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PROPERTY RIGHTS AND LAND POLICIES

Edited by Gregory K. Ingram and Yu-Hung Hong

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Property Rights Created Under a Federalist Approach to Tradable Emissions Policy

Dallas Burtraw and Richard Sweeney

Federal and state policies aimed at slowing the heating of the planet will impose potentially significant costs on the economy. To reduce such costs, economists have promoted the use of incentive-based approaches such as emission fees and cap and trade to complement other regulations for reducing greenhouse gases (GHGs). These approaches are particularly well suited for reducing GHG emissions because the emissions are uniformly mixing in the atmosphere and their damage is not related significantly to location or timing. Consequently, the administration of incentive-based programs is much simpler for GHGs than for a pollutant that has an important spatial or temporal dimension. Furthermore, there is tremendous variation in the cost of emissions reductions among agents in the economy, and indeed among nations; therefore, an incentive-based approach leads to much lower overall compliance costs than do

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traditional pollution control methods. Incentive-based approaches provide a financial signal to agents in the economy about the social opportunity cost of their actions, just as prices in a market provide a signal about the resource costs of goods and services. In each case, the signals help ensure that resource capabilities are allocated to their highest valued use.

Most experience with incentive-based regulation is with emissions cap and trade programs, which is the primary approach for comprehensive climate policy aimed especially at reducing carbon dioxide (CO_2), the most ubiquitous GHG. The United States has substantial experience with cap and trade policies, and the European Union launched the world's largest cap and trade program for CO_2 in 2005. As the name implies, a cap and trade approach has two elements. The emissions cap represents the maximum allowable emissions (for example, tons of CO_2) that can occur in the aggregate over all regulated emissions sources. The second element is the use of tradable emissions allowances, which introduces an intangible property right that can be bought and sold and, if banking is allowed, saved for use in the future. Every regulated source is required to surrender an emissions allowance for every ton it emits. While both the regulator and the regulated sources view the surrender of allowances as a requirement, an allowance also presents the regulated sources with a valuable and scarce right to emit.

One criterion that plays an important role in designing a regulatory program is the extent to which the policy disproportionately burdens any one segment of the population. This chapter provides evidence for how a cap and trade policy may affect different types of households and guidance for how to modify those effects. Because a cap and trade approach puts a price on CO_2, it can have a severe distributional effect. This effect depends on how the price on CO_2 changes expenditures and ultimately consumer surplus throughout the economy. Equally important, its distributional effect depends on how the policy distributes the value created by the imposition of a price on CO_2, such as the allocation of emissions allowances (Boyce and Riddle 2007; Dinan and Rogers 2002; Parry 2004).[1]

This chapter also examines the notion that state government may be better situated to address local issues and especially to ameliorate the distributional burden of policy on particular groups, and the possibility that states continue to play a leading role within the context of a federal cap and trade program. For example, states may be given the responsibility of allocating some portion of emissions allowances. Climate change is a global problem, and its solution will require international cooperation, which seemingly places the federal government in a central role. However, in the United States and some other nations, including Australia, state and local governments have been active in developing policy,

1. Another way climate policy will affect households is by affecting opportunities for employment, and some of the economic impacts may be concentrated in severely affected communities, which is not part of this analysis.

including regional cap and trade programs.[2] One hears at least two justifications for climate policy initiatives at the state and local levels. Local political bodies sense that they have to do something to address the problem. For over a century, state and local governments have had the primary role in enforcing environmental regulations and in land use planning, building codes, and so on. Second, state policy makers undoubtedly recognize the importance of broader efforts and view their own actions not as ultimate policy solutions, but rather as providing models and impetus for federal and even international action. Nonetheless, state policies will likely be designed to maximize the states' own net benefits, which raises the possibility for strategic behavior.

The example we consider is for states to be given latitude to determine some portion of the allocation of emissions allowances under a federal carbon dioxide emissions allowance cap and trade program. As we describe below, the common architecture of most previous cap and trade programs has held states to allocating emissions allowances, which is an element of the current leading federal proposals. One question is whether the action of one state affects the costs in another state. Will the combination of local interests and conditions result in a pattern of regulatory development that leads to higher costs of compliance overall?

In the United States the allocation of emissions allowances under a CO_2 program would constitute the largest creation and distribution of new property rights in more than a century. Depending on how the program is designed, the value of emissions allowances for an economy-wide CO_2 program could be \$130–\$370 billion annually by 2015 (Paltsev et al. 2007). This value would grow as the stringency of the program grows over time, at least over the first decades. Although the level of the emissions cap is the most visible decision facing policy makers, the assignment of the value of these rights is the most important aspect of the design of the policy. The allocation decision affects both the efficiency and the distributional consequences of the program. If allocation is not treated carefully, it could undermine the efficiency virtues of cap and trade and could lead to unexpected distributional outcomes. How allocation will occur, and the role of state governments within federalist climate policy, could lead to a range of possible outcomes.

The first part of this chapter provides background on the historic relationship between federal and state authority with respect to environmental policy. The second part briefly describes the emerging design of U.S. federal legislation and its plausible alternative, implementation of regulations by the U.S. Environmental Protection Agency (EPA) under the authority of the Clean Air Act. Then we provide an overview of the distribution of costs from climate policy across

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2. Ten northeastern states are participating in a regional CO_2 trading program that took effect in January 2009, and California is considering whether to use cap and trade to implement its own climate policy. Regional coalitions of states in the West and Midwest are also considering cap and trade programs.

income groups and across regions. This distribution can be quite uneven, posing a challenge for federal policy. Subsequently, we look at federalist aspects of the design of the program when some portion of the allocation decision is delegated to the states. States will inevitably try to address their own regional issues. We search for strategic elements in state-level decisions and how they may affect the overall performance of the program.

