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The Incidence of U.S. Climate Policy

Where You Stand Depends on Where You Sit

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RESOURCES FOR THE FUTURE

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Abstract

Federal policies aimed to slow global warming would impose potentially significant costs on households that vary depending on the policy approach that is used. This paper evaluates the effects of a carbon dioxide cap-and-trade program on households in each of 11 regions of the country and sorted into annual income deciles. We find tremendous 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 10 policy alternatives that yield results that range from moderately progressive (expansion of the Earned Income Tax Credit, investments in efficiency and cap-and-dividend) to severely regressive (reduce income taxes, free distribution to incumbent emitters and reduction of the payroll tax). To varying degrees the allocation of the value of emissions allowances amplifies or potentially resolves the tradeoff between equity and efficiency.

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

JEL Classification Numbers: H22, H23, Q52, Q54

Contents

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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 that 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 2008. For all policies we assume the government retains 35 percent of the allowance value in order to offset its own increase in costs at the federal and state level. We examine 10 alternative policies and find tremendous variation in their incidence.

Three types of policies are modestly progressive, including expansion of the Earned Income Tax Credit, investments in efficiency, and a cap-and-dividend program that directly returns revenue to households. Because of its simplicity, we treat cap-and-dividend as a benchmark. When policies do not use all of the revenue we distribute the remaining revenue as (taxable) per capita dividends.

In contrast, three policies appear severely regressive, even more so than before accounting for the use of the revenue. These include grandfathering, reducing the income tax, and reducing in the payroll tax. The latter two 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 this efficiency advantage may come at a distributional cost as low-income households appear to bear a large burden in these scenarios.

Other policies pose the converse trade-off between efficiency and distributional equity. The exclusion of personal transportation or home heating fuels leads to higher allowance prices because greater emissions reductions would have to be achieved in other sectors. The same is true if allowances are used to compensate electricity consumers, and the ramifications are even greater. Although all three of these options appear progressive once the allowance revenue is returned as a dividend, this increased progressivity comes at the expense of efficiency, and the outcomes are less progressive than cap-and-dividend.

Free allocation of emissions allowances to emitters (grandfathering) offers no trade off; it is costly and has negative distributional consequences as well. One reason is that free allocation directs about 10 percent of the allowance value overseas to foreign owners of shareholder equity. Additionally, because the value of the free allowances accrues primarily to higher-income households, this option is decidedly regressive.

To a different end, the equity-efficiency tradeoff is also not apparent in a policy that would invest allowance value to improve efficiency in the end use of electricity services. Such a policy is one of the most progressive we examined and would lead to lower allowance prices, indicating less cost would be imposed on other sectors. However, the implementation of this kind of policy is the most problematic of any that we consider.

While the case for equity across income groups is straightforward, interregional equity is more complicated due to differences in preexisting policies, energy prices, resources, and lifestyle choices. Nonetheless, important differences emerge, and the biggest regional differences affect poor households. Households in the lowest two deciles in various regions could incur a welfare *loss* as high as 10 percent of their income or a *gain* up to 6 percent depending on how revenues are distributed. Low-income households in the Northeast, Ohio Valley, and Florida are consistently among the most harmed. 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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1 Introduction

Federal policies aimed 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 that is 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 2008. Our policy scenarios consider a variety of potential government remedies for dealing with the impact of climate policy, especially on low-income households.

We focus on a carbon dioxide (CO_2) cap-and-trade program, the most likely approach to be adopted at the U.S. federal level and already the focus of the Regional Greenhouse Gas Initiative (RGGI) in the northeastern states, in California, and in the European Union. 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

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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).

Because a cap-and-trade policy will put a price on CO_2, it can have serious distributional consequences. This effect has two components. One part depends on how the price of 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. 2005, Boyce and Riddle 2007).

Existing literature on this topic has analyzed the distributional impacts, mostly by income group, of cap-and-trade and carbon taxes with redistribution of auction or tax revenues in a lump sum manner (a so-called “cap-and-dividend” or “tax-and-dividend” approach) and in the form of reductions in income and other taxes. Some of these studies, which we review below, have also considered free allocation (“grandfathering”) of allowances. We too consider these kinds of redistribution mechanisms, but we go beyond to evaluate a range of other options that are being discussed in policy circles. Our mechanisms fall into three broad categories: (1) cap-and-dividend options; (2) adjustments to preexisting distortionary taxes; and (3) energy and fuel sector remedies. We include as a fourth group a scenario with free allocation of allowances to shareholders of incumbent emitting facilities (grandfathering), which has been the approach used in most previous emissions trading programs. We consider the following specific scenarios:

(1) Cap-and-dividend options

- Per capita dividend of allowance revenues to households, pretax (i.e., income taxes would be paid on those dividends)
- Per capita dividend of allowance revenues to households, posttax

(2) Adjustments to preexisting taxes

- Reduction in income taxes
- Reduction in payroll taxes
- Expansion of the Earned Income Tax Credit

(3) Energy and fuel sector options

- Free allocation of allowances to consumers in the electricity sector (accomplished by allocation to local distribution companies, i.e., retail utilities)
- Exemption of transportation sector from the cap-and-trade program
- Exemption of home heating sector from the cap-and-trade program
- Investment in end-use energy efficiency

(4) Free allocation to emitters

- Grandfathering to incumbent emitters.

All of the scenarios are evaluated for a constant level of CO_2 emissions reductions. This means that the overall cost of the program will vary across scenarios because the scenarios have different incentive properties and alter relative prices. It is noteworthy that if a program inefficiently raises the overall cost of climate policy, it would likely increase the cost for all households, even as it may reduce the cost for one region or strata of the population relative to another. We calculate the change in the cost of the program as reflected in the CO_2 price, along with the accompanying distributional impacts. We focus both on the distribution of the impacts across income groups and across regions.

We find that the distributional consequences of CO_2 pricing policies vary widely depending on the structure of the policy and use of revenues. Households in the lowest two deciles could incur welfare losses as high as 10 percent of their income or welfare gains up to 6 percent of their income depending on how revenues are distributed. Several of our policy cases look sharply regressive before the distribution of revenues but approximately proportional or progressive after. Only three scenarios remain regressive after the return of revenue: grandfathering, reduction in the income tax, and reduction in the payroll tax. The latter two may have important efficiency advantages—many public finance economists have argued the merits of using so-called “green” taxes or auctioned allowances to reduce other distortionary taxes. Our results suggest that this efficiency advantage may come at a distributional cost as low-income households appear to bear a large burden in these scenarios.

Some earlier literature has concluded that regional differences from carbon policies are likely to be relatively small (Hassett et al. 2007). We find that the range of impacts on an average household can be as high as about $550. For example, under a cap-and-dividend policy (with dividends that are taxable) the average household in the Northeast experiences a consumer surplus loss of $1,150 per year while the average household in the Northwest loses only $625 per year. However, when expressed as a fraction of income, these differences are quite small. Where we do find significant differences across regions is for the poorer households. 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 3.8 percent of income (in Texas) or incur a consumer surplus loss equal to 1.2 percent of income (in the Northeast).

These results suggest that further explorations into alternative redistribution schemes for carbon pricing policies may be called for. Policymakers should be interested in finding options that can further reduce the burden on low-income households without sacrificing the efficiency of incentive-based options such as cap-and-trade. In addition, a more detailed look into the reasons for the regional differences, especially by income group, would be worthwhile.

2 Defining and Measuring Regressivity

One way to measure the distributional impact of a policy would be to look at the absolute measure of cost born by different types of households. However, because this absolute measure does not take into account the relative ability to pay, most incidence analyses focus on the cost of a policy relative to some measure of ability to pay. Ideally, a person's ability to pay would 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 only be constructed based on panel data, which is difficult to come by.[1] Some authors have constructed proxies for lifetime income based on age, education, and other factors (Rogers 1993; Casperson and Metcalf 1994; Bull, et al. Hassett, and Metcalf, 1994; Walls and Hanson 1999; Hassett et al. 2007). Still 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).

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

In our analysis, we use annual income, net of taxes and transfers, as the basis to assess the ability to pay for households as reported in the Consumer Expenditure Survey (CEX) for 2004–2006. Although it is well known that most taxes look more regressive using annual income rather than lifetime income (Fullerton and Rogers 1993), and this caveat should be kept in mind when viewing our results, some experts have argued that there is 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 shorter 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).

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 demand responses to higher carbon prices and calculating changes in consumer surplus.[2] We assume almost all of the price effects are passed forward to consumers and we account for

- 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 carbon 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 situation more carefully in Section 6.3. Although we allow for some behavioral responses to higher carbon prices, our analysis only reflects 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 carbon policy. In the long run consumers and investors would have the opportunity to make greater changes in response to price changes.

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

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 would 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 only on 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 as one would need an estimate of the benefits of carbon emissions reductions.

3 The Literature on Distributional Impacts of Climate Policies

A number of studies of the incidence of carbon taxes and cap-and-trade policies have been published in recent years.[3] Dinan and Rogers (2002) analyze the efficiency and distributional impacts of a cap-and-trade program. They incorporate behavioral responses (assumed 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 (e.g., Goulder et al. 1999). 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, 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.

Dinan and Rogers (2002) also highlight the trade-offs between efficiency and distributional concerns. They find that programs that auction allowances and reduce

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

corporate income taxes have the greatest potential for efficiency gains, while programs that implement lump sum revenue recycling would realize little to no increase in economic efficiency.

Several studies look at carbon 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, that is, a Btu tax, and 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 carbon taxes look quite regressive on an annual income basis, while 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 carbon 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 carbon, sulfur dioxide (SO2), and nitrogen oxide (NOx). He finds that using grandfathered emissions allowances to reduce carbon emissions by 10 percent and NOx 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 SO2 cap imposed by the Clean Air Act Amendments of 1990, which has reduced emissions by roughly 45 percent, is also regressive but much less so than the carbon and NOx policies.

A recent study adopts the methodology of Bull et al. (1993) 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 carbon tax (Hassett et al. 2007). 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.[4]

Finally, Holak et al. (2008) assess the overall impacts of three recent carbon 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.[5] 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, while only the two highest-income deciles experience a net loss. Shifting the burden back to shareholders also reduces the regressivity of the tax, as shareholders are predominantly in the higher-income groups.

In summary, the literature indicates that it is important to look at both the direct effects of climate policies—that is, the direct increase in the price of energy consumed by households—and the indirect effects—that is, 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 which revenues from a carbon 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

[4] 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 use kernal regression to estimate effects at a local scale, thereby accounting for rural versus urban differences in consumption.

[5] 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.

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 10 alternative scenarios for redistributing revenues and reducing the impacts of carbon 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 the 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 this data to anticipate the incidence of climate policy in the year 2015, with attention to variation across 11 regions and 10 income levels. 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).[6] The Bureau

[6] 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.

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.[7] Since we are interested in a finer level of geographic detail, we examine the data with state-level indicators. Because the 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 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. We aggregate the observations into 11 regions.[8] Observations with missing state identifiers are still used in our calculations at the national level.

[7] We distribute regional observations based on the CEX data into these national income deciles. It is important to keep in mind that these income "buckets" do not necessarily accurately represent regional income deciles; rather, they are constructed as deciles at the national level.

[8] BLS refers to observations as "consumer units," which we loosely interpret as households. The five missing states are Iowa, New Mexico, North Dakota, Vermont, and Wyoming. 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
CNV	CA, NV	627	878	897	1005	1035	1111	1102	1134	1292	1567	10648
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, MS, 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	300	348	384	409	443	376	355	371	385	347	3718
National		9751	9752	9752	9752	9752	9752	9752	9752	9752	9752	97519

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 while 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 (Table 2).

Table 2. National Highway Traffic Safety Administration Proposed CAFÉ 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

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 what is reflected in the 2006 CEX data, all else equal. Second, gasoline expenditures, all else equal, are lower than they would be without the new standards (and lower than 2006). Since vehicles are a durable good, new, more fuel-efficient vehicles only gradually replace older, less efficient ones. We briefly describe our assumptions about how the stock turns over and how the new regulations affect our expenditure calculations.

More expensive vehicles. According to data from the Bureau of Transportation Statistics, the percentage of new car sales out of total registered cars in a given year is 5.7 percent, and the percentage of new trucks is 7.6 percent.[9] We use these figures to gradually increase the proportion of vehicles on the road that meet the new standards and we rely on estimates in Fischer et al. (2007) to obtain our higher vehicle price for those new vehicle purchases.[10] A new car in 2015, meeting the 35.7 mpg standard, will cost $149 more than it would in 2006, all else equal; a new truck will cost $246 more. In order to account for these cost increases, we have increased new vehicle costs by this amount in the base case.

Lower gasoline consumption. The gradual vehicle turnover leads to improvements in on-road fleetwide average fuel efficiency. We estimate that in 2015, the average fuel efficiency of cars on the road will be 26.3 mpg, while 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.[11]

Although the higher average fuel economy for vehicles on the road reduces gasoline consumption, consumption does not fall in lock-step with the rise in miles per gallon because of what is known as the "rebound effect." When fuel economy increases, the cost per mile of driving falls and in response, people drive more. The net change in gasoline consumption thus equals fuel savings on current mileage from a unit reduction in miles per gallon, less the extra fuel consumption from the increase in vehicle miles traveled. Based on recent estimates, we assume this rebound effect is 10 percent–that is, a 1 percent decrease in the cost per mile of driving leads to a 10 percent increase in gasoline consumption (Small and Van Dender 2007; U.S. Department of Transportation 2008). As a result, assuming the implementation of the new CAFE standards, gradual turnover in the vehicle stock, and the 10 percent rebound effect, average gasoline expenditures per household in 2015 are estimated to be 15 percent lower than the 2006 levels.

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[9] These are the figures for 2005, the most recently available data. See http://www.bts.gov/publications/national_transportation_statistics/. The rate of replacement for new car and truck sales could also be affected by CAFE standards and the rising price of fuel that is not the result of carbon policy.

