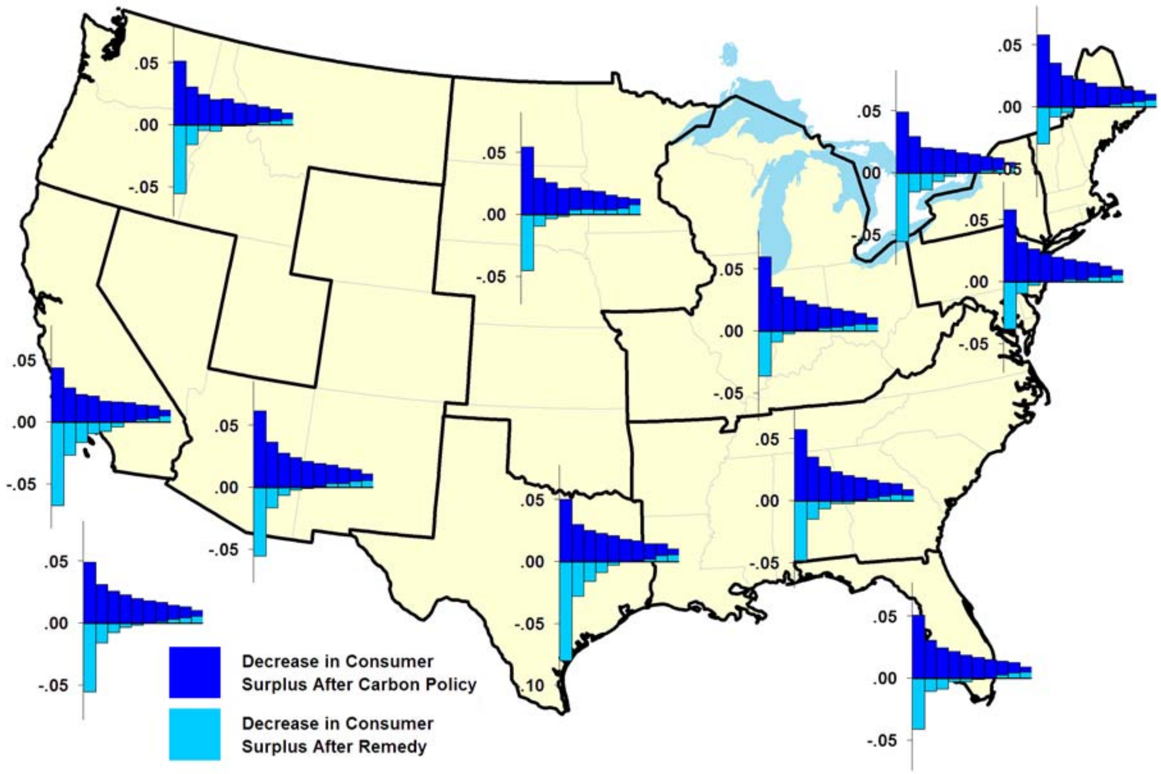
The bars with darker shading represent the loss in consumer surplus as a share of after-tax income, without accounting for the revenues. The bars with the lighter shading represent the incidence of the policy after distributing the value of allowances as a per capita dividend. The graph clearly shows that households in the lowest deciles see a dramatic improvement in their well-being as a result of the lump-sum dividend of allowance revenues. The average household in decile 1 incurs a consumer surplus loss slightly greater than 5 percent of its income without the dividend but gets a consumer surplus gain equal to 5.5 percent of income with the dividend. The figure also shows that households in all deciles benefit from the lump-sum return of revenues. Although households in the higher income deciles do not experience a net gain, on average, they do incur a much smaller loss as a result of the rebate. The Suits Index from the tax is –0.18, indicating that the CO_2 price is regressive; however, the Suits Index from the rebate is –0.4, which is strongly progressive. On net, the graph makes it clear that the cap-and-dividend option is a progressive policy.

The table portion of Figure 5 shows the net dollar loss in consumer surplus (including the dividend), along with the loss as a percentage of income, for an average household in each region and for an average household in deciles 1 and 2 (those making less than $19,208 per year).

Positive numbers in the table indicate a loss and negative numbers indicate a gain, consistent with the graph. The important take-away messages from table are the variation in impacts across regions for households in deciles 1 and 2 and the relatively small difference across regions for average households. In Texas, households making less than $19,208 experience a consumer surplus gain of $516, or 5.4 percent of income, on average, whereas households in this same income group in the Northeast gain $164, or 1.87 percent of income. By contrast, the variation for the mean household across regions is much smaller, especially as a percentage of income. The region with the smallest welfare loss is Texas—an average household there basically breaks even—but an average household in the Plains loses $285, or 0.45 percent of income.

To illustrate the incidence of policy across all income groups and regions, we display a map in Figure 6. Again, the bars with darker shading represent the loss in consumer surplus as a share of after-tax income, and the bars with the lighter shading represent the net loss after distributing the value of allowances as a per capita dividend. The figure for the nation is replicated in the lower-left corner, and the region-specific figures are displayed for each of the 11 regions we model. The map indicates that the regional differences come into consideration for the lower- and middle-income groups, but there is little variation among the upper-income groups across regions.

Figure 6. Regional Differences with Cap-and-Dividend (Taxable)

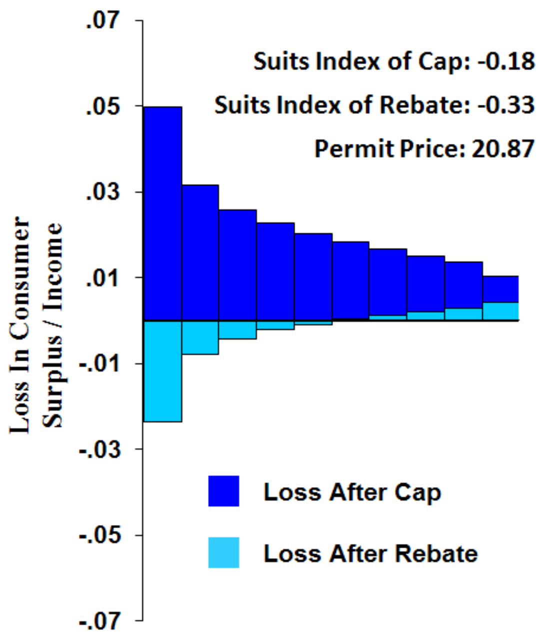


6.1.2 Nontaxable Dividends

It is not clear whether CO_2 allowance dividends in a new cap-and-trade program would be treated as taxable or nontaxable income. In this scenario, we treat the dividends as untaxed. This case is similar to the 2008 federal tax rebates, which were also untaxed.

Figure 7 shows a bar graph of the distributional impacts of the policy at the national level and a table of regional results. Similar to the previously analyzed cap-and-dividend policy, the bar graph illustrates that this policy benefits lower-income households. The net gain in consumer surplus for the average household in the lowest income decile, after the lump-sum return of revenue, is 2.5 percent of income, compared with a loss of 5 percent before the return of revenue. Again, as in our first policy scenario, all households are better off with the dividend, but only average households in the lowest five income deciles experience an overall net gain.

Figure 7. Cap-and-Dividend (Nontaxable)



	Average Welfare Loss for Households in the Bottom Two Deciles Nationally		Average Welfare Loss for All Households	
	$	%	$	%
Southeast	-$102	-1.09%	$93	0.16%
CA	-$259	-2.55%	$3	0.00%
TX	-$289	-2.92%	$9	0.02%
FL	-$76	-0.81%	$47	0.09%
Ohio Valley	-$31	-0.38%	$199	0.33%
Mid-Atlantic	-$49	-0.54%	$177	0.27%
Northeast	-$13	-0.17%	$202	0.29%
Northwest	-$139	-1.53%	$66	0.11%
NY	-$138	-1.56%	$39	0.06%
Plains	-$74	-0.88%	$266	0.42%
Mountains	-$124	-1.35%	$131	0.22%
National	-$142	-1.57%	$86	0.15%

Note: Negative numbers in the table reflect gains in welfare. A negative Suits Index number represents regressive taxation and positive rebates. The bottom two deciles nationally consist of households earning less than $19,208 in annual income after taxes and transfers.

In comparison with the first scenario, in which dividends are taxed, the nontaxable dividend option tends to lead to a slightly more equal distribution of the net burden across income groups. The lower-income households do not experience quite as large a gain, and the higher-income households do not incur quite as large a loss. This happens because of the differences in the marginal tax rates across income groups. When the dividend is taxed, the *relative* gain to the lower deciles is greater because of their lower marginal tax rates. In this scenario, where the dividends are untaxed, these tax rate differences do not play a role. The difference shows up in the Suits Index for the rebate, which at –0.33 is less negative than in our first policy scenario. Both cap-and-dividend options are progressive, but the taxable dividend option is more progressive.