Federal and State Conflict Over a Vast, Newly Created Intangible Property Right

The use of air and water for disposal of waste has always had substantial economic value, but in prior approaches to regulation the value has been implicit because there was no formal market for these resources. The ownership of common-pool resources such as air and water is generally seen as vested in the public, held in "public trust" for the benefit of the public. Historic conflicts over air and water pollution have been about what share of these public resources should be allocated to waste disposal services and what share should be reserved to protect public consumption of air and water. For as long as environmental policy was viewed primarily as an issue of what regulations to apply to the use of the air and water, the value of environmental resources remained implicit; the issue of ownership did not arise; and the discussion of environmental federalism was in terms of what level of government had the power to establish and enforce regulatory standards. The introduction of formal markets for tradable emissions allowances makes the value explicit, portending a dramatic shift in the level of authority for resource management (Burtraw and Shobe 2007).

Emissions allowance trading took a long time to come to fruition in public policy. Pigou (1920) was the first economist to suggest that incentive-based policies for environmental policy, specifically an emissions fee, would be a way to internalize the environmental costs of pollution into private decisions. Emissions trading was identified as an alternative far later when Crocker (1966) proposed that the government set a cap on aggregate emissions and let the market determine the degree of abatement at individual facilities and the price of emissions, rather than having the government set the price through an emissions fee.

The earliest application of trading emissions rights introduced flexibility to the traditional way of implementing environmental regulation. In the late 1970s, the U.S. government began to impose sanctions such as restrictions on highway funds on areas of the country that were in "nonattainment" with local ambient air quality standards.[3] It was also recognized that these standards and sanctions might restrict economic growth in regions in violation. To enable localities violating the air quality standards to continue to enjoy economic development without

3. Standards for local air quality are set by the federal government.

further increasing emissions, the EPA designed a system whereby new emitting sources could pay existing sources to reduce their emissions sufficiently to offset any increase in emissions. Related programs included the "bubble" policy that allowed a facility to comply with a standard defined over multiple sources, rather than having to comply with individual restrictions for each source. In the 1977 Clean Air Act amendments, Congress recognized the offset policy in law and also made it possible for existing sources to bank emissions reductions for later use. While an improvement from the status quo, these programs constituted an informal market in which property rights were not well defined. Trades had to be preapproved by the environmental regulator. There was limited ability to bank reductions; some unused emissions reduction credits were lost; and the transaction costs for each trade approached 50 percent of the value of the trade.

Title IV of the 1990 Clean Air Act amendments provided for the advent of emissions allowance trading within a formal market in the sulfur dioxide (SO_2) emissions allowance trading program. The introduction of a formal market transformed the disposal services of atmospheric resources into an asset with a stream of valuable monetary returns. The power to regulate in a formal cap and trade program implies the power to determine the disposition of the stream of valuable returns on the regulated activity. Although no one seemed to remark on it at the time, by transferring the right to allocate the economic value of SO_2 emissions from sources covered by the law, the program transferred a valuable ownership interest from the states to the federal government. For all intents and purposes, an asset that had been held in trust by state governments became the property of the federal government. The law created an asset with substantial market value and gave the asset to the regulated firms free of charge. The current annual market value of SO_2 allowances is approximately $5 billion, just under 1 percent of all state expenditures in 2006.

Although there have been subsequent trading programs, the SO_2 program is unique as the only example of appropriation of the common-pool resource value of the atmosphere by the federal government. The second large federal experiment in cap and trade, the nitrogen oxide (NOx) budget program, is comparable in terms of the value of emissions allowances and followed a different pattern. The program was the result of negotiations among the participating states to establish state budgets for allowable emissions of NOx. Implemented with the oversight, monitoring, and enforcement of the federal EPA, this program gave the states control over how the allowances were allocated to firms. A variety of approaches were used, including various forms of free allocation for the majority of allowances and some portion of direct sale (Kentucky) and auction (Virginia).

The two existing mandatory programs for cap and trade of CO_2 also follow the precedent of the NOx budget program rather than the SO_2 program. The European Union (EU) Emissions Trading Scheme leaves the allocation of emissions allowances to member states. In the first two phases of the program (2005–2012), the EU provided guidelines on allocation and approved allocation plans, but this was mostly because the member states had the authority to determine which sources would be included in the program. The important constraint was the requirement that the vast majority of allowances had to be given away for free. Beginning with the third phase (2013–2020), the EU will require the member states to auction over two-thirds of allowances, including 100 percent to the electricity sector, but the member states will retain broad discretion about the disposition of funds from the auction. The second mandatory program is the Regional Greenhouse Gas Initiative, which leaves the allocation decision to the 10 participating northeast states. At least 25 percent of the allowances are required to be auctioned, with revenues dedicated to complementary program goals. In practice, nearly 90 percent of the allowances will be distributed by the states through auction. It is noteworthy that these states are, in fact, claiming ownership of assets that various legislative proposals for a U.S. federal cap and trade program would claim for the U.S. Treasury or for federally determined free allocation to other interests.

A Fork in the Road for U.S. Climate Policy

In the years leading up to 2006, the lack of momentum for climate policy in Washington, DC, set the stage for the emergence of initiatives at the state and regional levels. Inaction in Washington also helped precipitate a recent Supreme Court ruling (discussed below) requiring the EPA to initiate regulatory activities pertaining to climate change, under the auspices of the Clean Air Act, that must go forward in the absence of new legislative direction. However, a growing flurry of legislative activity since the election of 2006 could preempt both state and regional actions and other federal regulatory developments.