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

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

Figure 1. National Direct Energy Expenditures as a Fraction of Income

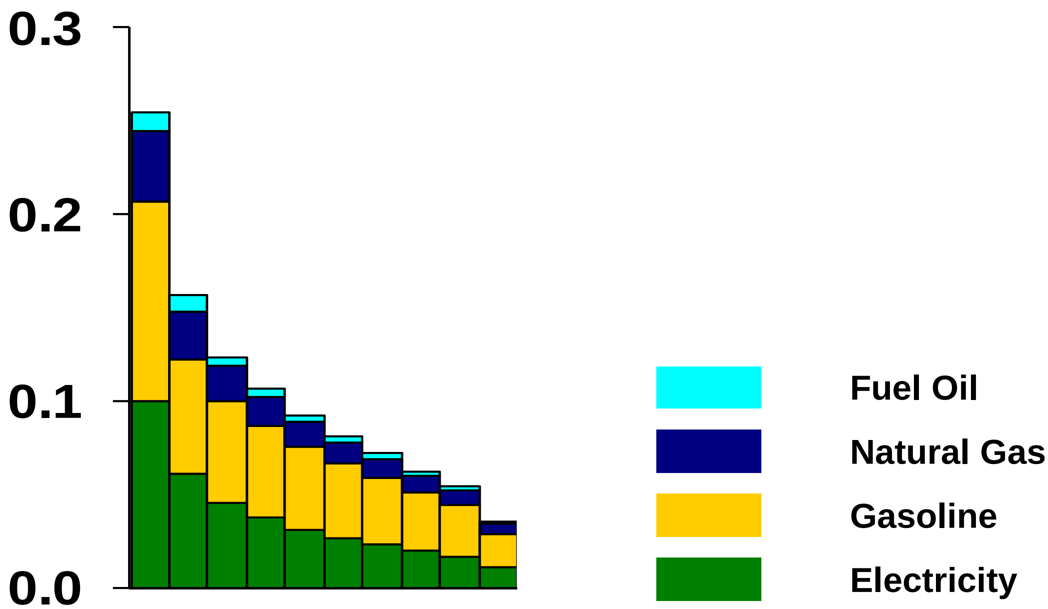
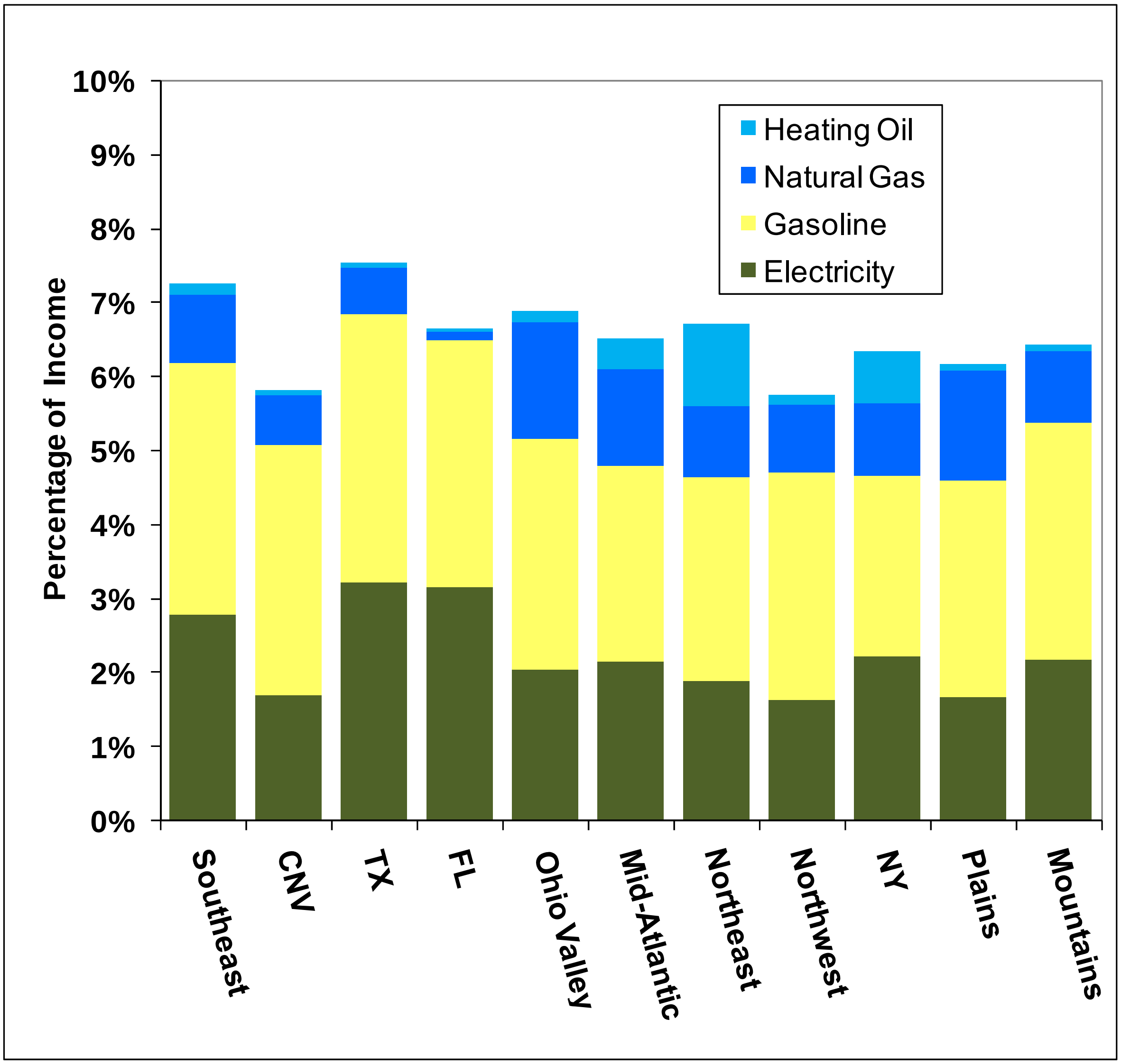


Figure 1 illustrates the direct annual expenditures as a percentage of reported annual income by expenditure category at the national level. The 10 vertical bars represent income deciles, and the amount of expenditure in various categories, as a percentage of income, is displayed for the average household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

At the national level, direct expenditure on energy represents 25.5 percent of annual income among the households in the lowest-income category, which is the greatest percentage of any group. For the highest-income households it is 3.6 percent. On average across all income groups the share of expenditure on energy is 6.7 percent of annual income.

Figure 2. Average Household Expenditures by Region on Direct Fuel Purchases as Percentage 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. This is consistent with the findings in Hassett et al. (2007). However, when one looks at the distribution across income deciles for each region, some larger differences show up. As we stated above, the lowest decile has average direct expenditures equal to 25.5 percent of income. This figure ranges from 22 percent in California and Nevada to 38.0 percent in the Northeast states, a difference of almost 14 percent. The ratio of expenditures as a fraction of income for the lowest decile to that for the highest is 11.5 in the Southeast—i.e., households in the lowest decile pay 11.5 times as much as those in the highest decile, as a percentage of income. In California and Nevada, the comparable figure is 7.7. These findings presage some of our policy scenario results in the next section of the paper.

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 Midatlantic area, 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 represents a sort of transition, with 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 CO_2 content varies depending on the fuel used for generation over seasonal and diurnal periods in different regions. This pattern is identified from the Haiku electricity market model built and maintained by Resources for the Future.[12]

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

4.2 Estimating the Indirect CO_2 Content of Other Expenditures

The second category we incorporate in the analysis is spending on energy embodied indirectly in goods and services, the most important of which are food, durable goods, and services. CO_2 emissions resulting from indirect energy consumption are calculated on the basis of data in Hassett et al. (2007), who provide information on the emissions intensity of goods aggregated into 38 indirect expenditure categories by updating methods developed in Metcalf (1999).[13]

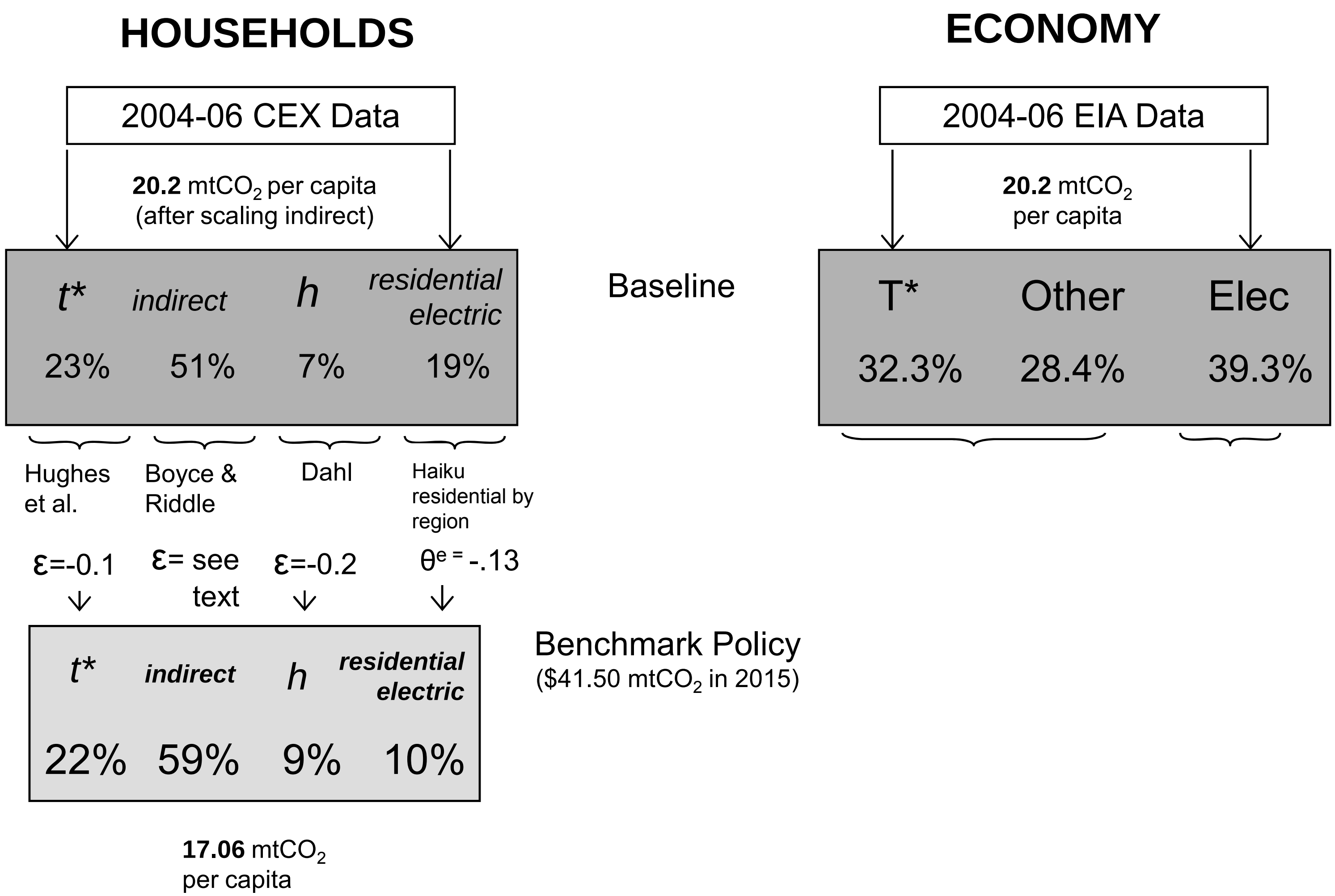
The estimates of direct fuel use and the implied CO_2 emissions based on the CEX data correspond well to data collected by EIA (2007), as do those of Batz et al. (2007). However, the total emissions we calculate fall short of economywide EIA estimates. Our analysis of the CEX data accounts for per capita emissions of 16.9 metric tons CO_2 ($mtCO_2$), where information from EIA indicates per capita emissions of 20.2 $mtCO_2$.[14] 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 but are missing from CEX data because input–output tables would not account for process emissions. Other possible sources of discrepancy are the estimate of the CO_2 content of goods and services or errors in mapping CEX data into expenditure categories. Finally, it is possible that this discrepancy could reflect emissions from exports, which would show up in production data but not consumption data. However, the production data also would not account for emissions associated with the production of goods imported to the United States.

The literature reveals a variety of approaches to deal with inconsistency 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 they align with expenditures reported in the National Income Product Accounts, which implicitly scales 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. (2007) appear to account for emissions of 24.4 $mtCO_2$ per capita, well above the EIA estimate.

[13] Hassett et al. (2007) provide information on the change in product price assuming no behavioral adjustments in response to a tax of $15 per $mtCO_2$. Dividing these price changes by 15 yields the implied CO_2 content per dollar spent in each category. Metcalf (1999) has been the basis for similar calculations elsewhere in the literature (Dinan and Rogers 2002; Boyce and Riddle 2007).

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

Figure 3. Emissions and Changes by Category



* Baseline total and transportation (*t*) emissions do not reflect CAFE adjustment. Policy case does.