As the table in Figure 7 shows, this policy still leads to substantial variation across regions for the average household in the lowest-income deciles but not for the average household overall. Again, poor households in the Northeast gain the least, $13 per year, or 0.17 percent of income, and poor households in Texas gain the most, $289 per year, or 2.9 percent of income. The regional differences for average households, however, on a percentage of income basis, are much smaller. The average consumer surplus loss ranges from virtually zero to 0.42 percent of income. The average consumer surplus loss for this policy across all households in the United States is $86, or 0.15 percent of annual income, the same as the scenario in which dividends were taxed.

6.2 Reducing Preexisting Taxes

A prominent suggestion from the public finance literature is to direct revenues collected under federal climate policy to reduce preexisting taxes that distort behavior away from economic efficiency (Bovenberg and de Mooij 1994; Bovenberg and Goulder 1996; Goulder et al. 1999; Parry et al. 1999). Studies show that such an option improves the overall efficiency of the policy because it removes the distortions those preexisting taxes cause in factor markets. In fact, failure to reduce those taxes can impose a hidden cost of climate policy.[21] If climate policy is more expensive than it otherwise needs to be, then this inevitably affects households in all income groups. Therefore, designing policy to be as cost-effective as possible can be thought of as an important component of addressing the impact on low-income households.

Measuring the effect of interactions with other regulations and taxes and the benefits of revenue recycling requires a general equilibrium framework or linked partial equilibrium models that include labor or capital supply decisions. Dinan and Rogers (2002) include a reduced-form representation of the benefits of revenue recycling using estimates of the welfare loss in factor markets from Parry et al. (1999). We do not include the effects in factor markets in this analysis, in part because the exact way in which those effects are distributed among households in different regions has not been studied previously. However, we do model the direct effect on household finances of using CO_2 revenue to reduce the income tax, reduce the payroll tax, and augment the Earned Income Tax Credit, ignoring the welfare issues associated with changes in the supply of labor.

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[21] Theory suggests that any tax or regulatory cost causes a difference between the value of marginal product and opportunity cost in the affected factor markets. By raising costs, a new regulation, such as climate policy, acts like a virtual tax by lowering the real wage, which causes a reduction in the supply of relevant factors, such as labor or capital. Moreover, a new regulatory cost exacerbates the inefficiency that arises from preexisting regulations and taxes, raising costs at an increasing rate. If revenue is used to reduce preexisting taxes, then this effect can be offset to a considerable degree.

6.2.1 Reducing Income Tax

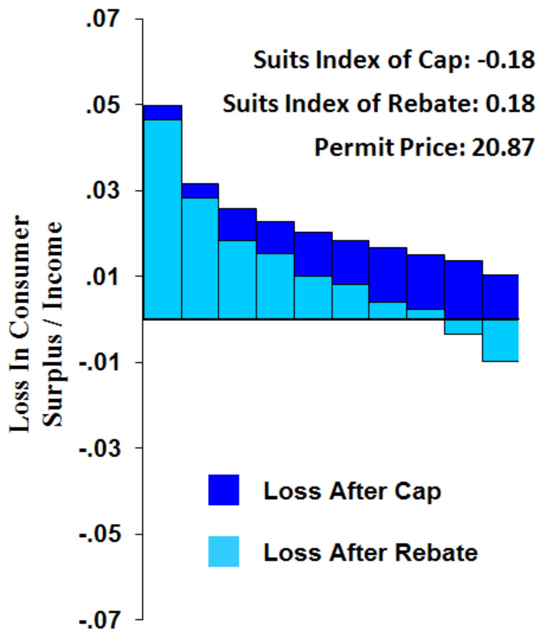
A reduction in the income tax could be implemented in many ways. In this scenario, we assume an overall reduction in tax collections in proportion to the amount paid by households in each income bracket.[22] This is effectively like an equal reduction in average tax rates across all households. It disproportionately benefits the highest-income groups because they have the highest average and marginal rate, and the rate is applied to the most income. Nonetheless, this approach follows from the underlying theory that changes in labor supply affect economic growth most significantly if they involve those individuals with the highest value of marginal product, such as the highest wage. Thus this scenario is useful to analyze.

The Congressional Budget Office (2005) reports the average tax burden of U.S. households by income decile (see Appendix E). We multiply this percentage by the amount of income earned by each decile to get a share of total income tax burden by decile. Finally, we distribute CO_2 revenue proportional to each household's estimated share of the total income tax burden. Figure 8 shows the incidence of the policy.

The bar graph illustrates that the lowest-income groups receive very little benefit from this approach to reducing taxes. Most of the benefit accrues to the highest-income deciles, and the average family in the top decile ends up with a net gain of $1,720 per year, or 0.96 percent of annual income. By contrast, the average family in the lowest-income decile incurs a net cost of $327, more than 5 percent of income. The figure makes clear that the return of revenues to households has increasing importance as we move up the income distribution: the gap between the dark blue and light blue bars—that is, between the gross and net impacts on consumer surplus—increases as we move up the deciles. The average household in decile 8 would be indifferent between this option and the taxable cap-and-dividend scenario because that household's net consumer surplus loss is the same in each scenario. Households in higher-income deciles would prefer this approach; those in lower deciles would, on average, be better off with cap-and-dividend. The Suits Index for this rebate is 0.18, indicating that the option is strongly regressive.

[22] Another option would be to assume that future tax increases and/or benefit decreases associated with deficits would be evenly distributed across the population (Rogers 2007). In this case, deficit reduction would be progressive. A fixed per capita reduction in future tax claims is analogous to the nontaxable cap-and-dividend approach as modeled here. For this reason we do not explicitly consider this policy.

Figure 8. Reducing the Income Tax



	Average Welfare Loss for Households in the Bottom Two Deciles Nationally		Average Welfare Loss for All Households	
	$	%	$	%
Southeast	$448	4.38%	$127	0.23%
CA	$344	3.28%	-$101	-0.15%
TX	$390	3.75%	$88	0.15%
FL	$404	3.81%	$99	0.18%
Ohio Valley	$464	4.49%	$163	0.27%
Mid-Atlantic	$439	4.23%	$12	0.02%
Northeast	$444	4.39%	-$40	-0.06%
Northwest	$384	3.81%	$38	0.06%
NY	$368	3.64%	-$85	-0.13%
Plains	$394	3.94%	$153	0.24%
Mountains	$464	4.64%	$153	0.26%
National	$382	3.75%	$86	0.15%

Note: Negative numbers in the table reflect gains in welfare. A negative Suits Index number represents regressive taxation and positive rebates. The bottom two deciles nationally consist of households earning less than $19,208 in annual income after taxes and transfers.

The table in Figure 8 shows that, as in our first two policy options, the regional variation for an average household is quite small. However, the regional impacts are less pronounced for poor households here than in the previous two policies. The national average loss for a household making less than $19,208 per year is $382 per year, or 3.75 percent of income. The highest average loss for this group occurs in the Mountain region, at $464, or 4.64 percent of income, and the lowest is in California, at $344, or 3.28 percent. This is a dollar range of only $120, compared with a range of $352 for the taxable cap-and-dividend scenario. The regional variation for lower-income households is less in this scenario for two primary reasons. First, the pricing of CO_2 makes up a large portion of the net impact on low-income households, and the return of revenues makes up a small portion; as we discussed in Section 4.1 above, there are significant differences in energy expenditures across low-income households in different regions. Second, there are regional differences in income and income taxes paid, and thus returning revenues by reducing income taxes affects households differently in different regions.

6.2.2 Reducing Payroll Tax

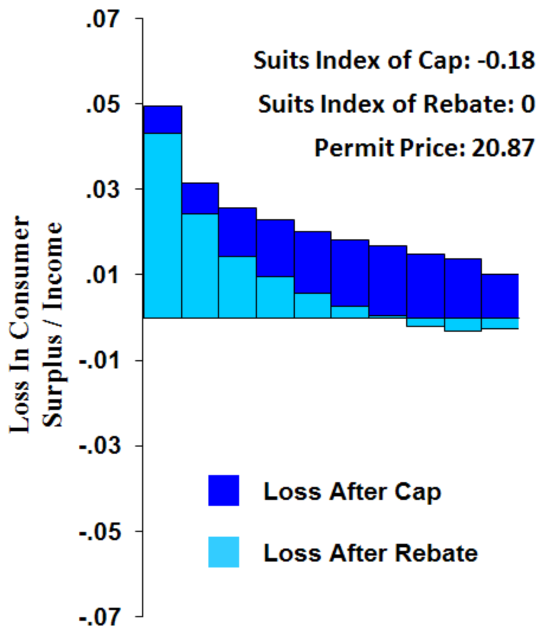
Using CO_2 allowance revenues to reduce payroll taxes such as Social Security is another option for “greening” the tax system that some experts have suggested. In addition to income taxes, employers are required to withhold one-half of each employee’s Social Security and Medicare tax requirements (equal to 12.4 percent and 2.8 percent, respectively). The employer then pays the other half; however, it is common to assume that this expense is passed on to employees in the form of lower wages. Together, these two taxes, also called Federal Insurance Contributions Act (FICA) taxes, are applied to the first $90,000 in wages for each employee.[23] For this policy case we modeled a 12.4 percent reduction in payroll taxes. Unfortunately, it is not easy to distinguish which member of the household earned what fraction of wage income in the BLS data.[24] To represent households with multiple wage earners, we cap eligible wages at $135,000.