POTENTIAL FEDERAL LEGISLATION

It is difficult to follow the plot in federal legislative proposals. At least 12 major bills are being considered by Congress. The leading vehicle in 2008 was the Lieberman-Warner proposal (SB 2191), which would implement an economy-wide approach based on a mix of upstream and midstream compliance responsibilities.[4]

The allowance distribution plan for SB 2191 reflects a variety of goals and interests, but about 22 percent of the allowances in the year 2012 would be allocated to states in one fashion or another.[5] One major portion is directed to electricity load-serving entities (9 percent) and natural gas distribution companies (2 percent), the retail entities that interact directly with customers. These allocations are intended to address a variety of purposes, including promotion of

4. This legislation is the reincarnation of the previous McCain-Lieberman proposal (SB 280). Over time, the evolution of SB 280 to SB 2191 included a growing role for auctioning allowances and adoption of the compliance architecture of Bingaman-Specter (SB 1766).

5. The remainder is allocated using a mix of free allocation to industry and an auction.

investment in end-use efficiency and direct rate relief for customers. Discretion in large part is left to state regulators. The states also receive a general allocation (4.5 percent) for unrestricted use of allowance value. A portion (1 percent) goes to states to promote mass transit. Another portion (5 percent) provides incentives for a variety of specific programs, including decoupling of electricity revenues from sales, rewards for early reductions, land use planning, and efficiency investments. A final portion (0.5 percent) is directed to tribal governments.

EPA RESPONSIBILITY UNDER THE CLEAN AIR ACT

In the absence of new federal legislation, responsibility appears to fall to the EPA. Although the Clean Air Act provides broad applicability to different pollutants and sources, the EPA had declined to regulate CO_2 based on the claim that it does not fit the act's definition of an air pollutant. In April 2007 the U.S. Supreme Court found in *Massachusetts v. EPA*, 549 US 497 (2007), that "greenhouse gases fit well within the Act's capacious definition of 'air pollutant'" and therefore may be regulated under the Clean Air Act.[6] The practical implication is that the EPA is required to take steps, beginning with a determination of the danger of CO_2, and subsequently to develop and promulgate regulations to mitigate the harm.

A second recent decision addressed the EPA's ability to adopt cap and trade as a strategy for regulating pollutants under the Clean Air Act. In *New Jersey v. EPA*, 517 F.3d 574 (D.C. Cir. 2008), the Washington, DC, Circuit Court invalidated the EPA's Clean Air mercury rule, which would have implemented a cap and trade program for mercury. The trading program was premised on the EPA's decision that mercury should not have been classified as a hazardous air pollutant, which would preclude the use of trading in compliance. It is notable that the decision did not address the legality of cap and trade per se, leaving open the possibility that the EPA could itself administer a cap and trade program for CO_2.

The third decision led to the demise of the Clean Air Interstate Rule, which was an important regulatory measure to tighten emissions of SO_2 and NOx from electricity generating units and major industrial sources. In *North Carolina v. EPA* et al., No. 05-1244 (D.C. Cir.) (2008), the Washington, DC, Circuit Court ruled that the cap and trade approach failed to follow the mandates of the Clean Air Act in part because it could not ensure that pollution sources in one state did not cause significant pollution loads in other states. The reason is that emission

6. Massachusetts and other states, along with some environmental groups, sued the EPA after the EPA denied the states' petition to regulate CO_2 from vehicles. The court found that the "EPA can avoid promulgating regulations only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do." While the ruling of the court focused narrowly on vehicle emissions, it is generally believed that, in the absence of new legislation, the ruling would also affect the regulation of CO_2 emissions from fixed sources through a finding of endangerment from CO_2.

reductions in one state might lead to the transfer of emissions allowances to an upwind state. CO_2 emissions do not have geographically specific consequences, so this leaves open the possibility that the EPA could administer a cap and trade program for CO_2, but a variety of other regulatory outcomes are also possible.

One plausible approach would be for the EPA to adopt a national cap on CO_2 covering point sources and to delegate responsibility and limited authority to the states to achieve those goals. As under the existing NOx trading programs, the states could be apportioned CO_2 emissions budgets as a share of a national cap and could allow their sources to participate in a federally managed trading program. The states would retain the value of the emissions allowances and could allocate the rights as they wished. They could even choose to opt out of the trading program if sources in the state do not emit more than allowed under the state's share of the cap.

Given the structure of the Clean Air Act, there might be multiple caps on CO_2, each being specific to a sector. This would reduce the efficiency of the program. If sources were separated by their sector, each sector would face a different price for CO_2 emissions, and trading opportunities that reduced overall resource costs would be unrealized. Furthermore, the EPA might revert to the familiar paradigm of prescriptive regulations, for example, by promulgating prescriptive emissions standards for some or all sectors and treating new sources differently from existing ones. The most likely outcome is that the EPA would have to borrow from each of these possible strategies to regulate many source categories. This mix of potential outcomes, along with the heterogeneous allocation of allowance value that could emerge under federal legislation, motivates interest in the possible distributional consequences across regions of the country.

Regional Impacts from National Climate Policy

Climate policy implemented in a uniform way at the national level will have nonuniform effects on regions of the country. This section of the chapter presents an analysis of how different approaches affect different income groups by region of the country under a national cap and trade program.[7] Results are illustrated for each of 11 regions in the country and for households sorted into annual income deciles. Effects are calibrated to roughly correspond to effects that would occur in 2015 from policies enacted in 2008. Most of the previous literature focuses on income distributions at the national level and the impact of the policy on each income category. We extend this literature by focusing on regional differences that we and some other analyses (such as Batz, Pizer, and Sanchirico 2007) find to be important.