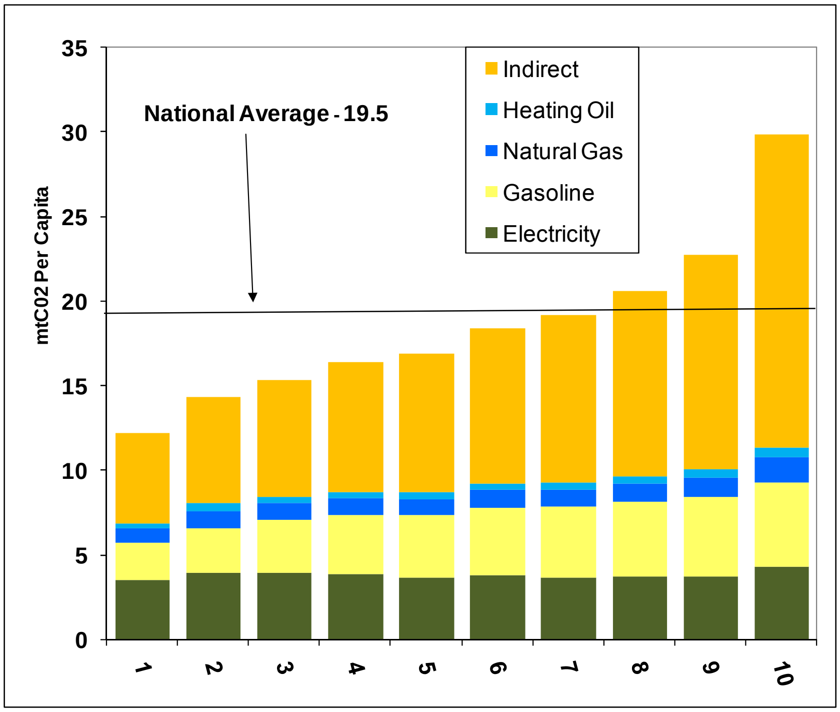
To measure the effects on households in a way that more closely resembles the EIA data, we scale the emissions intensity of nonfuel expenditures in the CEX data so that the total emissions correspond with EIA estimates. Therefore we only scale the emissions intensity of the indirect expenditure category, increasing it by 47 percent (3.31 $mtCO_2$ per capita) to achieve overall EIA emissions levels.

The left side of Figure 3 reflects data and assumptions used in our analysis built on the CEX data. The upper left reports our estimate of 20.2 $mtCO_2$ per capita after scaling indirect expenditures. The upper boxes indicate our accounting for emissions in the baseline (no climate policy). The analysis of household expenditures on the left side of the figure includes percentages of emissions attributed to four categories of economic activity: personal transportation (t*), emissions from consumption of other goods and services after scaling so that total emissions match EIA (indirect), home heating with natural gas and fuel oil (h), and residential electricity. We discuss the elasticities and the benchmark policy results in Section 5 below.

The right side of Figure 3 displays information about economywide emissions and the percentage of per capita emissions that are attributable to all transportation (T*), other sources (Other), and all electricity (Elec), according to EIA (2007). After adjusting for CAFE increases that will take effect by 2015 the emissions per capita fall from 20.2 to 19.52 $mtCO_2$. We interpret this information as our baseline (no climate policy) average emissions per capita scenario for 2015.

Figure 4. Emissions ($mtCO_2$) per Capita by Alternative Measures

Panel A: Income Decile



Panel B: Region

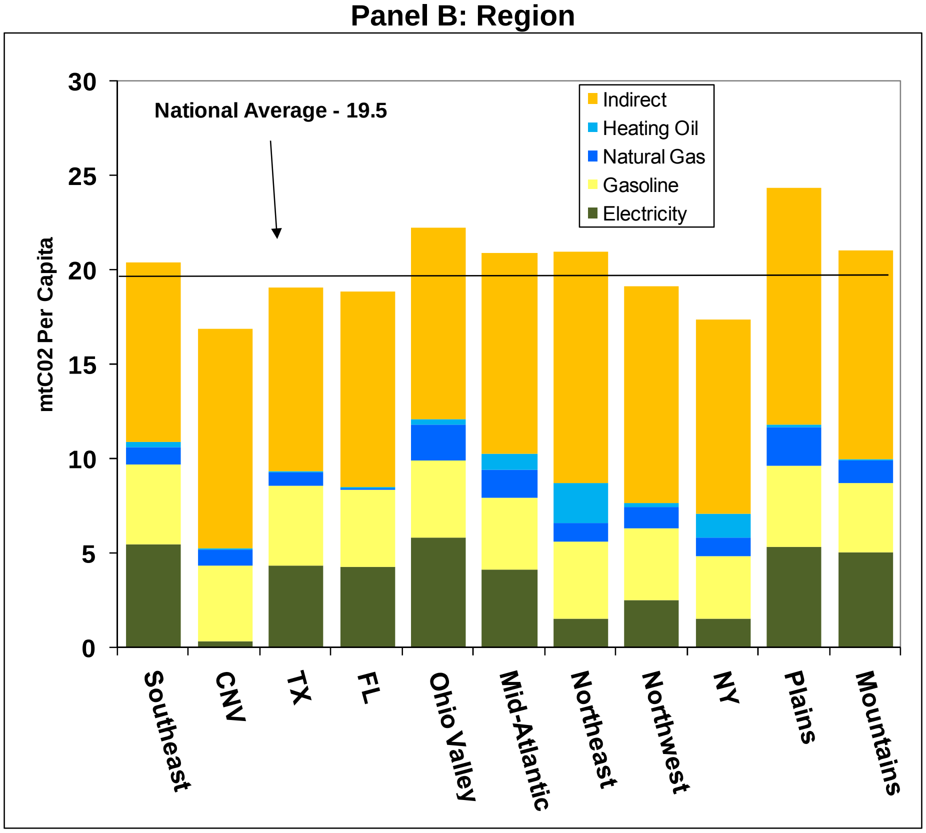
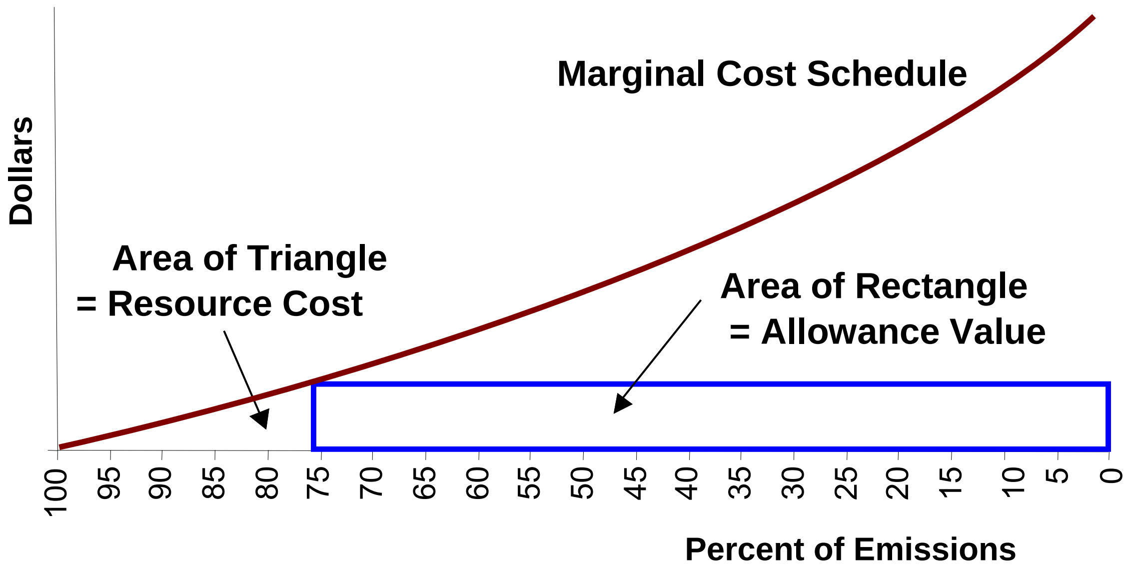


Figure 4 (panel A) illustrates the CO_2 content of expenditures for direct and indirect fuel purchases for the average household in each income group at the national level. The expenditures for direct fuel purchases are distributed fairly evenly across income groups. The big difference emerges in the 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 4 shows that there are 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 5 illustrates the mechanism of a 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 the stylized graph, 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. These facts highlight the important role played by the allocation of emissions allowances in determining the regressivity of climate policy under an incentive-based policy such as cap-and-trade or a carbon tax.

Figure 5. Resource Cost and Allowance Value in a CO_2 Cap-and-Trade Program



An emissions cap-and-trade program (or equivalently an emissions tax) serves as a central policy case to provide a benchmark for our comparison of policies. We benchmark the stringency to an emissions reduction of 3.13 $mtCO_2$ per capita, including the CAFE adjustment, resulting from a price of $41.50 (in 2006 dollars) per ton of CO_2.[15] We assume the policy is announced in 2008 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. In evaluating alternative policies that could be pursued to address distributional effects we scale the CO_2 price in order to hold per capita emissions constant so that these alternatives can be compared with the benchmark climate policy in an emissions-neutral manner.

To calculate the change in emissions we multiply the CO_2 price by the CO_2 content of expenditures in each category except electricity and add this to the product

[15] This price reflects a marginal cost approximately three times greater than what would have been expected from the McCain–Lieberman proposal (S.280) and is roughly equal to the price of emissions allowances in the E.U. Emissions Trading Scheme for the second trading period (2008–2012), which were trading at about $40 per $mtCO_2$ in 2008. The irregular price number results from converting units and the dollar-year for which data are reported.

price to calculate new levels of expenditure. 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. As reported in the left side of Figure 3, we use short-run elasticity (ε) for gasoline of –0.1 taken from Hughes et al. (2008). For indirect expenditures, we use several short-run elasticities take from Boyce and Riddle (2007) that range from –0.25 to –1.3.[16] For natural gas we use –0.2 taken from Dahl (1993); we also use this elasticity for fuel oil. To model the change in residential electricity demand we use the Haiku model, which solves for equilibria including changes in investment in generation capacity, electricity price, and demand at the regional level. The change in carbon emissions (mtCO_2) for residential customers in the electricity sector for a \$1.00 change in the carbon price is $\Theta^e = -0.13$. These estimates allow us to calculate the new quantity of consumption, which can be multiplied by the new price to find the new level of expenditures. The net effect of these changes in expenditures is an emissions level of 17.06 mtCO_2 per capita. With an eye on changes that would be likely to occur by 2015, the use of short-run elasticities is probably appropriate; however, it may underrepresent the behavioral changes that would occur under climate policy as more adjustments could be made in the seven-year time period.

This approach implicitly assumes all changes in costs are fully passed through to consumers in every industry except electricity, which we model in greater detail. 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 born by producers.[17] 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 (2008) assesses the distributional impacts of a carbon tax under alternative assumptions about the share of burden borne by consumers and producers.

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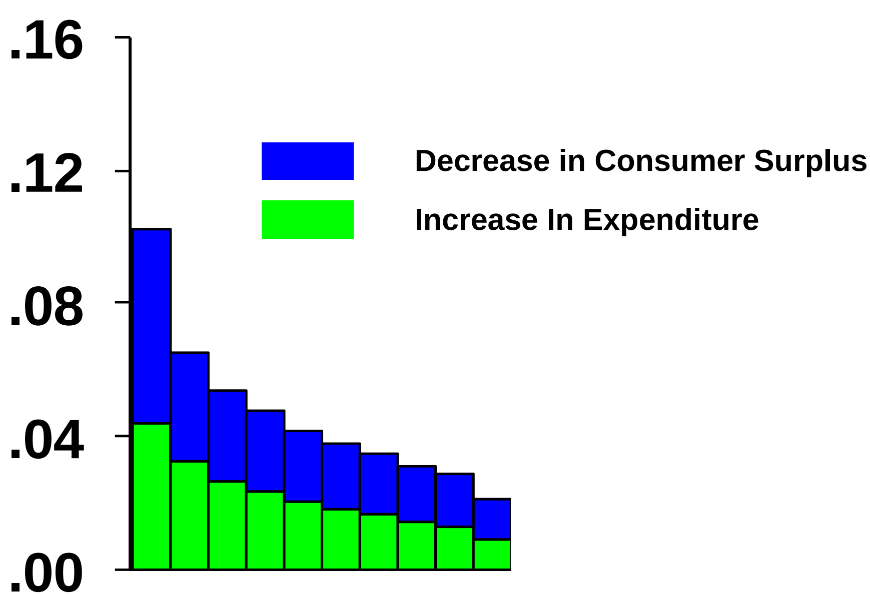
[16] These indirect elasticities are –0.6 for food; –1.3 for industrial goods; –1 for services; and –0.25 for air and other transport.

[17] Burtraw and Palmer (2008).

5.1 How to Interpret Incidence and Alternative Policy Remedies

The \$41.50 CO_2 price that we model in the benchmark policy case is expected to yield a reduction of 16 percent in CO_2 emissions per capita according to our model of household expenditures. Figure 6 illustrates the distribution of costs over income groups at the national level after accounting for changes in expenditures. To understand the numbers in Figure 6, consider an average family in the fifth decile. If one were to ignore the change in consumption that would be expected, as has been done in much of the previous literature, then the introduction of the CO_2 price would cause expenditures for direct energy use to increase by \$807 (1.9 percent) and total expenditures to increase by \$1,711 (4.1 percent). However, after accounting for changes in consumption behavior in response to the higher prices, this family would experience an increase in expenditures of only \$868 (2.1 percent), which is indicated by the smaller bar in the figure. This does not account for the revenue from allowances; it is simply an illustration of how expenditures for direct fuel use and for consumption of goods and services with indirect emissions would change if the prices were to reflect the price of allowances, accounting for behavioral responses in each market as described previously. The figure illustrates that the changes as a percentage of income appear the greatest for low-income households because they spend proportionately more on energy-related expenditures.

Figure 6. Expenditures and Consumer Surplus Loss as Fraction of Income by Income Decile



The change in expenditure can differ importantly from the change in consumer surplus. To illustrate the differences between the two measures, imagine an expenditure category with own-price elasticity of demand equal to –1. In this case, an increase in price would lead to a reduction in quantity but there would be no change in expenditure. Simply equating expenditure change with well-being therefore would underestimate the cost of constraining carbon; all other things equal, consumers are clearly harmed if they are forced to consume less. The larger quantities in the bar graph in Figure 6 indicate the changes in consumer surplus as a percentage of income; the change in consumer surplus is always larger than the change in expenditure. Positive values indicate the absolute value of the magnitude of the loss. Again, the greatest changes (loss in consumer surplus) as a percentage of income occur for low-income households. [18]

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 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 connoting 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. We modify the standard interpretation to measure the incidence on households according to their loss in consumer surplus rather than taxes paid. Second, we allow for negative tax payments and other forms of subsidies, so our modified Suits Index (MSI) is not bounded by –1 and 1. At the national level, not accounting for the revenue that may be collected or the allocation of emissions allowances, the MSI value for the CO_2 price of $41.50 is -0.18.

[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.