Like the income tax reduction scenario we analyzed above, the payroll tax deduction makes for a net regressive CO_2 policy. The distribution of net consumer surplus losses across the deciles is shown in Figure 9. The bar graph illustrates that although the burden is reduced from rebating the revenues through reductions in this preexisting tax—that is, the light blue bars all lie below the dark blue ones—the distribution of the impacts across deciles remains virtually the same. Poor households are still disproportionately harmed by the policy. Households in the top three income deciles end up benefiting from this policy option: with the payroll tax deduction, the CO_2 policy actually yields a net consumer surplus gain for average households in those deciles. Although the magnitude of the effects is different, directionally the results are quite similar to the income tax scenario in the preceding section. The Suits Index associated with the reduction in the payroll tax is essentially 0, indicating that this rebate is income neutral. However, given that the CO_2 policy itself is regressive, the net effect of this program is also regressive.

[23] The $90,000 cap was in effect in 2005, the middle of our sample period, and we use that figure in our analysis here. A slightly higher cap was in effect in 2006 in these deciles.

[24] Note the distinction between wages and income.

Figure 9. Reducing the Payroll Tax



	Average Welfare Loss for Households in the Bottom Two Deciles Nationally		Average Welfare Loss for All Households	
	$	%	$	%
Southeast	$399	3.98%	$92	0.16%
CA	$298	2.91%	-$19	-0.03%
TX	$329	3.25%	$59	0.10%
FL	$377	3.59%	$99	0.18%
Ohio Valley	$426	4.18%	$161	0.27%
Mid-Atlantic	$414	4.03%	$39	0.06%
Northeast	$422	4.21%	-$11	-0.02%
Northwest	$316	3.17%	$50	0.08%
NY	$320	3.22%	-$36	-0.05%
Plains	$342	3.53%	$114	0.18%
Mountains	$415	4.20%	$137	0.24%
National	$339	3.38%	$86	0.15%

Note: Negative numbers in the table reflect gains in welfare. A negative Suits Index number represents regressive taxation and positive rebates. The bottom two deciles nationally consist of households earning less than $19,208 in annual income after taxes and transfers.

As with the income tax reduction policy, the payroll tax option does not impose major differences at the regional level, either for average households or for households in the lowest two income deciles. Again, poor households in the Ohio Valley and the Northeast experience the largest loss and those in California the smallest, but the differences are not great.

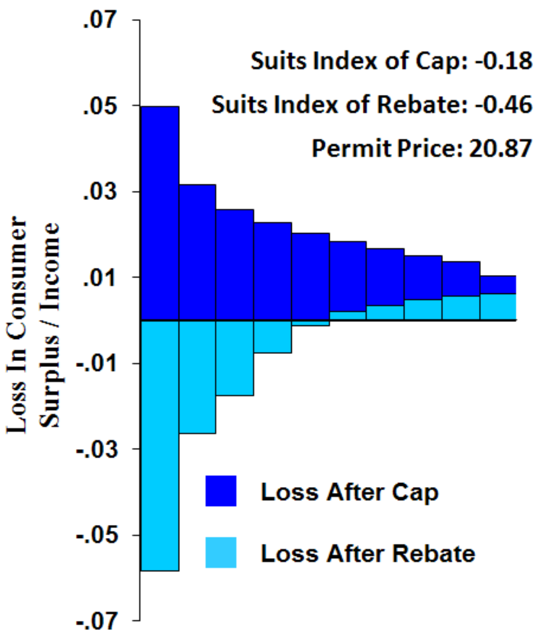
6.2.3 Expanding Earned Income Tax Credits

Greenstein et al. (2008) have suggested that revenues generated under a cap-and-trade program or a CO_2 tax should be used to expand the Earned Income Tax Credit. The tax credit is available to families earning wages below a particular threshold.[25] The amount of the credit falls as income rises, is higher for families with children, and is adjusted each year. For example, in 2007, the credit for a family with two or more children was equal to 40 percent of the first $11,790 of earned income; for earnings beyond $15,399, the credit drops to 21 percent, and it

[25] Here, note that we are distinguishing between wages and income. Although the tax credit does phase out at a given wage level, it is possible for a family's total income to exceed that. For this reason, we see some families receiving the tax credit in every decile.

falls to zero when earnings pass $37,782. In our policy scenario, we first estimate the current credit for each observation based on the 2006 parameters. We then take half of this estimate and redistribute it to each household, which is analogous to increasing the program by 50 percent. This fairly substantial expansion accounted for just 14 percent of total revenue raised by the CO_2 policy, leaving 86 percent to be distributed as per capita dividends.

Figure 10. Expanding the Earned Income Tax Credit



	Average Welfare Loss for Households in the Bottom Two Deciles Nationally		Average Welfare Loss for All Households	
	$	%	$	%
Southeast	-$407	-4.03%	$67	0.12%
CA	-$571	-5.57%	$32	0.05%
TX	-$762	-7.43%	-$64	-0.11%
FL	-$295	-2.98%	$55	0.10%
Ohio Valley	-$278	-2.78%	$225	0.37%
Mid-Atlantic	-$297	-2.93%	$221	0.34%
Northeast	-$185	-1.97%	$270	0.39%
Northwest	-$424	-4.44%	$91	0.15%
NY	-$388	-4.11%	$74	0.11%
Plains	-$319	-3.32%	$290	0.46%
Mountains	-$477	-4.93%	$127	0.22%
National	-$406	-4.22%	$86	0.15%

Note: Negative numbers in the table reflect gains in welfare. A negative Suits Index number represents regressive taxation and positive rebates. The bottom two deciles nationally consist of households earning less than $19,208 in annual income after taxes and transfers.

The distributional results for our Earned Income Tax Credit expansion policy are shown in Figure 10. As expected, households in the lower-income deciles benefit the most from this policy. The average household in decile 1 earns a net consumer surplus gain of nearly 6 percent of its income. As the last line of the table shows, the average household in deciles 1 and 2 experiences a net consumer surplus gain of $406, or 4.2 percent of income. Comparing the dark and light blue bars in the graph indicates that the redistribution of revenues through the program dramatically changes the regressivity of the policy. The Suits Index is –0.46, making this policy the most progressive of the options we have analyzed here.

As is the case with many of our policies, households are affected differently depending on where they live. As the table portion of Figure 10 shows, the average household in the Plains region incurs the largest dollar and percentage losses in consumer surplus. The starkest regional contrast shows up for households in the lowest-income groups. Although every household earning less than $19,208 per year experiences a gain, and the average gain for the United States as a whole for these households is $406, the average household in this income range in the Northeast gains only $185 per year, or 1.97 percent of annual income. By contrast, the average household in this income category in Texas gains $762, or 7.4 percent of income. The range across regions for these deciles is $577.

7 Discussion and Concluding Comments

To conclude, we provide observations, followed by a discussion of the options for policymakers and the identification of limitations of the analysis.

7.1 Observations and Major Trade-Offs

Climate policy may impose important costs on the economy. For a cap-and-trade policy, the primary determinant of how these costs are distributed across the population is the allocation of CO_2 allowances and dispensation of any auctioned CO_2 revenue. This paper has calculated the distributional effects of five CO_2 policies across two demographic dimensions, income and geography. Effects across income groups are most concisely illustrated through a Suits Index calculation. As we explained above, we calculate two indexes here: one for the impact of the direct CO_2 expenditures and one for the rebate, or distribution, of allowance values. Values less than zero indicate regressivity in the case of the index for pricing CO_2, but progressivity in the case of the return of revenues (one can think of this as a subsidy).[26] Table 4 reports these indexes. Because all of the scenarios we analyze lead to the same CO_2 price, the Suits Index for pricing CO_2, ignoring return of revenues, is the same across all five scenarios. However, the index for the allocation of value differs. The index ranges from –0.46 for expansion of the Earned Income Tax Credit to 0.18 for reducing income taxes, indicating that CO_2 policy will have very different distributional effects depending on how the allowance value is allocated.