7. This analysis is updated and developed fully in Burtraw, Sweeney, and Walls (2008).

One way to measure the distributional impact is to look at the absolute measure of cost born by different types of households. However, an absolute measure does not take into account relative ability to pay. The term *vertical equity* is used to suggest that households with a greater ability to pay should be asked to pay more. From the perspective of vertical equity, a policy that affects households in a neutral way is usually thought to impose costs as an equal percentage of household income. A regressive policy imposes the greatest costs, as a percentage of household ability to pay, on lower-income households. Conversely a progressive policy imposes the greatest costs, as a percentage of ability to pay, on relatively wealthier households.

We measure ability to pay on the basis of imputed income, net of taxes and transfers, for households as reported in the Consumer Expenditure (CEX) survey for 2004–2006 (Bureau of Labor Statistics 2008). Substantial literature suggests that annual income may underestimate ability to pay for households at the lower and upper ranges of the scale. One reason is that lower-income households may have unreported income. In addition, younger and older persons may have low current income that does not reflect lifetime earnings or savings.[8] Most taxes look more regressive using annual income instead of lifetime income (Fullerton and Rogers 1993), and this caveat should be kept in mind when viewing our results.

There are several paths through which different mechanisms to control CO_2 emissions affect low-income households. We account for the following:

- Changes in prices of fossil fuels, which impose a direct cost on household expenditures and increase the cost of production of other goods consumed by households, which poses an indirect expense on households.
- Changes in quantities consumed that result from higher prices. We use a partial equilibrium approach employing elasticity estimates from a variety of sources and new calculations from a detailed electricity market model to estimate and account for these changes.
- Changes in producer behavior in the electricity sector (only).

8. Some authors have constructed proxies for lifetime income based on information on age, education, and other factors (Casperson and Metcalf 1994; Hassett, Mathur, and Metcalf 2009; Rogers 1993; Walls and Hanson 1999). Others have relied on annual consumption expenditures as a proxy for lifetime income, based on the permanent income hypothesis that annual consumption is a relatively constant proportion of lifetime income (Poterba 1989; West 2004). Some experts have argued that there is merit in using annual income. It may in fact underestimate the ability to pay at the upper-income levels, because these families may have substantial wealth that provides much greater ability to pay than is revealed by annual income, and thereby offset the potential bias among low-income families. Barthold (1993) argues that it is politically impractical to talk about lifetime income because of the inherent uncertainty in measuring it and because of the shorter time horizons of elected officials and the voting public. Moreover, empirical evidence on the permanent, or lifetime, income hypothesis is mixed (Shapiro and Slemrod 1994).

- Changes in consumer surplus resulting from the change in expenditures and the quantities of goods and services consumed.
- Changes in government taxes and transfers, including the allocation of CO_2 emissions allowance value created under an emissions trading program. For example, a cap and trade policy that freely distributes emissions allowances to emitters directs their value to owners of shareholder equity in these firms, at least in competitive industries. Households that own shares of these firms receive this value as a form of nonlabor income. When allowances are auctioned, the value is transferred to the government, which could potentially use the revenue to offset the cost of the program on the economy in general or on specific types of households in particular.

It may be equally helpful to understand what we do not account for:

- Ancillary effects from changes in employment and income that may result from a shift in economic activity away from relatively more-energy-intensive sectors of the economy to less-energy-intensive sectors
- The relative competitiveness of industries that are regulated by the policy, especially in an international context where they may face competition from unregulated competitors
- Changes in factor (labor and capital) markets that may have preexisting distortions away from economic efficiency (Goulder et al., 1999; Parry, Williams, and Goulder 1999)

ESTIMATING CONSUMER EXPENDITURES IN 2015

A variety of technological, economic, and demographic changes can be expected by 2015. We account only for changes in transportation-related emissions resulting from corporate average fuel efficiency (CAFE) standards that are likely to take effect based on recent legislation and proposed regulations. We also implicitly account for equilibrium changes in electricity markets, including incremental but important changes in investment in supply and demand technologies that occur under both the baseline and the climate policy by 2015. Otherwise, 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 CEX survey includes 110,301 observations for 40,843 households (one observation equals one household in one quarter), as summarized in table 13.1. The Bureau of Labor Statistics (BLS) builds a national sample and a regional sample in four census divisions, with corrections to achieve a statistically reliable sample at these geographic scales. We are interested in a finer level of geographic detail than is apparent in the four census divisions, so we examined the data with state-level indicators, ignoring observations in Alaska and Hawaii. Where confidentiality cannot be protected because of a small sample in any category, the BLS masks information at the finer geographic level, thereby

Table 13.1
Observations by Region and Income Group

	Region[a]	States	1	2	3	4	5	6	7	8	9	10	Total
			Less than $11,000	$11–19,999	$20–27,999	$28–37,999	$38–45,999	$46–59,999	$60–73,999	$74–93,999	$94–117,999	More than $118,000	
1	AEV	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	1,461	1,923	1,573	1,847	1,268	1,577	1,157	1,293	995	1,371	14,465
2	CNV	CA, NV	724	1,169	1,040	1,334	934	1,509	1,145	1,321	974	1,734	11,884
3	ERCOT	TX	493	677	675	804	551	799	611	579	424	644	6,257
4	FRCC	FL	473	766	615	839	512	746	560	565	341	439	5,856
5	MKIO	IL, IN, KY, MI, MS, OH, WV, WI	1,350	2,041	1,925	2,174	1,468	2,220	1,795	2,052	1,264	1,844	18,133
6	MPM	DE, MD, NJ, PA	666	1,131	1,115	1,290	829	1,289	1,094	1,152	785	1,452	10,803
7	NE	CT, ME, MA, NH, RI	310	416	440	412	357	600	450	529	421	673	4,608
8	NWP	ID, MT, OR, UT, WA	464	584	574	739	513	820	677	662	404	648	6,085
9	NY	NY	468	523	410	534	379	598	471	502	427	687	4,999
10	PPPP	KS, MN, NE, OK, SD	237	335	335	430	328	538	440	427	237	412	3,719
11	RA	AZ, CO	330	481	400	555	388	504	375	367	278	394	4,072
	National		10,557[b]	12,803	10,883	12,844	8,786	12,861	9,906	10,525	7,193	10,952	107,310