The impact of the policy on household direct energy expenditures differs across regions, as evident in Figure 2, and we also find differences with respect to changes in expenditure on goods and services that are affected by the CO_2 price. Hassett et al. (2007) conduct a comparison of the regional incidence of a carbon tax, finding it "quite remarkable how small" the differences are across regions. Batz et al. (2007) reach a different conclusion. Although they only look at direct energy use, they do so with much greater geographic detail than previous efforts by looking at data at the county level, and they look at differences in the emissions intensity of electricity generation across the country. They find "substantial variation in the incidence of a carbon emissions tax" across regions, which they explain as due to variation in energy use as well as differences in the carbon intensity of electricity generation. Our analysis does not have the detail at the county level, but it does have similar estimates of electricity generation by using an updated version of the model they use, and it includes indirect expenditures. These analyses do not look at the allocation of CO_2 revenue.

The $41.50 CO_2 price raises significant revenue that must be accounted for in some manner. We assume the first claimant for the revenue is government, which is subject to a budget constraint. The government budget is affected in at least three ways (Dinan and Rogers 2002). One is that government's energy-related expenses would increase under climate policy. Second, if the policy leads to a reduction in overall spending, government would see a decline in revenues from taxation. Third, the government could see an increase in the cost of social programs if the economy slows down as a consequence of the policy or if lower-income households are severely affected. Finally, we assume there will be an increase in government expenditures to fund climate-related research. To maintain the government's budget constraint (at the federal and state level combined), throughout the following analysis we assume that 35 percent of the revenue collected is immediately directed to the government, leaving 65 percent of the revenue for other purposes.[20] In some cases the climate policy could lead to additional sources of government revenue such as taxes collected on extra dividends that result if free allocation of allowances were given to emitters. In the policy scenarios that follow, we net out this effect so that the government retains a constant 35 percent share of revenue in each scenario.

[20] Dinan and Rogers (2002) estimate that the government would need about 23 percent of the allowance value to offset its higher costs stemming from its own consumption of allowances, adjustments to higher energy prices, higher transfer income payments, lower revenues, and automatic indexing of individual tax collections. We round up to 35 percent to provide for increased government expenditure on research and development and other measures to address climate change.

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 carbon policy. Evaluating alternative approaches to the distribution of the CO_2 revenue provides important information to policymakers trying to design an efficient and fair policy. We group our revenue scenarios into (1) cap-and-dividend options, (2) changes to preexisting taxes, (3) energy and fuel sector adjustments, and as a comparison, (4) a scenario with free allocation to incumbent emitters.

Some of the approaches we analyze have "leftover" revenue because of the level at which we set the remedy or the type of remedy. When this is the case, we assume the leftover revenue is distributed in the same manner as cap-and-dividend, that is, in a lump sum manner to each person, so all approaches can be directly compared. In all cases, we assume the government captures the first 35 percent of CO_2 revenue.

6.1 Cap-and-Dividend (Lump Sum Transfers)

One straight-forward remedy to alleviate the regressivity of the carbon 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.ii below, we consider a dividend that is not taxed.[21]

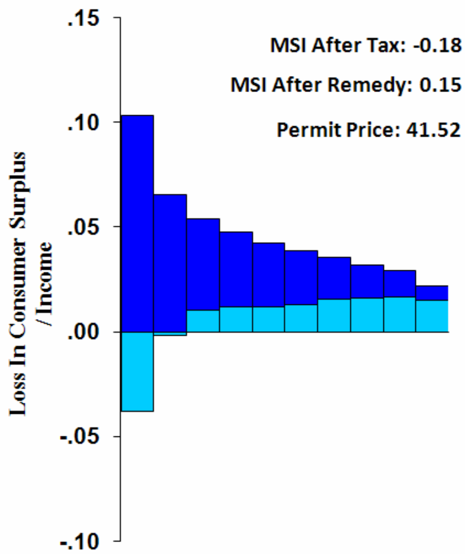
6.1.1 Taxed Dividends

The net effect of the first cap-and-dividend policy, by region and nationally, is shown in Figure 7. The bar graph illustrates the incidence of the policy, in consumer surplus loss, on the average household in each income group; the table portion of the

[21] 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 behavioural economics literature suggests that consumers are unlikely to factor the expectation of such payments into their shortrun energy consumption decisions (Sunstein and Thaler 2008).

figure shows the impacts for the average household in each region and for the households in the lowest two income deciles. The MSI and the carbon allowance price are also listed.

Figure 7. Cap-and-Dividend (Taxable)



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	-$99	-1.41%	$748	1.32%
CNV	-$295	-3.25%	$851	1.24%
TX	-$342	-3.80%	$829	1.41%
FL	$85	0.43%	$847	1.56%
Ohio Valley	$85	0.46%	$1,072	1.78%
Mid-Atlantic	-$3	-0.37%	$949	1.44%
Northeast	$151	1.23%	$1,150	1.65%
Northwest	-$262	-3.08%	$625	1.02%
NY	-$81	-1.36%	$844	1.26%
Plains	-$76	-1.22%	$1,093	1.73%
Mountains	-$165	-1.97%	$828	1.44%
National	-$145	-1.97%	$809	1.39%

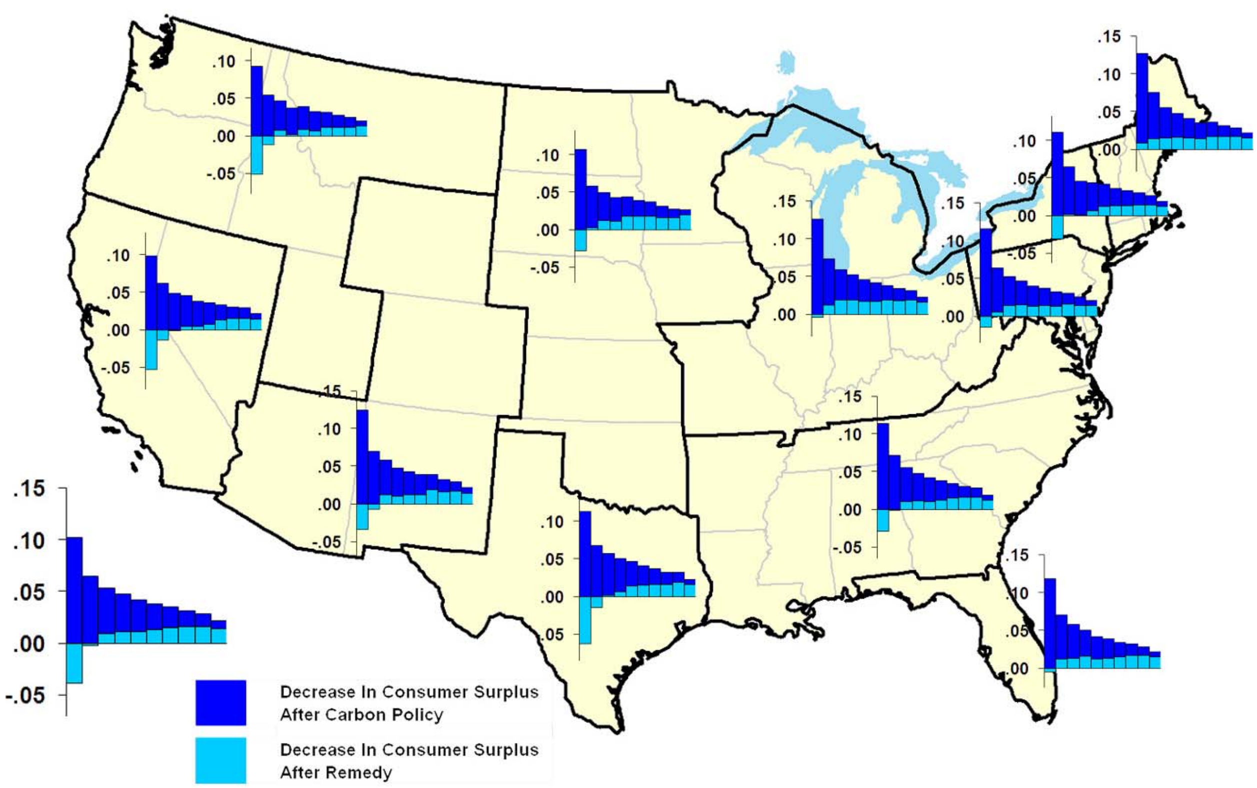
Note: Negative numbers reflect gains in welfare.

The bar with darker shading and the greatest vertical height represents the loss in consumer surplus as a share of after tax income. (This value repeats information that was illustrated in Figure 6). The bar with the lighter shading represents the incidence of the policy after distributing the value of allowances as a per capita dividend. The first finding that is obvious from the graph is the fact 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 10 percent of its income without the dividend but gets a consumer surplus gain equal to 3.8 percent of income with the dividend.

The second interesting result is that the dividend equalizes the net burden across income groups. The net consumer surplus loss as a percentage of income across deciles 2 through 10 ranges from approximately zero for decile 2 to only 1.68 percent for decile 9. These results highlight the fact that the dividend, as a percentage of income, obviously has a much greater impact for poorer households than for wealthier ones. The MSI reinforces these findings: as stated above, the MSI for the carbon pricing policy alone (without the redistribution of allowance revenues) is –0.18; the MSI with the (taxed) lump sum redistribution of revenues is 0.15. Thus the policy goes from being regressive to mildly progressive.

The table portion of Figure 7 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. (Positive numbers in the table indicate a loss and negative numbers indicate a gain, consistent with the graph.) The important take-away message from the numbers in the table is the significant variation in impacts across regions for households in deciles 1 and 2. In Texas, these households experience a consumer surplus gain of $342, or 3.8 percent of income, while households in deciles 1 and 2 in the Northeast incur a loss of $151, or 1.23 percent of income. By contrast, the variation for the mean household across regions is relatively small when viewed as a percentage of income—the lowest region is the Northwest, with a loss equal to approximately 1 percent of income, while the highest is the Ohio Valley at 1.78 percent.

Figure 8. Cap-and-Dividend (Taxable)

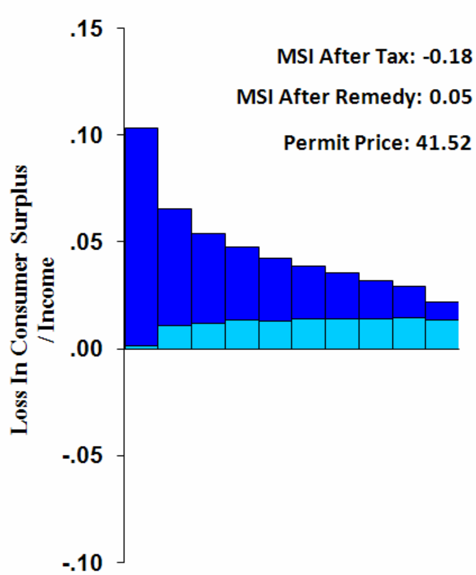


To illustrate the incidence of policy across all income groups and regions we display a map in Figure 8. Again, the bars with darker shading and the greatest vertical height represent the loss in consumer surplus as a share of after-tax income, and the bars with the lighter shading represent the net 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-income groups and for the average consumers. There is relatively little variation among the upper-income groups across regions.

6.1.2 Nontaxable Dividends

It is not clear whether carbon allowance dividends in a new cap-and-trade program would be treated as taxable or nontaxable income. Our first scenario considered them as taxable, the same as most other sources of income. In other words, the government was assumed to collect the allowance revenue and redistribute the entire amount (less the 35 percent that is withheld in all our scenarios) to households that would then pay taxes on that money at their standard marginal rate. In this scenario, we treat the dividends as untaxed. This case is similar to the 2008 federal tax rebates, which were also untaxed.

Figure 9. Cap-and-Dividend (Nontaxable)



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	$146	1.24%	$746	1.32%
CNV	-$28	-0.44%	$804	1.17%
TX	-$39	-0.59%	$821	1.40%
FL	$304	2.70%	$840	1.55%
Ohio Valley	$309	2.84%	$1,041	1.73%
Mid-Atlantic	$221	1.98%	$906	1.37%
Northeast	$355	3.45%	$1,095	1.57%
Northwest	-$27	-0.47%	$592	0.96%
NY	$147	1.19%	$808	1.21%
Plains	$140	1.18%	$1,052	1.67%
Mountains	$99	0.94%	$815	1.42%
National	$90	0.62%	$795	1.36%

Note: Negative numbers reflect gains in welfare.

Figure 9 shows a bar graph of the distributional impacts of the policy at the national level and a table of regional results. Similar to the previous cap-and-dividend policy we analyzed, the bar graph illustrates that this policy tends to equalize the burden across income groups. The loss as a percentage of income across deciles 2 through 10 is almost constant—ranging from only 1.1 percent to 1.45 percent. The MSI is 0.05, indicating that the policy is progressive. Unlike the previous policy, however, none of the income deciles here shows a gain in consumer surplus. This happens because of the differences in the marginal tax rates across income groups that affected the results for the previous policy. 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 differences do not play a role.

As the table in Figure 9 shows, there is still substantial variation across regions for the lowest-income deciles for this policy. Again, households in the Northeast lose the most—$355 per year, or 3.45 percent of income for the average household in the lowest two deciles; by contrast, the average household in these deciles in Texas, California/Nevada, and the Northwest experiences a consumer surplus gain.

The average consumer surplus loss for this policy across all households in the United States is $795, just slightly less than our first 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). The failure to do so can impose a hidden cost of climate policy that can magnify the overall cost to the economy.[22] 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.

[22] 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 considerable degree.

To measure the effect of interactions with other regulations and taxes and the benefits of revenue recycling to offset the effect 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. We do not include the effects in factor markets in this analysis, in part because the exact way in which those effects accrue throughout the economy 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 (EITC), ignoring the welfare issues associated with changes in the supply of labor.

6.2.1 Reducing the Income Tax

A reduction in the income tax could be implemented in many ways. In this first scenario, we assume an overall reduction in tax collections in proportion to the amount paid by households in each income bracket.[23] The highest-income groups pay the most in taxes because they have the highest average and marginal tax rate and the rate is applied to the most income. Therefore this approach benefits the highest-income groups disproportionately. 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, for example, the highest wage. Thus this scenario is useful to analyze.