[26] Also, as explained in Section 5.1, our Suits Indexes are based on consumer surplus losses, not just expenditure changes.

Table 4. Suits Index by Policy

Scenario	Suits Index of CO2 Cap	Suits Index of Rebate
Cap-and-Dividend (Taxable)	-0.18	-0.40
Cap-and-Dividend (Non-Taxable)	-0.18	-0.33
Reduce Income Tax	-0.18	0.18
Reduce Payroll Tax	-0.18	0.00
Expansion of EITC	-0.18	-0.46

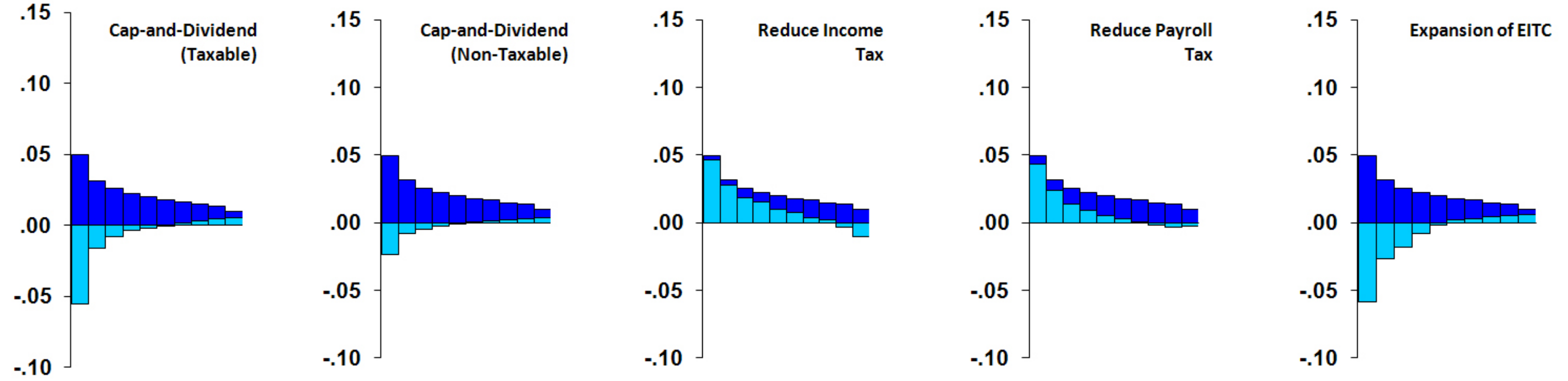
A negative Suits Index number represents regressive taxation and progressive rebates.

Figure 11 shows a comparison of the impacts across income deciles at the national level of all five policy scenarios. The top part of the figure shows both the changes in expenditures and the net consumer surplus loss as fractions of income; these results were discussed for each of the individual scenarios above. The bottom part of Figure 11 shows the same impacts as a fraction of total annual consumption expenditures. As we explained in Section 2, it has long been argued by economists that some measure of lifetime, or permanent, income is a better measure of ability to pay than is annual income. Since information on lifetime income is difficult to come by, however, many studies have used consumption as a proxy. Consumption has its own problems, but we show our results for purposes of comparison with our results based on annual income.

Clearly, all of the policy scenarios using annual consumption expenditures look much less regressive, both before and after return of the revenues, than they do using annual income. Pricing CO_2 appears to have about an equal impact, in terms of consumer surplus loss as a percentage of consumption, across income deciles. Thus, the policy looks approximately proportional. Returning the revenues makes the policy appear progressive in most cases—that is, the graph shows that the lighter blue bars get larger as income increases. The only scenarios in which this does not hold are, as expected, the scenarios in which income or payroll taxes are reduced. These findings are consistent with those of others who have found that the regressivity of many taxes is muted when consumption is used in place of income.

Figure 11. Incidence of Policies across Income Deciles as Fraction of Income

(Net Consumer Surplus Loss as Fraction of Annual Household Income)



Incidence of Policies across Income Deciles as Fraction of Consumption

(Net Consumer Surplus Loss as Fraction of Annual Household Consumption)

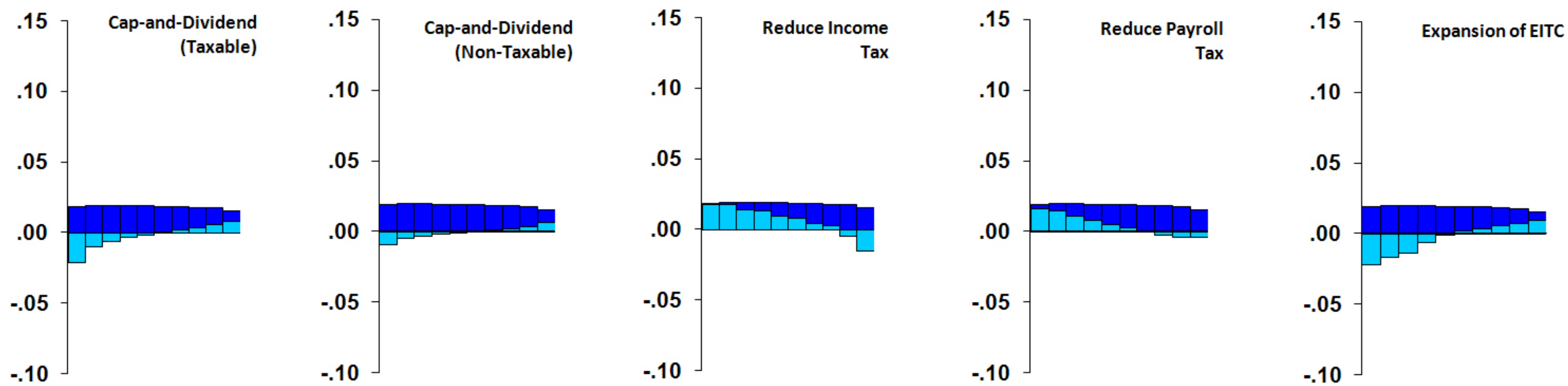


Figure 12 brings information on the regional impacts for each scenario together in two graphs. Panel A shows the average consumer surplus loss as a fraction of income in each region of the country for each of the five policies. Panel B shows the same thing for an average household in the lowest two income deciles, those earning less than $19,208 per year. Note that the scale on the vertical axis in each panel is different. Panel A makes clear that although the average impact varies across regions and policies, those differences are relatively small for the cap that we analyze. The largest average loss reaches only slightly more than 0.4 percent of income and the largest average gain is less than 0.2 percent. Panel B highlights both the larger impacts on poorer households and the greater regional differences for those households for the two cap-and-dividend options and the Earned Income Tax Credit option. As we pointed out above, the regional differences are smaller for the income tax and payroll tax scenarios.

Although the case for equity across income groups is straightforward, interregional equity is somewhat complicated. To the extent that some regions have already enacted policies to reduce their CO_2 footprints, one can argue that their citizens deserve any extraordinary benefits that incentive-based policies would bring them. On the other hand, there is considerable resource and lifestyle heterogeneity across regions, and some states do not have the resources to reduce their CO_2 consumption quite so easily. Despite the ambiguity over the merits of interregional equity, there is no doubt that the relative burden of climate policy across regions will shape political considerations as such policies come to fruition.