[a] The region names are not acronyms. They are from the North American Electricity Reliability Council, the U.S. Department of Energy, and the authors.
Source: Bureau of Labor Statistics. 2008. *Consumer Expenditure Survey Public Use Microdata*, http://www.bls.gov/cex/csxmicro.htm.
[b] Numbers in this row are not column totals.

blocking responses from five states. Consequently we have 90,881 observations for 33,315 households in 43 states plus the District of Columbia, aggregated into 11 regions.[9]

We construct income groups based on national-level household-level after-tax income deciles. We then distribute observations based on the CEX survey data into these income groups. It is important to keep in mind that the income "buckets" do not represent regional income deciles; rather, they are constructed as deciles at the national level, based on 2006 BLS estimates.

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. These standards would bring the fuel economy standard for cars to 35.7 miles per gallon (mpg) and for trucks to 28.6 mpg by the 2015 model year.

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 survey data, all else equal. According to data from the Bureau of Transportation Statistics (BTS), 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.[10] 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, Harrington, and Parry (2007) to obtain the higher vehicle price for those new vehicle purchases.[11] A new car in 2015 that meets the 35.7 mpg standard will cost $149 more than it would in 2006, all else equal; a new truck will cost $246 more. To account for these cost increases, we have increased new vehicle costs by this amount in the base case.

Second, gasoline expenditures, all else equal, are lower than they would be without the new standards (and lower than in 2006) because the gradual vehicle turnover leads to improvements in on-road fleet-wide average fuel efficiency. We estimate that the average fuel efficiency of cars on the road will be 26.3 mpg in 2015, while the average for trucks will be 21.9 mpg. These are improvements of 17

9. 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. Observations with missing state identifiers are used in our calculations at the national level. Further documentation of the methods used here can be found in Burtraw, Sweeney, and Walls (2008).

10. 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.

11. Fischer, Harrington, and Parry (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.

percent and 22 percent, respectively, over the fleet-wide average in 2006.[12] When fuel economy increases, the cost per mile of driving falls, and people drive more. The net change in gasoline consumption thus equals fuel savings on current mileage from a unit reduction in mpg, less the extra fuel consumption from the increase in vehicle miles traveled. Based on recent estimates, we assume this rebound effect is 10 percent—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 new CAFE standards, gradual turnover in the vehicle stock, and the 10 percent rebound effect, baseline average gasoline expenditures per household in 2015 are estimated to be 15 percent lower than the 2006 levels.

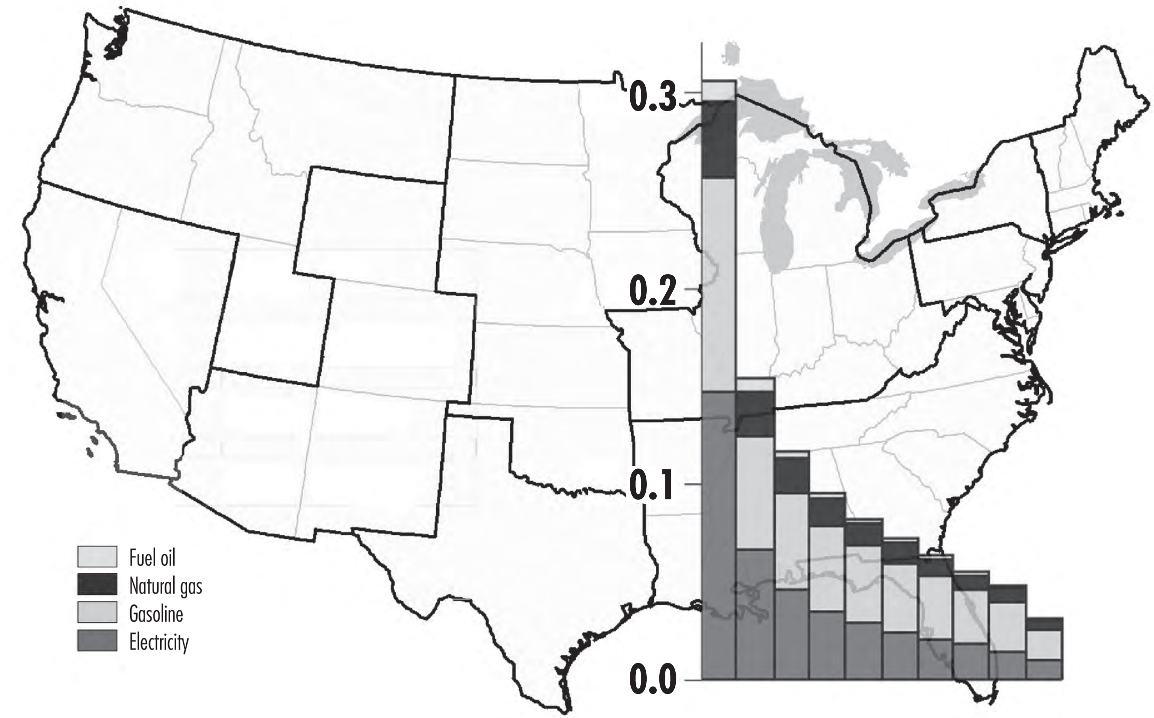
Figure 13.1 illustrates the direct expenditure categories as a percentage of reported income at the national level. The 10 vertical bars represent income deciles, and the amount of expenditure in various categories is displayed for the average household within each decile. The categories that are reported include four categories representing direct purchase by the average household of electricity, gasoline, natural gas, and heating oil. These are relevant because their consumption leads directly to CO_2 emissions, and climate policy would directly increase their cost. At the national level, direct expenditure on energy represents 30.6 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 3.2 percent. On average across all income groups, the share of expenditure on energy is 6.3 percent of annual income.