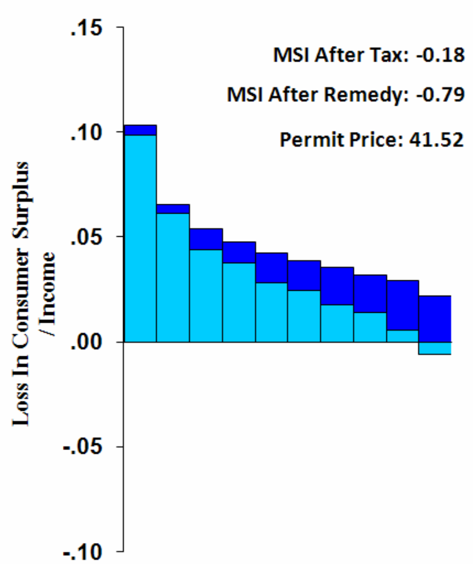
The Congressional Budget Office (2005) reports the average tax burden of U.S. households by income decile. We multiply this percentage by the amount of income earned by each decile to get a share of total income tax burden by decile. Finally, we distribute carbon revenue proportional to each household's estimated share of the total income tax burden. Figure 10 shows the incidence of the policy across income groups; again, the dark bar shows the policy before the return of revenue, and the lighter-colored bar shows the net effects after the allowance revenues are used to reduce income taxes. The accompanying table shows the regional effects.

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

[23] 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 cap-and-dividend approach as modeled here. For this reason we do not explicitly consider this policy.

groups, and the very highest-income group, decile 10, ends up with a net gain under this climate policy. An average family in decile 10 nets a consumer surplus gain of $996 per year, 0.56 percent of annual income. By contrast, the average family in the lowest-income decile incurs a net cost of $694, nearly 10 percent of income. The MSI for this policy is –0.79, indicating that the option is strongly regressive.

Figure 10. Reducing the Income Tax



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	$910	8.85%	$794	1.40%
CNV	$806	7.66%	$666	0.97%
TX	$904	8.67%	$931	1.59%
FL	$970	9.12%	$911	1.68%
Ohio Valley	$996	9.61%	$992	1.65%
Mid-Atlantic	$898	8.62%	$677	1.03%
Northeast	$989	9.77%	$758	1.09%
Northwest	$699	6.95%	$554	0.90%
NY	$850	8.40%	$636	0.95%
Plains	$790	7.88%	$895	1.42%
Mountains	$923	9.28%	$875	1.53%
National	$818	8.00%	$795	1.36%

Note: Negative numbers reflect gains in welfare.

The regional impacts are less pronounced than the impacts for the previous two policies. Nonetheless, our findings continue to show that poor households in the Ohio Valley and the Northeast are affected relatively more than poor households in the Northwest and California/Nevada. The average household in the lowest two deciles in the Northeast incurs a consumer surplus loss of 9.8 percent of annual income, while the average household in the lowest two deciles in the Northwest incurs a loss just less than 7 percent of income. As with many of our other policies, the regional differences are more pronounced for these lower-income households than they are for the mean households.

6.2.2 Reducing the Payroll Tax

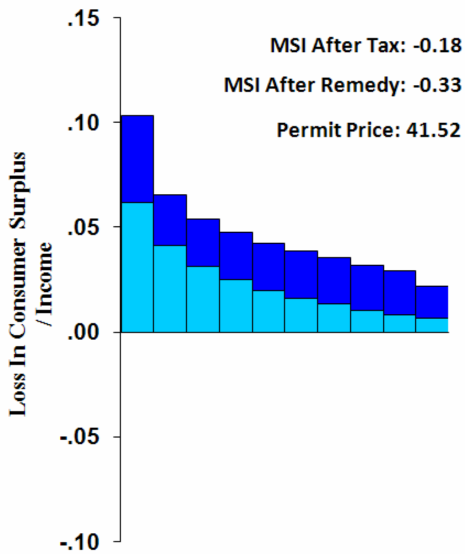
Using carbon allowance revenues to reduce payroll taxes such as Social Security is another option for "greening" the tax system that some experts have suggested. In addition to income taxes, employers are required to withhold one-half of each employee's Social Security and Medicare tax requirements (equal 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.[24] For this policy case we modeled a 2 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.[25] To represent households with multiple wage earners, we cap eligible wages at $135,000. After reducing payroll taxes paid from 15.3 percent to 13.3 percent, the scenario leads to some "leftover" allowance revenues—as we explained in the introduction to section 6 above, some of our remedies do not exhaust all of the allowance revenue—thus the remainder is distributed in a lump sum fashion on as a taxable per capita dividend to everyone. The payroll deduction accounted for 16 percent of total revenue raised by the program, leaving 49 percent to be distributed as a per capita dividend.

Like the income tax reduction scenario we analyzed above, the payroll tax deduction makes for a regressive carbon policy (even with a substantial proportion of the revenues distributed lump-sum). The distribution of net consumer surplus losses across the deciles is shown in Figure 11. The bar graph illustrates that, while the burden is reduced from rebating the revenues through reductions in this preexisting tax—that is, the light blue bars all lay 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. The MSI, while not as negative as for the income tax reduction, is still negative at -0.33. An average household in the lowest-income decile experiences a net consumer surplus loss of approximately $435, which is equal to 6.2 percent of income. The impact falls as a percentage of income as income rises; the average decile 10 household pays only 0.7 percent of its income for the carbon policy.

[24] 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.

[25] Note the distinction between wages and income.

Figure 11. Reducing the Payroll Tax



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	$611	5.91%	$742	1.31%
CNV	$487	4.59%	$785	1.15%
TX	$535	5.09%	$871	1.49%
FL	$724	6.75%	$893	1.64%
Ohio Valley	$733	7.03%	$1,006	1.67%
Mid-Atlantic	$652	6.20%	$769	1.16%
Northeast	$761	7.49%	$881	1.26%
Northwest	$391	3.82%	$580	0.94%
NY	$571	5.57%	$735	1.10%
Plains	$522	5.22%	$899	1.42%
Mountains	$601	6.05%	$839	1.46%
National	$537	5.17%	$795	1.36%

Note: Negative numbers reflect gains in welfare.

As with the income tax reduction policy, the payroll tax option does not impose major differences at the regional level. The Northwest is harmed relatively less and the Northeast relatively more, as with several of our other policies, but the range in impacts for the lowest two deciles is not as great as for some of our other policy options. Most of the story for this policy option, as with the reducing income tax option, is told at the national level.

6.2.3 Expanding the Earned Income Tax Credit

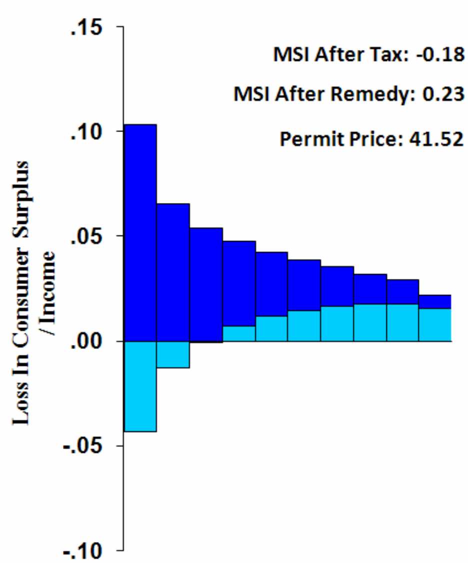
Greenstein et al. (2008) has suggested that revenues generated under a cap-and-trade program or a carbon tax should be used to expand the Earned Income Tax Credit (EITC). The EITC is available to families earning wages below a particular threshold.[26] The amount of the credit falls as income rises and 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

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

beyond $15,399, the credit drops to 21 percent and falls to zero when earnings pass $37,782. In our policy scenario, we first estimate the current EITC for each observation based on the 2006 EITC parameters. We then take half of this estimate and redistribute it to each household, which is analogous to increasing the EITC program by 50 percent. The expansion of the EITC accounted for 59 percent of total revenue raised by the program, leaving 6 percent to be distributed as per capita dividends.

The distributional results for our EITC expansion policy are shown in Figure 12. As expected, households in the lower-income deciles benefit the most from this policy. The average household in decile 1 experiences a net consumer surplus gain of $301, which is 4.3 percent of annual income, and the average household in decile 2 experiences a gain of $190, 1.23 percent of income. Comparing the dark and light blue bars in the graph indicates that the redistribution of revenues through the EITC program dramatically changes the regressivity of the policy. The MSI for this option is 0.23, compared with –0.18 for the carbon policy without the return of revenues.

Figure 12. Expanding the Earned Income Tax Credit



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	-$234	-2.45%	$716	1.27%
CNV	-$419	-4.29%	$842	1.23%
TX	-$603	-6.00%	$746	1.27%
FL	$19	-0.11%	$846	1.56%
Ohio Valley	-$6	-0.22%	$1,073	1.78%
Mid-Atlantic	-$94	-1.06%	$959	1.45%
Northeast	$120	1.02%	$1,173	1.68%
Northwest	-$384	-4.11%	$624	1.01%
NY	-$172	-2.08%	$848	1.27%
Plains	-$170	-1.93%	$1,084	1.72%
Mountains	-$349	-3.51%	$793	1.38%
National	-$245	-2.76%	$795	1.36%

Note: Negative numbers reflect gains in welfare.

As is the case with many of our policies, households are affected differently depending on where they live. As the table portion of Figure 12 shows, the average household in the Northeast region incurs the largest dollar loss in consumer surplus, and is second only to the Ohio Valley region on a percentage of income basis. The starkest regional contrast shows up for households in the lowest two deciles. While most households in these groups experience a gain, and the average gain for the United States as a whole for deciles 1 and 2 is $245, two regions see their lowest-income households incurring a loss. In the Northeast, the average household in the bottom two deciles loses $120 per year, or slightly more than 1 percent of annual income. The average household in the bottom two deciles in Florida also experiences a net loss. By contrast, the average household in Texas in the bottom two deciles earns a consumer surplus gain of $603, or 6 percent of income. The range across regions for these deciles is $723. This is a very large difference for poor households across regions.

6.3 Energy and Fuel Sector Adjustments

Several suggestions have been made for targeting allowance revenues under a cap-and-trade system to the fuel and energy sectors. The justifications range from a desire to directly offset higher energy costs, to a sense that some of these sectors are already targeted by other policies, to an attempt to spur energy efficiency improvements. For example, it is often argued that the transportation sector should be exempt from the cap because most studies have shown low price elasticity of demand for vehicle miles traveled or for gasoline use and the introduction of a CO_2 price would have a fairly small effect on the price of gasoline. In addition, personal motor vehicles are subject to fuel economy standards that have recently been tightened. Also, some have argued that home heating fuels should be exempt or that the federal Low-Income Home Energy Assistance Program (LIHEAP), which provides one-time financial assistance to low-income households for home heating or cooling bills, should be expanded. Others have recommended that allowances be given to electricity consumers to offset the relatively large expected increase in prices in that sector. And finally, expansion of energy efficiency programs usually run by electricity and gas utilities has been suggested. We consider each of these options with the exception of expanding LIHEAP because the program is operated differently in each state, making it difficult to accurately model an expansion in this program in our framework. Our home heating oil scenario results are expected to be somewhat similar to an expansion of LIHEAP.

6.3.1 Excluding the Transportation Sector

The transportation sector is responsible for 32.3 percent of emissions nationally, and the CEX data indicate that personal automobile transportation–related emissions from use of gasoline account for about 21 percent of total per capita emissions associated with direct fuel use by households. Gasoline use is not spread equally around the nation. Appendix A illustrates that gasoline use in the West and Southwest is considerably higher than the Northeast Furthermore, as illustrated in Figure 1, transportation expense is not distributed evenly across income groups; the largest expense as a share of income belongs to the lowest decile, and this share decreases as households move up the income ladder.

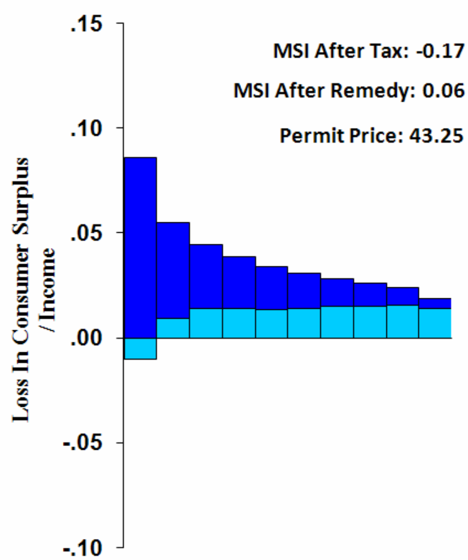
Because the demand for gasoline is inelastic in the short run, the expected reduction in emissions associated with personal transportation is only 2.2 percent in 2015 due to the imposition of a price on CO_2. Many authors have suggested that policies other than those that raise the cost of transportation are necessary to realize important changes in the performance of automobiles as well as changes in personal transportation habits. One example is the revised CAFE standards that are assumed to be in place throughout all of our scenarios, helping to achieve emissions reductions compared with 2006 emissions.. Therefore, one way to lessen the incidence of the CO_2 price without undermining environmental goals might be to exclude the transportation sector from coverage. This approach would resemble the design of the E.U. Emissions Trading Scheme, which covers major point source emissions totaling roughly 50 percent of total CO_2 emissions in the European Union, but which excludes the transportation sector as well as direct fuel use for home heating or cooling.

Although a CO_2 price in transportation may not be especially effective in achieving emissions reductions, exclusion of the transportation sector nonetheless erodes the emissions reductions that otherwise would be expected to occur in the sector from the imposition of a CO_2 price. In order to meet the aggregate emissions goal more reductions have to be achieved in other sectors, thereby raising the costs in those sectors. Nationally, we estimate the allowance price has to rise from $41.50 per mt$CO_2$ under an economywide approach to $42.83 when the transportation sector is not included, which in turn has implications for the incidence of costs incurred in other sectors.