Figure 12. Panel A: Average Welfare Loss as a Fraction of Income, All Households

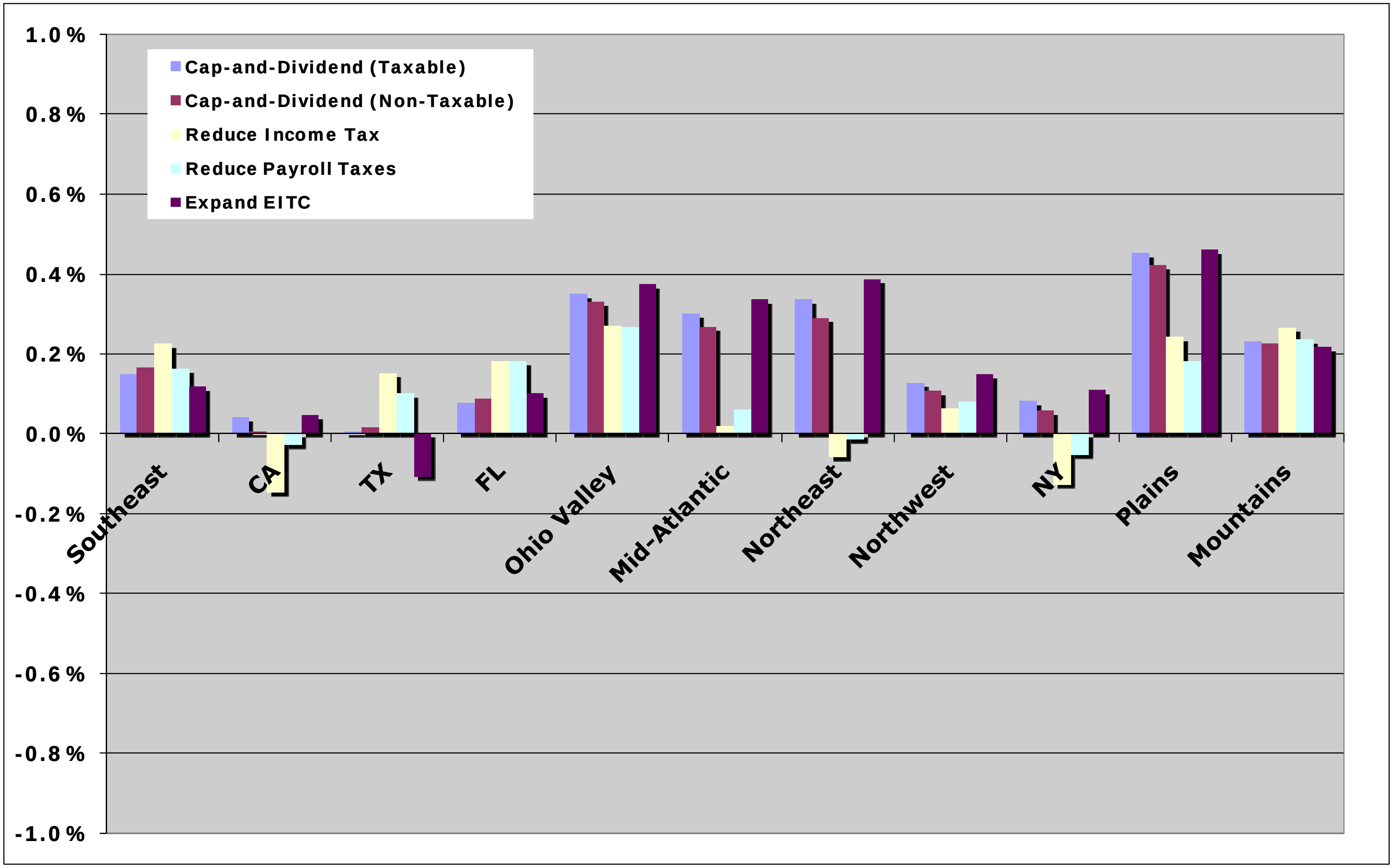
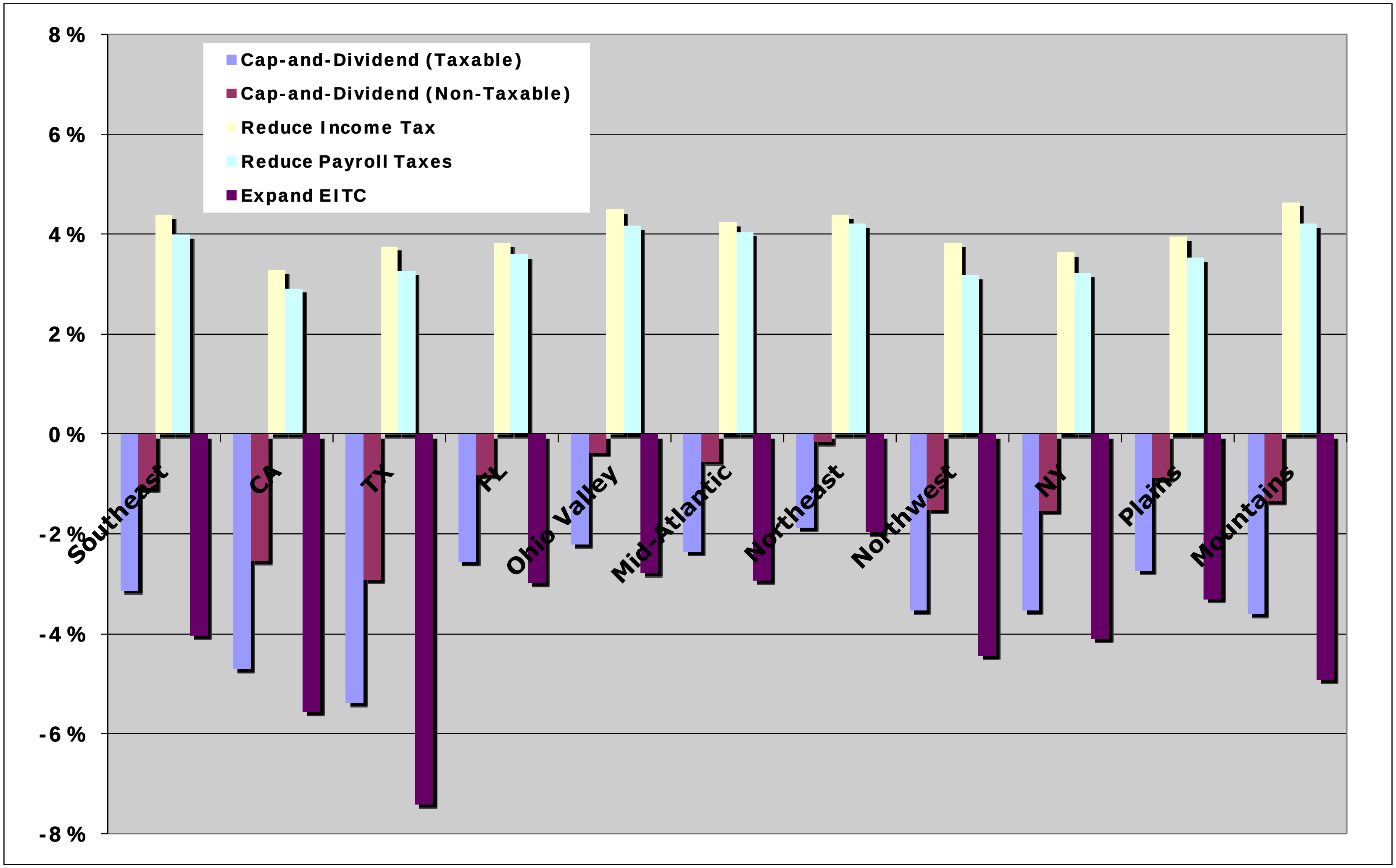


Figure 12. Panel B: Average Welfare Loss as a Fraction of Income, Bottom Two Deciles Nationally



7.2 Conclusions

Rather than offering a normative ranking of the relative merits of each policy, this paper should be viewed as a menu of climate policy options. Our results provide evidence on the direction of the impact on households of particular policy options, and this information can be useful for climate policy design. However, policymakers in the real world are likely to mix and match components of each approach to temper the magnitude or scope of the incidence of climate policy. Furthermore, as opposed to redistributing all of the CO_2 revenue raised, some portion of it could be used to fund other endeavors, such as development of new transportation or electricity infrastructure. Additional analysis of scenarios that combine remedies would be useful.

Although we feel that our work is one of the most detailed and comprehensive looks at the distributional burdens across households in different income groups nationally and regionally, there are a number of uncertainties and limitations to our results that we hope to address in future work. The following important issues should be considered:

- further explorations into proxies for lifetime income rather than strict use of annual income as a measure of ability to pay;
- expansion of the model to account for secondary effects and the interplay with labor and capital markets;
- examination of interregional income and price differences to better isolate the true incidence of the policies (CEX data reliability at the regional level is uncertain in some cases, especially for the five states that are not included in the regional analysis because of small samples);
- further exploration into modifications of the remedies we have included, analysis of alternative remedies (such as free allocation to the electricity sector and investment in energy efficiency), and combinations of options (such as a partial dividend combined with reductions in payroll taxes); and
- sensitivity analyses of some parameters, such as the various elasticities we use to calculate consumer surplus losses.

Although climate change is a long-run problem, climate policy has an important short-run political dynamic. Therefore, delivering compensation or finding ways to alleviate disproportional burdens of the policy seems especially important in the early years of climate policy. Similarly, if all politics is local, then the local and regional effects of policy may be fundamentally important to building the political coalition necessary to enact climate policy. Although temporal and marginal shifts may be nonlinear, in the short run, the direction and magnitude of our results can be viewed as scalable over a reasonable range of prices or CO_2 reduction targets. Our main message is that allocation of the value of the CO_2 permits or the revenues from a CO_2 auction is critical in determining who loses and who gains from climate policy and the magnitude of those impacts.