The nation is divided into 11 regions in our analysis. Figure 13.2 displays the regions with overlays representing the percentage of household expenditure dedicated to direct energy use in each income bracket. To understand the graph, imagine you live in Nebraska with a family income of $41,854. Your household would fall into the fifth income bucket for states in the region, which also includes Minnesota, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Oklahoma. Figure 13.2 indicates that your family spends $3,072 annually on direct energy expenditures, equal to 7.3 percent of your household's income. Of this, 2.2 percent goes to electricity, 3.2 percent to gasoline, and 1.9 percent to natural gas and fuel oil.

In all regions of the country, lower-income households have the highest direct energy use as a percentage of income. Moreover, there is a large difference in the magnitude of expenditure as a percentage of income for lower-income households across regions. For the two lowest income brackets, the highest values are observed in New England, the mid-Atlantic, the South from Texas to Florida, and the Midwest, where expenditures exceed 30 percent of income.

12. On-road average fuel efficiency is available from BTS. See http://www.bts.gov/publications/national_transportation_statistics/.

Figure 13.1
Household Direct Energy Expenditures as a Fraction of Income, by Energy Types



Note: The vertical axis of the bar chart is share of income, and the horizontal axis is income decile.
Source: Bureau of Labor Statistics (2008). *Consumer Expenditure Survey Public Use Microdata*, http://www.bls.gov/cex/csxmicro.htm.

Figure 13.2
Household Direct Energy Expenditures as a Fraction of Income, by Region

Note: The vertical axis of the bar chart is share of income, and the horizontal axis is income decile.
Source: Bureau of Labor Statistics (2008). *Consumer Expenditure Survey Public Use Microdata*, http://www.bls.gov/cex/csxmicro.htm.

Consequently, concerns about the distributional effects of the policy may be more acute in some regions than others.

Moreover, the categories of expenditure vary considerably among the low-income group. In New England and the mid-Atlantic states, home heating contributes significantly to expenditures, but not so in the South, where electricity and gasoline expenditures are greater. The Midwest represents a sort of transition, with intermediate levels of expenditures in all categories among the eastern regions. New York's levels would be as high as the other regions except for lower gasoline expenditures. Overall expenditure in the West tends to be lower, but gasoline expenditure is relatively high, especially compared to the Northeast. As a consequence, the ways to provide relief to low-income households from the cost of climate policy may vary considerably by region.

ESTIMATING THE CO_2 CONTENT OF EXPENDITURES

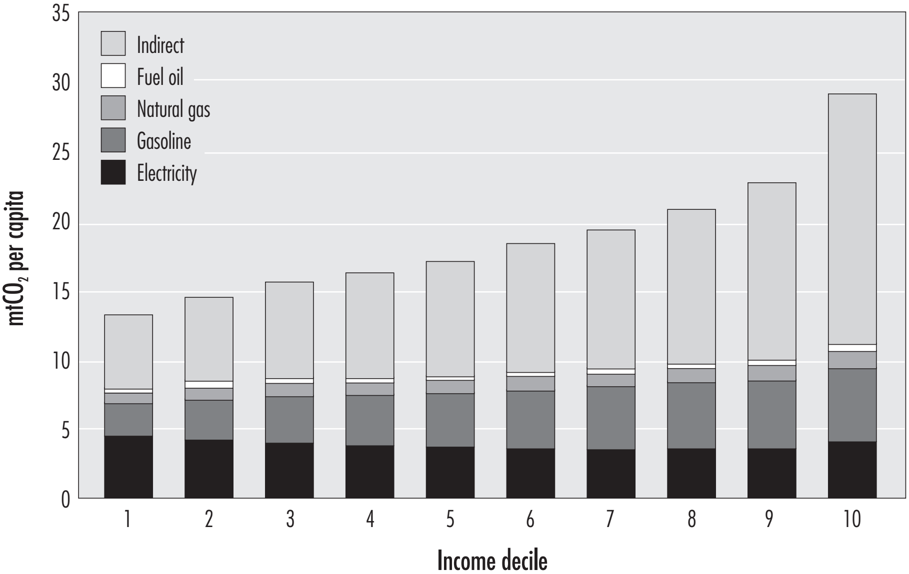
The first step in understanding how household expenditures would be affected by climate policy is to calculate the CO_2 emissions of the average household in each income group. Taking expenditures from BLS, we use fuel-specific, state-specific energy prices from the Energy Information Administration (EIA) to calculate the quantities of fuels purchased by households in each group. The carbon content of natural gas, fuel oil, and gasoline is well established. For electricity, the CO_2 content varies across regions depending on the fuel used for generation over seasonal and diurnal periods. This pattern is identified from the Haiku electricity market model built and maintained by Resources for the Future (Paul, Burtraw, and Palmer 2008).[13]

Expenditures are also affected by changes in the cost of energy embodied indirectly in other goods and services, especially food, durable goods, and services. Calculations of CO_2 emissions resulting from indirect energy consumption are based on data in Hassett, Mathur, and Metcalf (2009), who provide information on the emission intensity of goods aggregated into 38 indirect expenditure categories, updating methods developed in Metcalf (1999).[14] Although the estimates of direct fuel use and the implied CO_2 emissions based on the CEX survey data correspond well to data collected by EIA (Energy Information Administration 2007), the total emissions calculated fall short of economy-wide EIA estimates, and we

13. Haiku models regions with either regulated (cost-of-service) or market-based prices. Haiku finds the emission reductions that can be achieved by a given price of CO_2 to be slightly greater than the EIA model.