Before discussing the regional impacts and the impacts across income groups, however, we want to point out that the change in expenditures and the change in consumer surplus, before the return of allowance revenues, are both smaller in magnitude for the scenario in which transportation is excluded than for the basic economywide cap-and-dividend policy. This result is attributable to the relatively inelastic demand for transport compared with other sectors. Applying a slightly higher CO_2 price to the nontransport sectors including the indirect purchase of goods and services leads to less of an increase in expenditures and loss in consumer surplus than applying a slightly lower

CO_2 price more broadly to all goods and services. The average consumer surplus loss across all households from the transport-exempt policy is $1,620 before accounting for the allowance revenues, which is 2.78 percent of income. By contrast, the cap-and-dividend policy cost an average household almost $2,000, or 3.4 percent of income. But because the cap-and-dividend policy generates more revenue, the net consumer surplus loss, including return of the revenues, is smaller in the economywide cap-and-dividend policy than in the transport-exempt policy. In the cap-and-dividend policy the net consumer surplus loss is $809 for an average household (when dividends are taxed, our first scenario analyzed above), while it is $832 in the transport-exempt scenario. This number is shown in the last row of the table in Figure 13, which also shows the regional impacts. Figure 13 includes, as well, the bar graph illustrating gross and net consumer surplus loss for the average household in each income decile.

Figure 13. Excluding Transportation



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	$68	0.36%	$746	1.32%
CNV	-$87	-1.04%	$858	1.25%
TX	-$143	-1.72%	$815	1.39%
FL	$213	1.71%	$862	1.59%
Ohio Valley	$259	2.25%	$1,078	1.79%
Mid-Atlantic	$179	1.42%	$978	1.48%
Northeast	$298	2.74%	$1,152	1.65%
Northwest	-$111	-1.58%	$649	1.05%
NY	$128	0.80%	$926	1.38%
Plains	$57	0.26%	$1,078	1.71%
Mountains	$45	0.21%	$882	1.54%
National	$36	-0.03%	$832	1.43%

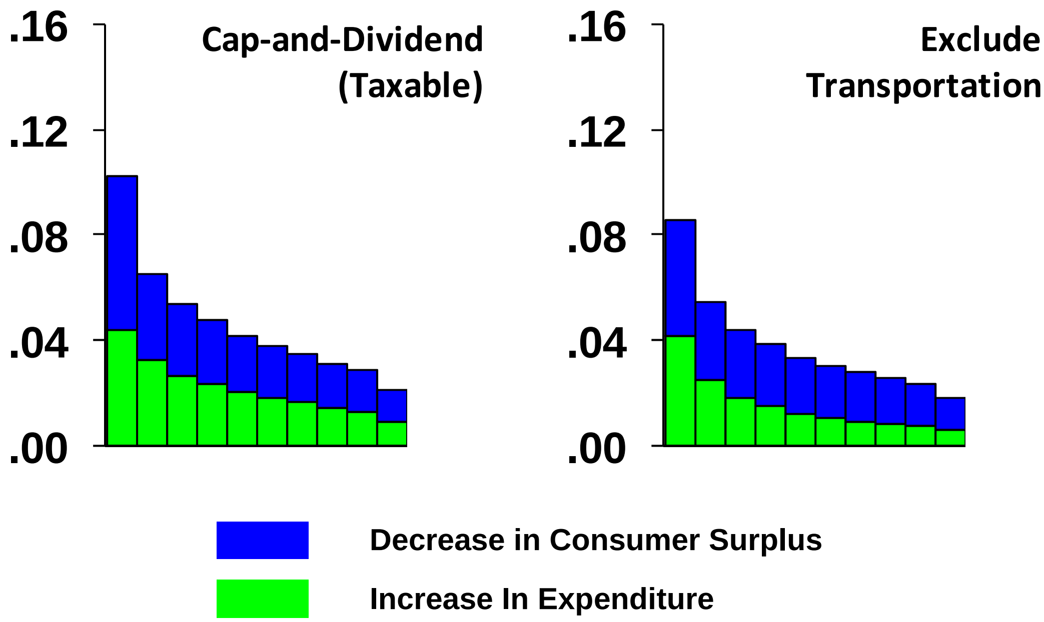
Note: Negative numbers reflect gains in welfare.

As the bar graph shows, excluding the transportation sector still leaves the lower-income groups incurring a larger consumer surplus loss as a percentage of income than the higher groups (the dark blue bars). It is only when the revenue is returned in a lump sum fashion that this regressivity is reduced (the light blue bars). At the national level, the MSI is 0.06 when transportation is excluded. This suggests that the policy is progressive, though less so than the cap-and-(taxed) dividend policy, which had an MSI of 0.15.

However, once again, the regional effects differ substantially for the different income groups. The table in Figure 13 illustrates this result. An average U.S. household incurs a net consumer surplus loss of $832, or 1.43 percent of annual income, but this figure varies from $649 in the Northwest to $1,152 in the Northeast. The difference in costs for low-income households across regions is more pronounced, varying from a loss of nearly $300 in the Northeast to a gain of $143 in Texas. As a percentage of income, these are large differences, as the table shows. These differences result, in part, from significant differences in transportation use and emissions across regions. These differences are shown in the Appendix A, which reports gasoline consumption by region and income decile.

Figure 14 compares the change in expenditures and loss in consumer surplus by income group for the transport-excluded scenario with our first scenario, the cap-and-(taxed) dividend. The graph shows the consumer surplus loss before the return of the revenues in order to isolate the impact on welfare of excluding transportation from the cap-and-trade policy. As can be seen from the graph, the initial increase in expenditures and loss in consumer surplus is lower for all 10 deciles when the transportation sector is excluded. However, excluding transportation does not create large relative differences among the deciles.

Figure 14. Comparison of Surplus Loss between Two Policies



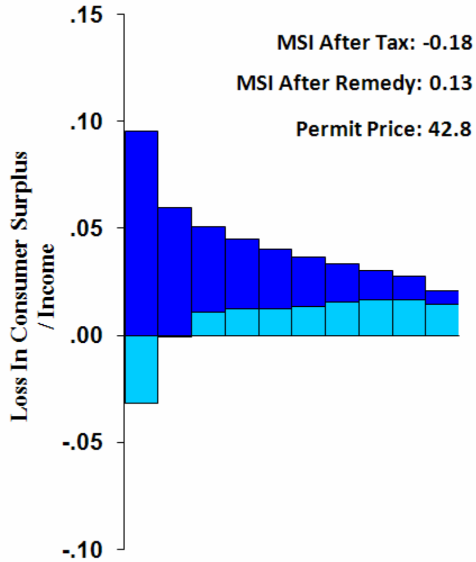
6.3.2 Excluding Home Heating

In this scenario we exclude all oil and natural gas used for home heating from the cap-and-trade system. Thus, just as in the case where transport is excluded, the carbon price must rise to achieve the necessary emissions target. We find that the price in this scenario is $42.80 per mt$CO_2$—almost $1.30 higher than under the economywide approach, but $0.45 lower than under the transport-excluded scenario. Other sectors have to work even harder in this scenario to achieve a given emissions target in order to make up for the loss in the home heating sector.

As in the case where transportation was excluded, the change in expenditures and the consumer surplus loss before the distribution of allowance revenues are smaller for this scenario than under the economywide cap. Again, this result occurs because the higher carbon price in this scenario is more than offset by the fact that a sector is exempted from the program. The differences are smaller, however, than in the transportation-excluded scenario.

Once the return of revenues is incorporated, the net consumer surplus loss from this scenario is approximately the same size, on average, across all households, as it is in the economywide cap-and-(taxed) dividend scenario. The net loss is $822 for an average household (1.41 percent of income) compared with $809 (1.39 percent of income) in the economywide program (with taxed dividends). Figure 15 shows the national and regional impacts from the policy. The net loss of $822 is shown on the bottom row of the table. The bar graph makes clear that even with excluding home heating from the program, lower-income households are disproportionately harmed by the carbon policy. Only the return of revenues reduces the regressivity of the program. Before the remedy, the MSI for this scenario is –0.18; after return of revenues, it is 0.13. Thus, overall, the policy is progressive and very close to the economywide cap-and-dividend scenario, which had an MSI of 0.15.

Figure 15. Excluding Home Heating



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	-$68	-1.10%	$792	1.40%
CNV	-$222	-2.54%	$927	1.35%
TX	-$243	-2.81%	$937	1.60%
FL	$197	1.52%	$1,001	1.84%
Ohio Valley	$61	0.26%	$1,024	1.70%
Mid-Atlantic	-$61	-0.85%	$886	1.34%
Northeast	$50	0.40%	$1,007	1.44%
Northwest	-$203	-2.42%	$650	1.06%
NY	-$102	-1.34%	$777	1.16%
Plains	-$63	-1.04%	$1,043	1.65%
Mountains	-$117	-1.44%	$865	1.51%
National	-$114	-1.59%	$822	1.41%

Note: Negative numbers reflect gains in welfare.

The regional differences are fairly substantial, especially for the lower-income deciles. The tables in Appendices C and D report consumption on natural gas and home heating by households in different regions and income groups. The table in Figure 15 shows that under the policy excluding home heating from the cap-and-trade program the lowest two income groups experience a net gain in seven of the regions and a net loss in the rest. The Northeast is one of the regions in which the average household incurs a loss, but the loss—$50 per year or 0.4 percent of income—is far lower than in the other scenarios we examine. Excluding home heating provides a relative benefit in this region of the country. Poor households in Texas, California and Nevada, and the Northwest experience the largest gain from this policy—in Texas, the average household in the bottom two deciles reaps a net benefit of $243, or 2.8 percent of annual income.

6.3.3 Free Allocation to Electricity Consumers

Free allocation of allowances on behalf of electricity consumers can be accomplished by allocation to local distribution companies (retail utilities), who would act as trustees on behalf of retail electricity customers. This idea is embodied in the

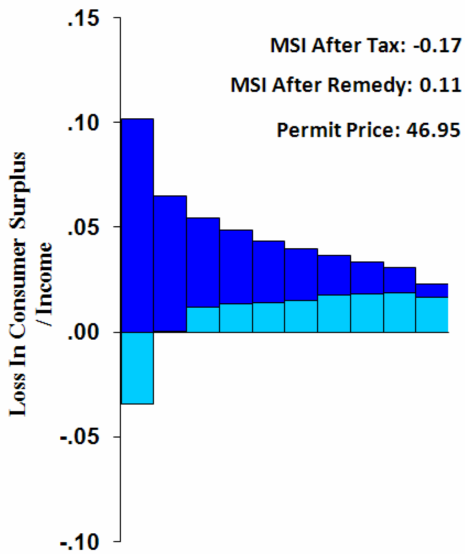
Liebeman–Warner bill (SB 2191) as well as other proposals and has been endorsed by the National Association of Regulatory Utility Commissioners.[27]

In a recent study Paul et al. (2008) used the Haiku electricity model to examine changes in electricity prices with load-based allocation under the Lieberman–Warner cap-and-trade proposal. Returning allowance value to customers through their local distribution companies would raise electricity prices little or not at all, thereby greatly reducing the burden of climate policy. However, the small price rise also means that consumers receive a weak signal to reduce consumption or invest in improving end-use efficiency. In effect, allocation to consumers is a subsidy to electricity consumption that raises the overall cost of the cap-and-trade program. As a consequence of the fact that consumers do not see higher prices, the amount of reduction necessary elsewhere in the economy goes up. Total emissions in the electricity sector rise by 6 percent with free allocation to electricity consumers compared with the economywide cap-and-dividend policy. Consequently the allowance price increases to $46.68, approximately $5 higher than in the central cap-and-dividend case.

The total expenditure change under load-based allocation is less, on a national average basis, than under the economywide cap-and-dividend program. This is because electricity consumers are not experiencing the full impact of the carbon price. Once the revenues are allocated on a per capita basis, the load-based allocation policy is slightly more costly than the economywide cap-and-dividend approach. As shown in the last row of the table in Figure 16, an average household experiences a net cost of $918 with load-based allocation, approximately 1.6 percent of its annual income; this compares with $809, 1.4 percent of income, under the cap-and-dividend.

[27] Letter to Senators Lieberman and Warner, April 21, 2008.

Figure 16. Free Allocation to Electricity Consumers



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	-$118	-1.64%	$797	1.41%
CNV	-$208	-2.42%	$1,071	1.56%
TX	-$339	-3.78%	$877	1.50%
FL	$67	0.26%	$880	1.62%
Ohio Valley	$88	0.49%	$1,161	1.93%
Mid-Atlantic	$43	0.09%	$1,075	1.63%
Northeast	$221	1.94%	$1,324	1.90%
Northwest	-$208	-2.50%	$780	1.27%
NY	-$17	-0.74%	$1,003	1.50%
Plains	-$24	-0.69%	$1,248	1.98%
Mountains	-$122	-1.53%	$954	1.66%
National	-$116	-1.68%	$918	1.57%

Note: Negative numbers reflect gains in welfare.

Appendix B shows the pattern of electricity consumption by region and income decile, but these data do not reveal the CO_2 emissions associated with electricity consumption, which varies across the country and is captured in our modeling. Figure 16 shows the regional and national impacts of free allocation to electricity consumers by income decile after accounting for geographic differences in electricity generation and for the free allocation of emissions allowances to consumers on the basis of electricity consumption.[28] The MSI is 0.11, indicating that the load-based allocation approach is slightly progressive. Households in the bottom two deciles incur an average gain in consumer surplus of $116, or approximately 1.7 percent of income, but this amount varies widely across the regions. In Texas, the gain is as high as $339, while in the Northeast, the average household in the bottom two deciles incurs a loss of $221, 1.94 percent of annual income.

[28] The approach we model is allocation to local distribution companies on the basis of consumption, which is just one of at least three plausible approaches. Alternatives include allocation on a per capita basis, which would be identical to cap-and-dividend, or allocation on the basis of emissions. Paul et al. (2008) show that significantly different effects accrue across regions under these different metrics.