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Appendix A

Household Electricity (KWh) Consumption by Decile and Region

Region	States	Decile 1	2	3	4	5	6	7	8	9	10	Mean
Southeast	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	13,177	14,788	16,406	18,045	18,454	18,833	19,703	20,749	22,109	24,666	18,540
CA	CA	4,818	5,567	5,809	6,309	6,874	7,224	7,931	9,021	10,680	14,106	8,441
TX	TX	9,814	10,788	13,080	13,957	15,306	16,804	17,731	18,777	22,419	27,251	16,741
FL	FL	11,000	12,443	14,187	15,134	14,501	16,791	17,438	18,946	22,098	26,070	16,606
Ohio Valley	IL, IN, KY, MI, MO, OH, WV, WI	9,386	11,079	12,275	12,918	13,364	14,781	15,150	16,535	17,440	21,735	14,662
Mid-Atlantic	DE, MD, NJ, PA	8,256	9,280	10,632	11,409	12,550	13,190	15,284	16,283	16,792	21,634	14,129
Northeast	CT, ME, MA, NH, RI	4,666	6,819	6,752	6,856	7,425	7,789	8,830	10,063	11,722	14,569	9,188
Northwest	ID, MT, OR, UT, WA	6,933	11,228	11,185	12,677	14,037	13,936	14,819	16,412	18,029	19,659	14,211
NY	NY	5,139	6,126	5,995	7,710	8,921	8,263	9,327	10,170	11,936	14,635	9,204
Plains	KS, MN, NE, OK, SD	6,749	7,759	9,311	10,446	10,926	13,234	14,498	14,686	14,572	22,878	13,066
Mountains	AZ, CO, NV	8,990	10,557	10,053	12,010	12,821	13,838	15,194	15,932	17,139	20,939	13,856
National		7,313	9,828	11,138	12,305	12,859	13,656	14,572	15,585	16,899	20,298	13,445

Appendix B

Household Gasoline (Gallons) Consumption by Decile and Region

Region	States	Decile 1	2	3	4	5	6	7	8	9	10	Mean
Southeast	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	424	585	778	952	1,026	1,206	1,341	1,387	1,692	1,631	1,082
CA	CA	356	598	758	885	987	1,136	1,304	1,410	1,680	1,857	1,198
TX	TX	543	679	832	1,082	1,216	1,275	1,431	1,533	1,715	1,887	1,235
FL	FL	494	521	662	860	976	1,064	1,150	1,373	1,614	1,536	1,009
Ohio Valley	IL, IN, KY, MI, MO, OH, WV, WI	373	464	658	822	930	1,062	1,305	1,397	1,644	1,743	1,070
Mid-Atlantic	DE, MD, NJ, PA	403	366	537	752	815	985	1,119	1,268	1,339	1,562	971
Northeast	CT, ME, MA, NH, RI	379	481	634	711	841	934	1,114	1,309	1,454	1,654	1,046
Northwest	ID, MT, OR, UT, WA	513	458	670	820	981	1,062	1,160	1,298	1,403	1,555	1,029
NY	NY	332	345	432	625	806	926	954	1,246	1,336	1,457	894
Plains	KS, MN, NE, OK, SD	420	513	678	748	945	1,004	1,280	1,363	1,444	1,806	1,078
Mountains	AZ, CO, NV	395	496	644	744	846	971	1,210	1,266	1,408	1,662	979
National		360	492	672	829	962	1,089	1,244	1,361	1,564	1,682	1,025

Appendix C

Household Natural Gas (tcf) Consumption by Decile and Region

Region	States	Decile 1	2	3	4	5	6	7	8	9	10	Mean
Southeast	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	30	34	30	31	30	41	33	46	60	74	40
CA	CA	25	25	28	32	34	37	39	45	53	67	41
TX	TX	20	21	22	25	27	28	28	32	37	58	30
FL	FL	2	2	2	4	2	3	4	2	3	6	3
Ohio Valley	IL, IN, KY, MI, MO, OH, WV, WI	49	59	64	64	75	80	80	89	97	131	80
Mid-Atlantic	DE, MD, NJ, PA	35	44	43	51	58	53	57	59	77	101	60
Northeast	CT, ME, MA, NH, RI	23	38	39	40	32	49	34	39	40	54	40
Northwest	ID, MT, OR, UT, WA	15	27	31	35	40	47	63	64	70	84	50
NY	NY	22	34	26	31	36	46	45	51	63	67	44
Plains	KS, MN, NE, OK, SD	36	40	52	62	81	81	90	98	110	137	82
Mountains	AZ, CO, NV	28	35	37	40	40	46	52	65	64	92	50
National		22	31	35	38	41	47	48	55	63	82	46

Appendix D

Household Fuel Oil (Gallons) Consumption by Decile and Region

Region	States	Decile 1	2	3	4	5	6	7	8	9	10	Mean
Southeast	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	43	40	52	42	53	55	38	52	67	83	52
CA	CA	8	12	16	15	12	27	34	53	30	42	27
TX	TX	10	16	15	10	16	27	23	26	18	18	18
FL	FL	9	14	5	9	13	8	16	15	30	28	14
Ohio Valley	IL, IN, KY, MI, MO, OH, WV, WI	23	34	34	50	54	44	54	40	86	64	49
Mid-Atlantic	DE, MD, NJ, PA	130	168	146	130	110	131	162	156	128	207	149
Northeast	CT, ME, MA, NH, RI	175	353	242	374	395	233	381	400	505	667	397
Northwest	ID, MT, OR, UT, WA	20	25	22	47	39	62	38	66	58	58	45
NY	NY	49	229	95	163	212	154	280	266	305	514	244
Plains	KS, MN, NE, OK, SD	9	22	45	8	11	26	34	18	50	67	30
Mountains	AZ, CO, NV	22	18	19	30	16	11	20	38	7	14	20
National		38	71	59	70	77	73	91	93	114	148	83

Appendix E

Tax and Stock Ownership Inputs

Decile	Marginal Tax Rate	Average Tax Rate	Stock Ownership
1	-15%	4%	0.80%
2	3%	4%	0.50%
3	11%	10%	0.90%
4	16%	10%	1.70%
5	17%	14%	2.40%
6	19%	14%	4.20%
7	22%	17%	5.70%
8	27%	17%	7.00%
9	30%	23%	12.10%
10	36%	27%	64.70%

Sources: Supporting analysis for Cogressional Budget Office (2005);
Department of Treasury (2007)

Appendix F

National Highway Traffic Safety Administration
Proposed CAFE Standards

Model year	Cars, mpg	Trucks, mpg
2011	31.2	25.0
2012	32.8	26.4
2013	34.0	27.8
2014	34.8	28.2
2015	35.7	28.6

Appendix G (This table was corrected and updated on May 21, 2009.)

Haiku Modeling Results

Region	States	Baseline CO2 Emissions Per MWh of Generation	Post-Cap CO2 Emissions Per MWh of Generation	Price Change	Change in Consumption
Southeast	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	0.583	0.464	13%	-5%
California	CA	0.170	0.166	4%	-1%
Texas	TX	0.549	0.549	8%	-3%
Florida	FL	0.538	0.448	10%	-3%
Ohio Valley	IL, IN, KY, MI, MO, OH, WV, WI	0.794	0.654	19%	-7%
Mid-Atlantic	DE, MD, NJ, PA	0.573	0.512	14%	-3%
Northeast	CT, ME, MA, NH, RI	0.372	0.317	7%	-3%
Northwest	ID, MT, OR, UT, WA	0.344	0.195	10%	-4%
New York	NY	0.308	0.288	8%	-1%
Plains	KS, MN, NE, OK, SD	0.835	0.749	18%	-9%
Mountains	AZ, CO, NV	0.627	0.471	16%	-7%
National		0.596	0.492	13%	-5%