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

Figure 13.3
Emissions ($mtCO_2$) per Capita by Income Decile for the Nation



scale up our indirect emissions estimates so that the total corresponds with EIA estimates.[15]

The EIA estimate of metric tons CO_2 ($mtCO_2$) per capita is 20.2 (Energy Information Administration 2007a). After scaling the indirect expenditure category in the CEX survey data and before the CAFE adjustment, we find that personal transportation accounts for 21 percent, home heating for 7 percent, residential electricity use for 20 percent, and indirect expenditures for 52 percent. After adjusting for CAFE, the emissions per capita fall from 20.2 to 19.3 $mtCO_2$. Figure 13.3 illustrates the CO_2 content of expenditures for the average household in

15. Prior to scaling, our analysis of the CEX survey data accounts for per capita emissions of 16.4 metric tons of CO_2 ($mtCO_2$), where information from EIA indicates per capita emissions of 20.2 $mtCO_2$, based on U.S. population in 2006. We scale the emission intensity of the indirect expenditure category, increasing it by 54 percent (3.65 $mtCO_2$ per capita) to achieve overall EIA emission levels. The literature reveals a variety of approaches to deal with the inconsistency. Batz, Pizer, and Sanchirico (2007) correct for oversampling in their demographic model. Dinan and Rogers (2002) scale the CEX survey data so that 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, Mathur, and Metcalf (2009) appear to account for emissions of 24.4 $mtCO_2$ per capita, well above the EIA estimate.

each income group at the national level. We interpret this as a proxy for baseline (no climate policy) emissions per capita in 2015.

ESTIMATING THE EFFECT OF PLACING A PRICE ON CO_2

Cap and trade incorporates not only the cost of investments and changes in processes into product prices, but also the value of emissions allowances. For the next couple of decades at least, the value of emissions allowances under a cap and trade program can be expected to be substantially larger than the value of resources actually used to achieve emissions reductions. Hence, the allocation of emissions allowances plays the key role in determining the regressivity of climate policy under incentive-based policy.

We benchmark the stringency of climate policy to an emissions reduction of 3.17 $mtCO_2$ per capita, including the CAFE adjustment, resulting from a price of \$41.50 per ton of CO_2 (2006 dollars) in a cap and trade program.[16] The 2015 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, we scale the CO_2 price in order to hold per capita emissions constant so that the alternatives can be compared to the benchmark climate policy in an emissions-neutral manner.

The change in product prices is expected to lead to a change in consumer expenditures, which we calculate using short-run elasticity estimates specific to each fuel.[17] The policy-case emissions of 16.9 $mtCO_2$ per capita, a 16 percent reduction from baseline, are distributed across categories, with 21 percent for transportation, 8 percent for home heating, 11 percent for residential electricity use, and 60 percent for indirect goods and services. This approach implicitly assumes that all cost changes are fully passed through to consumers in every industry except electricity, due to the long-lived nature of in-place capital in that sector.

Figure 13.4 illustrates the distribution of costs over income groups at the regional level after accounting for changes in expenditures but before accounting

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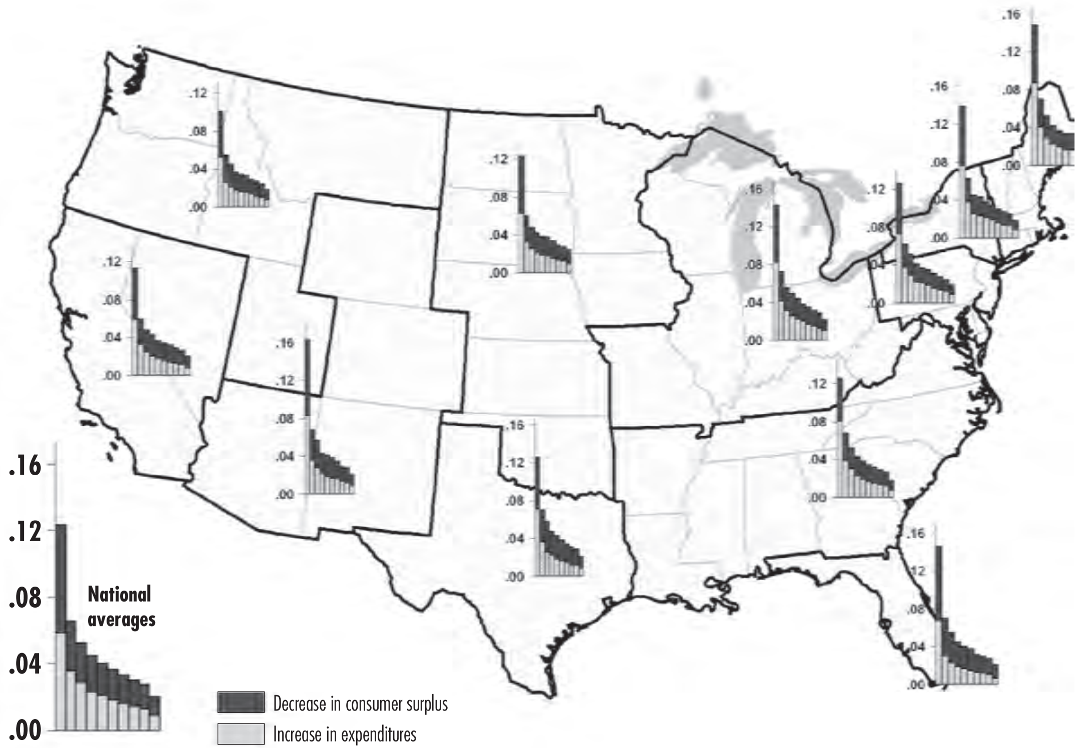
16. This price reflects a marginal cost approximately three times greater than what would have been expected from the McCain-Lieberman proposal (SB 280) and is roughly equal to the price of emissions allowances in the EU Emission Trading Scheme for the second trading period (2008–2012), which are currently trading at about US\$40 $mtCO_2$. The irregular price number results from converting units and the dollar-year for which data are reported.