6.3.4 Investment of Allowance Value in End-Use Efficiency Programs

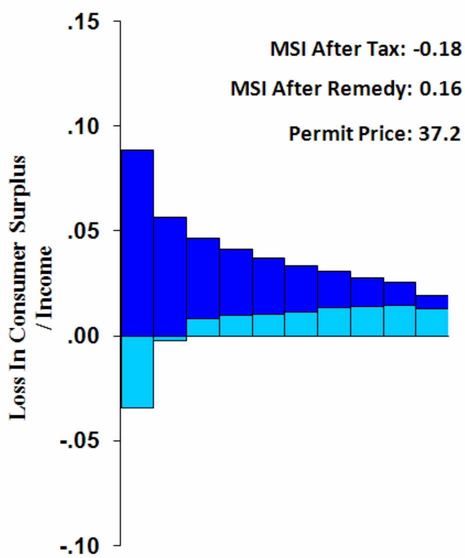
Various proposals have called for investment of CO_2 revenue to improve end-use energy efficiency in the economy. The RGGI, which implements a modest cap-and-trade program for electricity generators in 10 northeast states in 2009, requires each state to dedicate at least 25 percent of the value of emissions allowances to strategic energy initiatives. The European Union has proposed a similar requirement to take effect in the third phase of the Emissions Trading Scheme beginning in 2013. In addition, proposed federal legislation has a similar provision at the national level in the United States.

Investment in end-use energy efficiency is expected to reduce energy demand and therefore reduce energy prices and the delivered costs of energy services. Ruth et al. (2008) use engineering estimates of the opportunity for efficiency improvements to analyze the effect of such investments in the State of Maryland and find that these investments can virtually offset the increase in electricity price that would otherwise result from the state joining RGGI. The Center for Integrative Environmental Research (CIER) (2008) conducted a similar analysis for the entire RGGI region and explored different levels of efficiency investment. Using a newly estimated structure for demand, they find that investing in energy efficiency offsets price increases from a carbon policy across the region.

Starting with a demand model that distinguishes between long-run and short-run demand, similar to CIER (2008), we use Haiku to model a program where 25 percent of the CO_2 revenue collected from the electricity sector nationally is invested to improve efficiency in the sector. This revenue subsidizes the purchase of more efficient electricity-consuming capital for consumers who are close to indifferent between consuming and not consuming additional units of electricity services. This methodology takes advantage of information in demand curve that represents the quantity choice decision of consumers based on the marginal willingness to pay for electricity consumption. For the last unit consumed, the consumer is expected to be approximately indifferent between consumption and avoiding consumption at the given retail price of electricity. It follows that the consumer would require only small compensation to reduce this unit of consumption, and for further demand reduction the consumer would require increasing levels of compensation. This information about the marginal willingness to accept compensation for demand reduction embodied in the demand curve of consumers is used as a proxy for the marginal value of capital investments in end use efficiency, and in addition to this cost of compensating the consumer we add a substantial administrative cost. Since capital goods that consume electricity are long-lived investments, there are immediate annual demand reductions and a stream of reductions that follow. In our model these reductions lead to electricity sector emissions that are 16 percent lower than cap-and-dividend emissions for the same price level in 2015. This increased efficiency in eliminating CO_2 lowers the cost of the program as a whole, driving the allowance price down to $37.20. The remainder of the revenue is returned as a per capita dividend.

Figure 17 illustrates that this policy reduces the size of the average consumer surplus loss for the nation as a whole, improves the position of the lowest-income groups, and works to equalize the net burden across deciles 3 through 10. The MSI for this policy is 0.16, approximately the same as in the cap-and-(taxed) dividend option.

Figure 17. Invest in Efficiency



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	-$101	-1.38%	$649	1.15%
CNV	-$252	-2.79%	$768	1.12%
TX	-$317	-3.50%	$705	1.20%
FL	$62	0.26%	$733	1.35%
Ohio Valley	$40	0.07%	$903	1.50%
Mid-Atlantic	-$13	-0.42%	$823	1.25%
Northeast	$141	1.17%	$1,031	1.48%
Northwest	-$223	-2.63%	$569	0.92%
NY	-$80	-1.29%	$733	1.10%
Plains	-$60	-1.00%	$980	1.55%
Mountains	-$138	-1.66%	$745	1.30%
National	-$136	-1.81%	$705	1.21%

Note: Negative numbers reflect gains in welfare.

Again, there are substantial differences for the lower-income households across regions. In 8 of 11 regions, households in the bottom two deciles experience a net gain from this policy. Only poor households in the Ohio Valley, Florida, and the Northeast incur net losses. At opposite ends of the range, poor households in Texas gain, on average, $317 or 3.5 percent of annual income, while poor households in the Northeast lose $141, or 1.17 percent of income.

Our energy efficiency investment scenario may be a best-case scenario for such a policy. There are important institutional challenges to achieving gains from end-use efficiency investments. Nonetheless, our modeling suggests that if these challenges can be overcome such a policy might have important distributional benefits.

6.4 Free Allocation to Emitters

The last scenario we analyze is one in which allowances are given away for free to emitters. There are several ways that this can be done. One is on the basis of each emitter's share of production, known as "output-based allocation." Another is on the basis of inputs to production. Moreover, these measures can be updated each period to reflect recent economic activity. However, the most common method has been to give allowances away for free to incumbent emitters on the basis of historic measures.

6.4.1 Grandfathering to Incumbent Emitters

Free allocation to incumbent emitters, often referred to as grandfathering, is typically based on a historically observable measure such as emissions, fuel use, or economic activity. The first large application of cap-and-trade began with the 1990 Clean Air Act Amendments that launched the SO_2 trading program, and in that program emissions allowances were allocated for free to emitters (incumbent facilities) based on a formula that accounted for activity levels (heat input) in a 1985–1987 base period. Free allocation based on a historic measure provides no incentive to change behavior in order to affect one's allocation. The value of emissions allowances accrues to the firm independent of ongoing economic activity, so it can be viewed as compensation to shareholders.

Other authors have analyzed the distributional consequences of grandfathering emissions allowances. Both Dinan and Rogers (2002) and Parry (2004) have shown that grandfathering can be extremely regressive because the value of the allowances accrues to shareholders, who are predominantly from higher-income households. Our findings are consistent with these earlier results. We include the scenario here for comparison purposes with our other policy options.

To model free allocation to emitters we assume the allocation goes to corporate entities midstream or upstream in the fuel cycle. We assume allocation goes to fossil-fired generators (emitters) in the electricity sector. Customers in the electricity sector are affected in different ways in different parts of the country depending on the amount they spend on electricity, the way price is determined in their regional electricity market, and on the carbon intensity of electricity generation. Burtraw and Palmer (2008) use the Haiku electricity market model to analyze the effects of free allocation and find that customers in regions of the country under cost-of-service regulation can expect to gain the benefit of free allocation through reductions in electricity prices because regulators in those regions will apply the value of allowances to offset other changes in costs in the wholesale power market. However, firms in competitive regions of the country would behave like competitive firms in other sectors, and the prices seen by customers would be based on opportunity cost. Hence, in these cases the value of the free allocation accrues directly to shareholders.

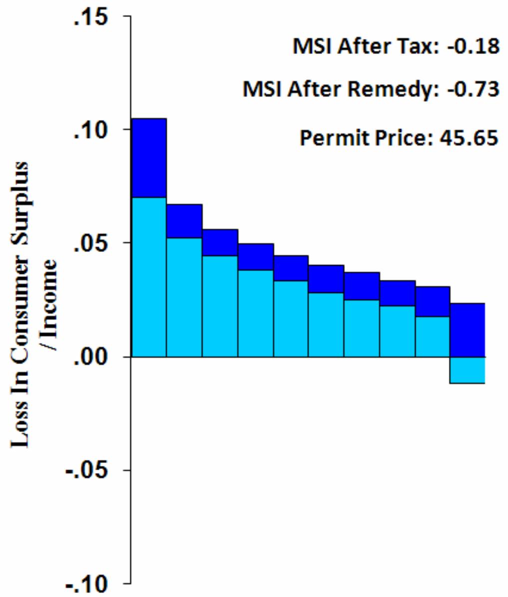
With the exception of regulated electricity markets, the value of allowances accrues as an increase in shareholder value and will be taxed both at the corporate level and personal level. Following Dinan and Rogers (2002), we assign corporate tax liabilities to households based on their personal capital income and conclude that the government would capture 45 percent of the value distributed through free allocation. This is calculated based on an average marginal corporate tax rate of 30 percent, an additional 10 percent captured by dividend and capital gains taxes paid by households, and 5 percent captured by state and local governments, totaling an amount that exceeds the value necessary to keep government whole. We assume that 10.2 percent of the value to shareholders accrues to foreign interests (Department of the Treasury 2007). The remainder of the value to shareholders is distributed according to the percentage of equity held by their income group, which we take from 2004 Survey of Consumer Finances.[29] Finally, the additional 10 percent in taxes that the government collected is redistributed via per capita dividend.

Figure 18 shows the distributional results for the scenario with free allocation to emitters. The table in the figure illustrates that the consumer surplus loss from free allocation to emitters accrues across the nation. Regional differences stemming from differences in electricity regulation are not as important as differences across income groups. The greatest impact in terms of percentage of income accrues to the lowest- and highest-income groups. The lowest-income groups experience relatively large losses as a percentage of income—6.15 percent of income, on average, ranging from 5.12 percent in the Northwest to more than 9 percent in the Northeast. The highest-income decile, by contrast, enjoys a net consumer surplus gain from this policy. These results are attributable to the fact that high-income households hold a relatively large share of

[29] http://www.federalreserve.gov/PUBS/oss/oss2/2004/scf2004home.html (accessed May 13, 2008).

corporate stock and thus reap most of the benefits of the allowance values. At the national level, the MSI is –0.73, further highlighting the regressivity of this policy.

Figure 18. Free Allocation to Emitters



	Loss of Welfare for Bottom 2 Deciles		Average Loss of Welfare	
	$	%	$	%
Southeast	$651	6.08%	$813	1.44%
CNV	$669	6.17%	$859	1.25%
TX	$776	7.24%	$1,172	2.00%
FL	$780	7.17%	$1,013	1.86%
Ohio Valley	$822	7.76%	$1,137	1.89%
Mid-Atlantic	$823	7.73%	$929	1.41%
Northeast	$932	9.04%	$1,052	1.51%
Northwest	$533	5.12%	$704	1.14%
NY	$764	7.33%	$866	1.29%
Plains	$603	5.83%	$1,001	1.59%
Mountains	$664	6.51%	$913	1.59%
National	$652	6.15%	$936	1.60%

Note: Negative numbers reflect gains in welfare.

7 Discussion and Concluding Remarks

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 those costs are distributed across the population is the allocation of carbon allowances and dispensation of any auctioned carbon revenue. This paper has calculated the distributional effects of 10 different carbon policies across two demographic dimensions, income and geography. Effects across income groups are most concisely illustrated through the calculation of an MSI.[30] Table 3 reports the values

[30] As a reminder, our Suits Index is modified for two reasons. First, we use consumer surplus loss rather than tax payments or expenditure changes, as in the conventional Suits Index. Second, our measure is not bounded by –1 and 1 because some of our policies lead to a gain in consumer surplus rather than a loss.

for the index for the 10 scenarios we have explored. Values greater than zero indicate progressivity; values less than zero, regressivity. Essentially there is little variation in the initial value of the index, prior to the distribution of the revenue, even when the program is designed to exclude sectors, use free allocation, or auction allowances. The table indicates that after imposing the cap-and-trade policy that implements a CO_2 price throughout the economy, the index takes on a value of approximately –0.18, which is fairly regressive.

Table 3. Permit Prices, CO_2 Emissions, and Modified Suits Index by Policy

Scenario	Permit Price ($/ton)	Per Capita CO2 Emissions	MSI After CO2 Price	MSI After Revenue is Distributed
Cap-and-Dividend (Non-Taxable)	$41.52	17.06	-0.18	0.05
Cap-and-Dividend (Taxable)	$41.52	17.06	-0.18	0.15
Invest in Efficiency	$37.20	17.06	-0.18	0.16
Exclude Home Heating	$42.80	17.06	-0.18	0.13
Exclude Transportation	$43.25	17.06	-0.17	0.06
Expansion of EITC	$41.52	17.06	-0.18	0.23
Free Allocation to Emitters	$45.65	17.06	-0.18	-0.73
Free Allocation to Electricity Consumers	$46.95	17.06	-0.17	0.11
Reduce Income Tax	$41.52	17.06	-0.18	-0.79
Reduce Payroll Tax	$41.52	17.06	-0.18	-0.33

When one explores the way that the program allocates the value of emissions allowances, however, the MSI varies considerably across policy cases. The most regressive policy is the use of revenue to reduce income taxes, which has an MSI of –0.79. This value results because we assume a proportional reduction in taxes paid across all income groups. The most progressive approach is also tax related. Using some allowance revenue to expand the EITC results in an MSI of 0.23. Seven of the policy scenarios we analyze are progressive and three are regressive.

Policymakers face a trade-off between efficiency and distributional equity when designing a cap-and-trade program. We evaluate our options for a fixed emissions reduction target and then solve for the allowance price necessary to achieve that target. This price provides information on the efficiency cost of each policy.