Appendix H

Consumer Surplus Loss After Carbon Policy

Region	Decile	Avg Income	Gasoline	Electricity	Natural Gas	Fuel Oil	Indirect	Total Loss
Southeast	1	7,174	86	146	37	12	136	417
Southeast	2	15,359	118	164	42	11	218	553
Southeast	3	23,096	157	183	37	14	256	646
Southeast	4	31,039	192	200	38	11	303	745
Southeast	5	39,548	207	204	37	14	357	820
Southeast	6	49,370	243	208	51	15	421	937
Southeast	7	61,363	271	219	40	10	506	1,046
Southeast	8	77,159	280	230	58	14	580	1,162
Southeast	9	100,969	341	245	74	18	730	1,408
Southeast	10	182,750	329	274	91	23	1,020	1,737
Southeast	Avg	56,528	218	206	50	14	441	929
California	1	7,537	72	24	31	2	203	332
California	2	15,457	121	28	30	3	246	429
California	3	23,019	153	29	34	4	302	522
California	4	30,800	179	32	40	4	402	655
California	5	39,786	199	34	42	3	411	690
California	6	49,656	229	36	45	7	508	826
California	7	61,313	263	40	48	9	606	966
California	8	77,381	284	45	56	14	709	1,108
California	9	100,041	339	54	65	8	881	1,346
California	10	178,631	375	71	82	11	1,269	1,808
California	Avg	69,317	242	42	51	7	625	967
Texas	1	7,558	109	86	25	3	159	383
Texas	2	15,344	137	95	26	4	207	469
Texas	3	23,135	168	114	28	4	279	593
Texas	4	31,015	218	124	31	3	342	718
Texas	5	39,824	245	136	34	4	427	846
Texas	6	49,621	257	146	35	7	467	912
Texas	7	61,314	289	157	34	6	565	1,052
Texas	8	76,424	309	167	39	7	598	1,120
Texas	9	99,838	346	198	46	5	865	1,460
Texas	10	171,804	380	238	71	5	1,089	1,783
Texas	Avg	58,586	249	147	37	5	506	944
Florida	1	7,801	100	116	2	2	181	401
Florida	2	15,500	105	132	3	4	236	479
Florida	3	23,112	134	151	3	1	293	582
Florida	4	31,095	174	161	5	2	351	693
Florida	5	39,241	197	155	3	4	381	739
Florida	6	49,143	215	179	4	2	448	847
Florida	7	61,766	232	184	5	4	515	940
Florida	8	76,941	277	202	3	4	619	1,105
Florida	9	100,195	325	235	4	8	728	1,301
Florida	10	173,488	310	277	8	8	1,071	1,672
Florida	Avg	54,325	203	176	4	4	465	852
Ohio Valley	1	7,413	75	152	60	6	155	449
Ohio Valley	2	15,518	94	179	73	9	196	551
Ohio Valley	3	23,115	133	197	79	9	235	653
Ohio Valley	4	31,161	166	208	80	14	315	781
Ohio Valley	5	39,673	188	218	92	15	367	880
Ohio Valley	6	49,639	214	238	99	12	422	985
Ohio Valley	7	61,878	263	245	99	15	509	1,130
Ohio Valley	8	76,991	282	270	110	11	589	1,263
Ohio Valley	9	99,602	331	285	120	23	719	1,479
Ohio Valley	10	177,756	352	353	162	17	1,077	1,962
Ohio Valley	Avg	60,237	216	238	99	13	471	1,036
Mid-Atlantic	1	7,692	81	117	44	35	173	450
Mid-Atlantic	2	15,463	74	133	55	46	193	500
Mid-Atlantic	3	22,794	108	151	53	40	254	606
Mid-Atlantic	4	31,051	152	163	63	35	312	725
Mid-Atlantic	5	39,436	164	177	72	30	354	798
Mid-Atlantic	6	49,579	199	189	65	36	429	917
Mid-Atlantic	7	61,863	226	214	71	44	469	1,024
Mid-Atlantic	8	77,081	256	231	73	42	565	1,167
Mid-Atlantic	9	101,109	270	239	95	35	660	1,300
Mid-Atlantic	10	182,398	315	315	125	56	1,045	1,857
Mid-Atlantic	Avg	66,037	196	202	75	41	482	995

Note: Deciles constructed at the national level. All positive welfare losses reflect decreases in consumer surplus.

Consumer Surplus Loss After Carbon Policy

Region	Decile	Avg Income	Gasoline	Electricity	Natural Gas	Fuel Oil	Indirect	Total Loss
Northeast	1	6,974	76	50	29	48	207	409
Northeast	2	15,503	97	70	46	96	241	551
Northeast	3	22,909	128	71	48	66	277	590
Northeast	4	31,022	143	72	50	102	324	691
Northeast	5	39,823	170	77	40	107	378	772
Northeast	6	49,999	188	83	60	63	436	830
Northeast	7	61,157	225	92	42	104	552	1,015
Northeast	8	77,414	264	105	48	109	611	1,137
Northeast	9	101,309	293	122	50	137	776	1,378
Northeast	10	181,083	334	154	67	181	1,141	1,876
Northeast	Avg	69,702	211	96	50	108	557	1,021
Northwest	1	6,981	103	50	19	6	183	361
Northwest	2	15,481	92	80	33	7	267	479
Northwest	3	23,603	135	79	38	6	335	594
Northwest	4	31,225	165	91	43	13	331	643
Northwest	5	39,551	198	100	49	10	478	836
Northwest	6	49,921	214	99	58	17	485	873
Northwest	7	61,763	234	105	78	10	597	1,024
Northwest	8	77,098	262	116	79	18	654	1,130
Northwest	9	100,080	283	126	86	16	786	1,297
Northwest	10	176,106	314	139	104	16	1,234	1,807
Northwest	Avg	61,572	208	101	61	12	558	940
New York	1	6,868	67	62	27	13	170	339
New York	2	15,735	70	74	42	62	221	469
New York	3	23,294	87	72	33	26	263	481
New York	4	31,088	126	93	39	44	324	626
New York	5	39,497	163	108	44	58	383	755
New York	6	50,041	187	101	57	42	438	824
New York	7	61,583	192	113	55	76	495	931
New York	8	77,592	251	122	63	72	565	1,073
New York	9	101,015	269	144	78	83	663	1,237
New York	10	191,319	294	177	82	140	1,037	1,730
New York	Avg	66,930	180	111	54	66	489	901
Plains	1	7,223	85	94	45	3	173	398
Plains	2	15,404	103	111	50	6	192	462
Plains	3	23,279	137	133	65	12	259	606
Plains	4	31,075	151	146	76	2	293	668
Plains	5	39,453	190	155	100	3	427	875
Plains	6	49,864	202	190	100	7	478	977
Plains	7	61,592	258	207	111	9	588	1,173
Plains	8	76,723	275	211	120	5	593	1,204
Plains	9	98,620	291	211	135	14	724	1,375
Plains	10	181,054	364	332	169	18	1,495	2,378
Plains	Avg	63,131	217	187	102	8	556	1,070
Mountains	1	7,115	80	129	34	6	195	444
Mountains	2	15,155	100	153	44	5	255	557
Mountains	3	22,801	130	146	46	5	315	642
Mountains	4	31,050	150	174	50	8	367	749
Mountains	5	39,393	171	187	50	4	428	841
Mountains	6	49,655	196	202	57	3	502	960
Mountains	7	61,315	244	224	65	5	602	1,140
Mountains	8	76,844	255	235	80	10	627	1,208
Mountains	9	99,927	284	249	79	2	844	1,458
Mountains	10	170,924	335	308	114	4	1,124	1,885
Mountains	Avg	58,202	198	202	62	5	532	1,000
National	1	7,030	73	88	27	10	152	350
National	2	15,372	99	118	38	19	212	487
National	3	23,038	135	135	43	16	268	598
National	4	31,036	167	149	47	19	330	712
National	5	39,553	194	154	51	21	383	803
National	6	49,596	220	164	58	20	448	910
National	7	61,558	251	176	60	25	528	1,039
National	8	77,074	275	189	68	25	605	1,162
National	9	100,267	315	201	78	31	755	1,381
National	10	178,677	339	240	102	40	1,119	1,841
National	Avg	58,321	207	161	57	23	480	928

Note: Deciles constructed at the national level. All positive welfare losses reflect decreases in consumer surplus.