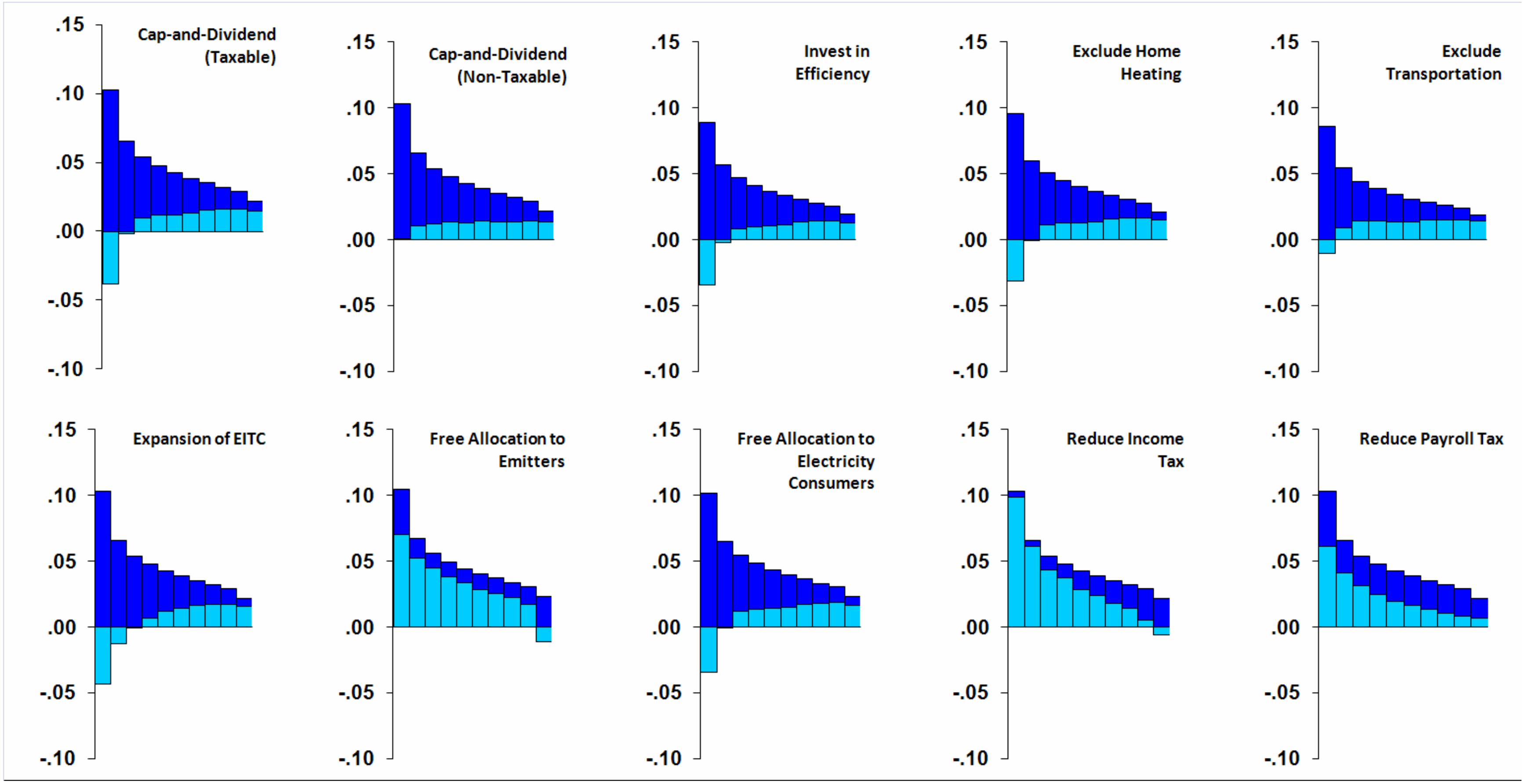
It is clear from Table 3 that some of our options come with an efficiency cost. The options that exclude particular sectors—transportation or home heating—lead to higher allowance prices. In effect, the other sectors of the economy have to work harder to achieve the targeted emissions reductions. The same is true of the scenario in which allowances are allocated free to electricity consumers, though the ramifications here are even greater—without getting the low-cost reductions from the electricity sector, we need the allowance price to rise even more. Thus, although all three of these options appear progressive, once the revenue is returned in a lump sum manner, this increased progressivity comes at the expense of efficiency. In contrast, policies that reduce pre-existing taxes may have efficiency benefits because of the incentives they provide to expand labor supply and these benefits are not captured in our framework. However, we find these policies are severely regressive. As shown in Table 3, the MSIs for reducing payroll and income taxes are both negative, indicating that the policies are regressive. Consequently this array of policies illustrates a tradeoff between equity and efficiency in the policy choice.

The scenario in which allowances are allocated free to emitters offers no trade off; it is costly and has negative distributional consequences as well. One component of this outcome stems from the fact that with free allocation to emitters about 10 percent of the allowance value flows overseas to foreign holders of shareholder equity. Also, electricity consumers in regions of the country with cost-of-service regulations do not see their prices rise as much in this scenario, the allowance price has to be higher to achieve the same overall level of emissions reduction. On top of this, since the value of the free allowances accrues primarily to higher-income households, this option is decidedly regressive.

However, the equity-efficiency tradeoff is also not apparent in the policy that would invest allowance value to improve efficiency in the end use of energy services. This policy is one of the most progressive we examined and would lead to lower allowance prices, indicating less cost would be imposed on other sectors of the economy in order to achieve the specified climate goal. However, the implementation of this policy is the most problematic of any that we consider. Engineering studies and other analysis identify ample opportunities to improve efficiency at relatively low cost. From an economic perspective, for such opportunities to exist would depend on persistent market failures or institutional failures. It is unclear whether the direct investment of allowance value in energy efficiency could overcome those failures and improve the efficiency of energy use in a cost effective manner, and indeed what institutions could be employed to achieve this result. Hence, we conclude that further consideration of this policy design is one of the most fruitful areas for further research.

Figure 19 shows a comparison of the impacts across income deciles at the national level of all 10 policy scenarios. Again, the dark blue shows the consumer surplus loss as a fraction of annual household income before distribution of the revenues, and the lighter blue shows the net consumer surplus loss after the revenues have been returned. The bar graphs clearly show that three options do little or nothing to reduce the regressivity of the carbon pricing policy: free allocation to emitters, reducing the income tax, and reducing the payroll tax. All three of these options reduce the cost of the policy—that is, the lighter bar lies below the darker one—but do not change the relative incidence. Most of the other options greatly reduce the burden on the lowest deciles and equalize the loss as a fraction of income across deciles. In several of these options—both cap-and-dividend cases and the two exclusion cases—these impacts result from the lump sum redistribution of the revenues. In the EITC scenario, the benefit of the tax credit goes to lower-income households. Finally, in cases where sectors are excluded or where money is spent on energy efficiency, the benefits are a combination of lower initial price increases and lump sum per capita redistributions of carbon allowance revenue.

Figure 19. Incidence of Alternative Cap-and-Trade Policies across Income Deciles: Net Consumer Surplus Loss as a Fraction of Annual Household Income

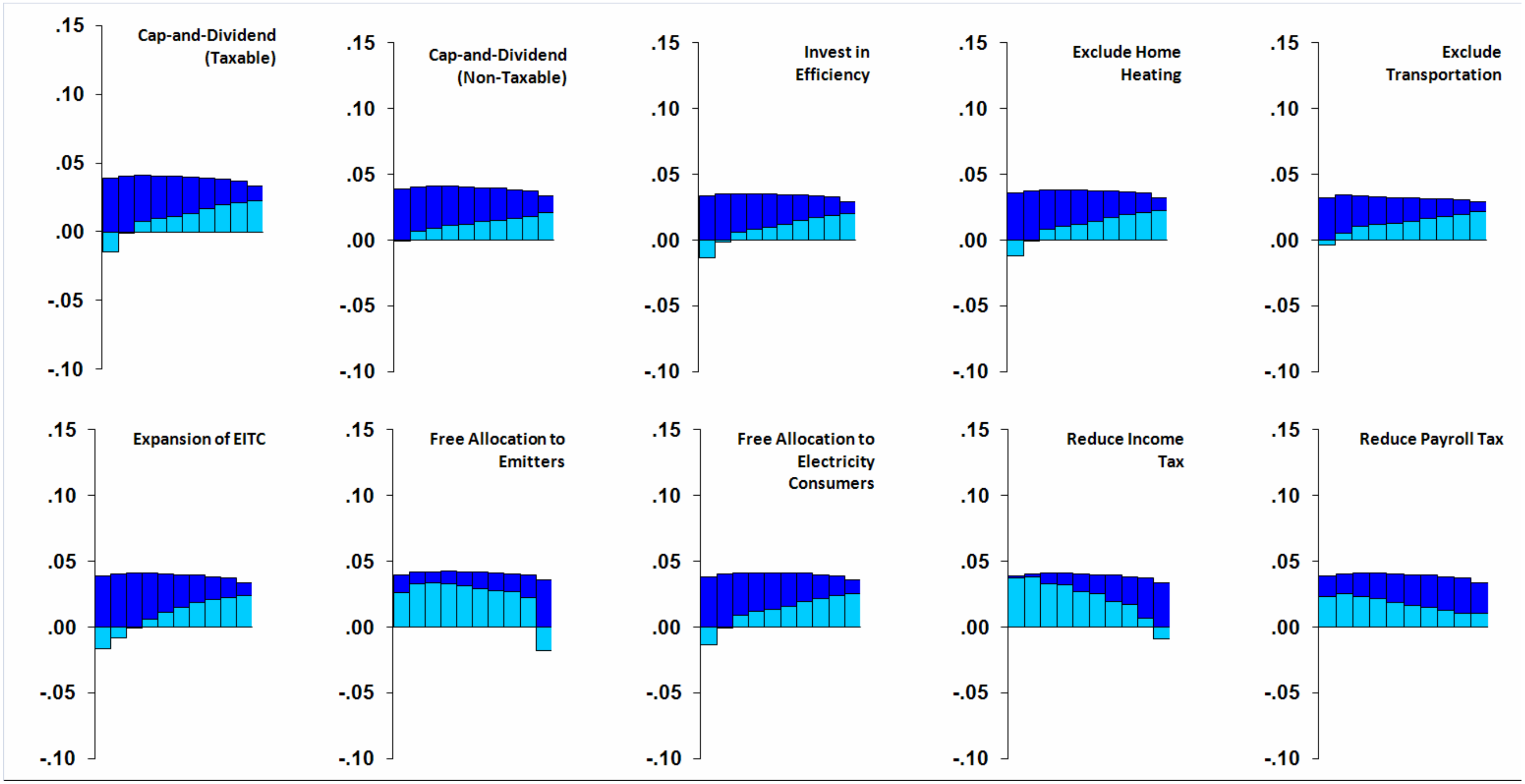


The policy scenarios also have different effects across regions of the country, and the biggest regional differences are for poor households. Households in the bottom two income deciles in the Northeast, Ohio Valley, and Florida are consistently harmed more than households in the bottom two deciles in other regions. The differences are particularly large for some policy cases: for example, welfare costs for poor households from the EITC expansion policy range from $120 per year in the Northeast to –$600 in Texas; free allocation to electricity consumers has welfare costs of $221 in the Northeast and –$339 in Texas. For average households, the differences in costs of the policy options are not as great, especially as a percentage of income. Average households in the Northwest (Idaho, Montana, Oregon, Utah, and Washington) and California/Nevada are harmed less than average households in other regions. Average households in the Plains, the Ohio Valley, Florida, and the Northeast are usually harmed more, but on a percentage of income basis, the range is not large.

While 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 carbon footprint, one can make the case that their citizens deserve any extraordinary benefits 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 available to reduce their carbon 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 20 includes the same information as Figure 19 except that we now show the consumer surplus loss as a fraction of total annual household consumption rather than annual income. 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 income.

Figure 20. Incidence of Alternative Cap-and-Trade Policies across Income Deciles: Net Consumer Surplus Loss as a Fraction of Annual Household Consumption



Clearly, all of the policy scenarios now look much less regressive before return of the revenues than they did in Figure 19. Pricing carbon 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 scenario in which emitters get free allocation and the scenarios in which income or payroll taxes are reduced. These findings are consistent with others who have found that the regressivity of many taxes is muted when consumption is used in place of income.

7.2 Options for Policymakers

The results presented in this paper represent bookend examples of potential climate policy design and revenue recycling programs. Rather than offering a normative ranking of the relative merits of each policy, this paper should be viewed as a menu of policy options. Each scenario is potentially viable on its own, but policymakers are likely to mix and match components of each approach to temper the magnitude or scope of the incidence of climate policy. For example, we analyzed each remedy individually and assumed that remaining funds would be returned as a dividend back to people on a per capita basis. However, programs such as investments in energy efficiency and expansion of the EITC could be undertaken simultaneously. Or, 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 system or electricity infrastructure.

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 are local, then the local and regional affects of policy may be fundamentally important to building the political coalition necessary to enact climate policy. While 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 carbon reduction targets.

7.3 Limitations and Research Needs

Although we feel that our work is more detailed and comprehensive than previous literature on this topic, there are a number of uncertainties and limitations to our results that we hope to address in future work. Some of the important issues that should be considered include

- 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 and analysis of alternative remedies.
- Sensitivity analyses of some parameters such as the various elasticities we use to calculate consumer surplus losses.

Finally, a policy that direct allowance value to improve the efficiency in the end use of energy is the most promising in terms of resolving the tradeoff between equity and economic efficiency. However, the institutions that would be employed to implement this policy are unclear. This policy may be one of the most fruitful areas for further research and analysis.

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Appendix A

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
CNV	CA, NV	338	592	737	863	968	1,109	1,272	1,383	1,657	1,833	1,172
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, MS, 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	438	487	664	763	847	1,003	1,272	1,296	1,418	1,706	993
National		360	492	672	829	962	1,089	1,244	1,361	1,564	1,682	1,025

Appendix B

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
CNV	CA, NV	5,287	6,137	6,079	6,893	7,513	7,604	8,685	9,831	11,089	14,858	8,982
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, MS, 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	8,704	10,353	10,539	11,969	13,088	14,652	15,715	15,914	17,379	19,706	13,845
National		7,313	9,828	11,138	12,305	12,859	13,656	14,572	15,585	16,899	20,298	13,445

Appendix C

Natural Gas (Cubic feet) 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
CNV	CA, NV	24	24	27	32	33	37	39	45	53	68	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, MS, 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	30	39	40	42	44	47	55	72	66	96	53
National		22	31	35	38	41	47	48	55	63	82	46

Appendix D

Fuel Oil (Gallons) Consumption by Decile and Region

		Decile										
Region	**States**	**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
CNV	CA, NV	12	14	15	14	11	25	30	47	28	40	25
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, MS, 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	16	16	22	36	19	12	27	50	8	15	22
National		38	71	59	70	77	73	91	93	114	148	83