Appendix I

Net Welfare Loss After Remedy

Region	Decile	Avg Income	Initial Consumer Surplus Loss	Cap and Dividend (Taxable)	Cap and Dividend (Non-Taxable)	Reduce Income Tax	Reduce Payroll Tax	Expand EITC
Southeast	1	7,174	417	(344)	(115)	394	373	(372)
Southeast	2	15,359	553	(225)	(89)	503	425	(442)
Southeast	3	23,096	646	(148)	(73)	474	369	(410)
Southeast	4	31,039	745	(70)	(33)	514	289	(190)
Southeast	5	39,548	820	(82)	(58)	414	213	(75)
Southeast	6	49,370	937	44	49	429	140	135
Southeast	7	61,363	1,046	152	125	264	17	254
Southeast	8	77,159	1,162	309	216	183	(162)	411
Southeast	9	100,969	1,408	502	370	(308)	(335)	621
Southeast	10	182,750	1,737	873	646	(1,823)	(569)	987
Southeast	Avg	56,528	929	85	93	127	92	67
California	1	7,537	332	(509)	(256)	309	289	(553)
California	2	15,457	429	(408)	(262)	379	306	(588)
California	3	23,019	522	(381)	(295)	350	254	(691)
California	4	30,800	655	(288)	(245)	424	266	(475)
California	5	39,786	690	(300)	(274)	284	110	(305)
California	6	49,656	826	(195)	(189)	317	78	(101)
California	7	61,313	966	19	(10)	184	8	105
California	8	77,381	1,108	186	86	130	(178)	298
California	9	100,041	1,346	340	192	(370)	(316)	471
California	10	178,631	1,808	905	668	(1,752)	(456)	1,022
California	Avg	69,317	967	29	3	(101)	(19)	32
Texas	1	7,558	383	(604)	(307)	360	330	(733)
Texas	2	15,344	469	(429)	(272)	419	329	(792)
Texas	3	23,135	593	(372)	(280)	421	284	(840)
Texas	4	31,015	718	(267)	(223)	486	237	(536)
Texas	5	39,824	846	(105)	(80)	440	222	(91)
Texas	6	49,621	912	9	14	404	147	89
Texas	7	61,314	1,052	50	20	270	72	160
Texas	8	76,424	1,120	159	55	142	(172)	264
Texas	9	99,838	1,460	493	351	(257)	(282)	612
Texas	10	171,804	1,783	975	762	(1,777)	(538)	1,086
Texas	Avg	58,586	944	3	9	88	59	(64)
Florida	1	7,801	401	(319)	(103)	378	364	(340)
Florida	2	15,500	479	(160)	(48)	429	390	(249)
Florida	3	23,112	582	(198)	(124)	410	325	(430)
Florida	4	31,095	693	(90)	(55)	461	341	(166)
Florida	5	39,241	739	(110)	(88)	333	182	(67)
Florida	6	49,143	847	(48)	(42)	338	147	56
Florida	7	61,766	940	31	4	159	(14)	148
Florida	8	76,941	1,105	236	141	126	(87)	340
Florida	9	100,195	1,301	448	323	(416)	(367)	560
Florida	10	173,488	1,672	879	671	(1,888)	(519)	989
Florida	Avg	54,325	852	42	47	99	99	55
Ohio Valley	1	7,413	449	(267)	(52)	426	406	(280)
Ohio Valley	2	15,518	551	(129)	(10)	502	446	(275)
Ohio Valley	3	23,115	653	(52)	15	482	415	(221)
Ohio Valley	4	31,161	781	25	59	550	405	(73)
Ohio Valley	5	39,673	880	50	72	474	324	50
Ohio Valley	6	49,639	985	125	130	476	229	199
Ohio Valley	7	61,878	1,130	215	187	348	131	317
Ohio Valley	8	76,991	1,263	331	230	284	(66)	452
Ohio Valley	9	99,602	1,479	556	421	(238)	(225)	674
Ohio Valley	10	177,756	1,962	1,077	844	(1,598)	(326)	1,199
Ohio Valley	Avg	60,237	1,036	210	199	163	161	225
Mid-Atlantic	1	7,692	450	(293)	(69)	427	413	(310)
Mid-Atlantic	2	15,463	500	(141)	(29)	450	416	(283)
Mid-Atlantic	3	22,794	606	(66)	(2)	434	375	(230)
Mid-Atlantic	4	31,051	725	16	48	494	309	(66)
Mid-Atlantic	5	39,436	798	24	45	392	222	53
Mid-Atlantic	6	49,579	917	104	109	408	162	171
Mid-Atlantic	7	61,863	1,024	101	73	242	23	211
Mid-Atlantic	8	77,081	1,167	318	227	189	(221)	432
Mid-Atlantic	9	101,109	1,300	377	242	(417)	(406)	492
Mid-Atlantic	10	182,398	1,857	1,017	797	(1,703)	(464)	1,133
Mid-Atlantic	Avg	66,037	995	198	177	12	39	221

Note: Deciles constructed at the national level. All negative welfare losses reflect a net increase in welfare after CO2 revenues are redistributed.

Region	Decile	Avg Income	Initial Consumer Surplus Loss	Cap and Dividend (Taxable)	Cap and Dividend (Non-Taxable)	Reduce Income Tax	Reduce Payroll Tax	Expand EITC
Northeast	1	6,974	409	(207)	(21)	386	376	(198)
Northeast	2	15,503	551	(122)	(4)	501	469	(172)
Northeast	3	22,909	590	(105)	(39)	418	347	(313)
Northeast	4	31,022	691	(7)	25	460	345	(117)
Northeast	5	39,823	772	11	31	366	185	36
Northeast	6	49,999	830	58	62	322	(29)	139
Northeast	7	61,157	1,015	147	121	234	(27)	253
Northeast	8	77,414	1,137	259	164	158	(188)	372
Northeast	9	101,309	1,378	492	362	(339)	(353)	608
Northeast	10	181,083	1,876	1,036	815	(1,684)	(479)	1,153
Northeast	Avg	69,702	1,021	234	202	(40)	(11)	270
Northwest	1	6,981	361	(385)	(161)	338	288	(434)
Northwest	2	15,481	479	(244)	(117)	429	344	(414)
Northwest	3	23,603	594	(110)	(43)	422	255	(321)
Northwest	4	31,225	643	(160)	(123)	411	186	(291)
Northwest	5	39,551	836	(35)	(12)	430	248	(0)
Northwest	6	49,921	873	(21)	(16)	365	128	53
Northwest	7	61,763	1,024	58	29	243	29	165
Northwest	8	77,098	1,130	169	65	151	(81)	286
Northwest	9	100,080	1,297	323	180	(420)	(323)	428
Northwest	10	176,106	1,807	950	725	(1,754)	(397)	1,069
Northwest	Avg	61,572	940	78	66	38	50	91
New York	1	6,868	339	(382)	(165)	317	290	(403)
New York	2	15,735	469	(235)	(112)	419	349	(373)
New York	3	23,294	481	(314)	(238)	310	214	(549)
New York	4	31,088	626	(206)	(168)	395	220	(350)
New York	5	39,497	755	(96)	(74)	350	202	(78)
New York	6	50,041	824	12	17	315	104	100
New York	7	61,583	931	10	(17)	149	(79)	111
New York	8	77,592	1,073	151	51	95	(221)	270
New York	9	101,015	1,237	285	145	(480)	(412)	414
New York	10	191,319	1,730	850	620	(1,830)	(613)	973
New York	Avg	66,930	901	56	39	(85)	(36)	74
Plains	1	7,223	398	(328)	(109)	376	358	(341)
Plains	2	15,404	462	(144)	(38)	412	325	(297)
Plains	3	23,279	606	(70)	(6)	434	315	(257)
Plains	4	31,075	668	(36)	(4)	437	199	(208)
Plains	5	39,453	875	148	167	469	305	133
Plains	6	49,864	977	235	239	468	200	295
Plains	7	61,592	1,173	250	222	392	67	345
Plains	8	76,723	1,204	298	200	226	(158)	390
Plains	9	98,620	1,375	522	397	(342)	(336)	635
Plains	10	181,054	2,378	1,525	1,301	(1,182)	95	1,631
Plains	Avg	63,131	1,070	285	266	153	114	290
Mountains	1	7,115	444	(396)	(143)	421	394	(478)
Mountains	2	15,155	557	(245)	(105)	508	435	(475)
Mountains	3	22,801	642	(139)	(65)	470	336	(441)
Mountains	4	31,050	749	(62)	(26)	518	307	(174)
Mountains	5	39,393	841	(7)	15	435	235	40
Mountains	6	49,655	960	50	56	451	174	162
Mountains	7	61,315	1,140	204	176	359	151	299
Mountains	8	76,844	1,208	283	183	229	(99)	402
Mountains	9	99,927	1,458	524	387	(259)	(239)	651
Mountains	10	170,924	1,885	1,024	798	(1,676)	(262)	1,129
Mountains	Avg	58,202	1,000	134	131	153	137	127
National	1	7,030	350	(388)	(166)	327	305	(409)
National	2	15,372	487	(247)	(119)	437	374	(402)
National	3	23,038	598	(173)	(99)	427	333	(401)
National	4	31,036	712	(97)	(61)	480	301	(230)
National	5	39,553	803	(64)	(41)	397	227	(51)
National	6	49,596	910	25	30	401	146	104
National	7	61,558	1,039	111	83	258	43	213
National	8	77,074	1,162	258	160	184	(137)	369
National	9	100,267	1,381	447	310	(336)	(309)	566
National	10	178,677	1,841	983	757	(1,720)	(429)	1,097
National	Avg	58,321	928	86	86	86	86	86

Note: Deciles constructed at the national level. All negative welfare losses reflect a net increase in welfare after CO2 revenues are redistributed.