17. We use a short-run elasticity (ε) for gasoline of –0.1 taken from Hughes, Knittel, and Sperling (2008). For indirect expenditures, we use several short-run elasticities taken from Boyce and Riddle (2007) and ranging from –0.25 to –1.3. 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 change in the carbon price is $\Theta = -0.13$.

Figure 13.4
Cost of Pricing Carbon as a Fraction of Income



Note: The vertical axis of the bar chart is share of income, and the horizontal axis is income decile.
Source: Bureau of Labor Statistics (2008). *Consumer Expenditure Survey Public Use Microdata*, http://www.bls.gov/cex/csxmicro.htm.

for the CO_2 revenues. The insert at the lower left presents the effect at the national level. Consider an average family in the fifth decile. Ignoring the change in consumption that would be expected, as has been done in much of the previous literature, 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 total expenditures of $868 (2.1 percent). The smaller bar in the figure indicates this change.

The change in expenditure does not account for the change in consumer surplus. To see how misleading this could be, imagine an expenditure category with own-price elasticity of demand equal to –1. 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 CO_2. To measure the impact on households, we calculate the change in consumer surplus associated with the change in consumption by measuring the change in area under the Marshalian demand curve corresponding to elasticity estimates provided in the previous footnote. The larger quantity in the bar graphs indicates the change in consumer surplus as a percentage of income. Positive values indicate the absolute value of the magnitude of the loss, which is always larger than the change in expenditure. Again, the greatest losses 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 Lorenz curve is constructed by plotting the relationship between cumulative tax paid and cumulative income earned.[19] The area under this curve is compared with the area under a proportional line in order 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). 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 modified Suits Index value for the CO_2 price of $41.50 is –0.19. This does not account for the revenue; it is simply an illustration of the distribution of the change in expenditures and consumer

18. West (2004) showed that, when demand elasticities vary by income group, using consumer surplus rather than expenditures can lead to different distributional findings.

19. A Lorenz curve graphically represents a cumulative distribution function showing the proportion of the distribution that is assumed by a given percent of values.

surplus. The figure illustrates that the changes as a percentage of income appear to be greatest for low-income households because they have proportionately higher energy-related expenditures.

In contrast to our findings, Hassett, Mathur, and Metcalf (2009) conduct a comparison of the incidence of a carbon tax across regions, finding it "quite remarkable how small" the differences are across regions. However, Batz, Pizer, and Sanchirico (2007) reach a different conclusion. Although they look at direct energy use only, they do so with much greater geographic detail than did previous efforts by looking at data at the county level and at differences in the emissions intensity of electricity generation across the country. They find "substantial variation in the incidence of a carbon emissions tax" (12) 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 more detailed estimates of electricity generation, and it includes indirect expenditures.

The Regional Effects of Policy Alternatives

The price on CO_2 emissions creates significant revenue that must be accounted for in some manner. We assume that the first claimant is government, which is subject to budget constraints (at the federal and state levels combined). Throughout the following analysis, we assume that 35 percent of the revenue collected is immediately directed to the government, leaving 65 percent 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 is given to emitters. In such a case we net out this effect so that the government retains a constant 35 percent share of revenue in each scenario. We examine three policies in detail.

CAP AND DIVIDEND (LUMP SUM TRANSFERS)

One straightforward policy 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 called "cap and dividend" (Boyce and Riddle 2007) and previously was known as "sky trust" (Barnes 2001; Kopp et al. 1999). Using information from the CEX survey, we identify the number of persons per household in each income group in each region and calculate the net change in expenditures given a per capita dividend payment.

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

The results are presented at the regional level in Figure 13.5, with vertical bars representing the effect on households in each income group. The bar with darker shading and the greatest vertical height represents the incidence of the CO_2 price, measured as the loss in consumer surplus as a share of after-tax income. (This value repeats information that was illustrated in Figure 13.4.) For example, a family in Nebraska with an income of $41,854 would fall into the fifth income bucket. Before considering the dividend, the climate policy would cause this family to increase its expenditures by $816. This amounts to a loss of consumer surplus of $1,597, which is equal to 3.8 percent of its household income.

The bar with the lighter shading represents the incidence of the policy after allocating the value of allowances as a per capita dividend. The family in Nebraska receives a post-tax payment of $973, and the incidence of the policy (measured as lost consumer surplus) falls from 3.8 percent to 1.5 percent of income.[21] The magnitude of the dividend varies across regions because of differences in persons per household. According to the CEX survey data, the national average number of persons per household is 2.57. The California/Nevada region has the greatest number of persons per household (2.9), and Florida has the smallest number (2.43). There is also a difference across income groups. The lowest income group has 1.6 persons per household, and the highest income group has 3.3 persons. These differences affect the size of the dividend received by households when it is paid on a per capita basis.

The inset bar graph in the lower left of Figure 13.5 represents the effects at the national level. Households in the lowest group realize gains from the dividend equal to 15 percent of their income. The coefficient reported in the inset is the Suits Index after accounting for the dividend. The value increases from –0.19 before accounting for the revenue to 0.10 after. The dividend has the biggest effects on low-income households when measured as a portion of income, making the dividend policy appear progressive. The lowest income groups in many regions and at the national level realize a net benefit under this policy.[22]

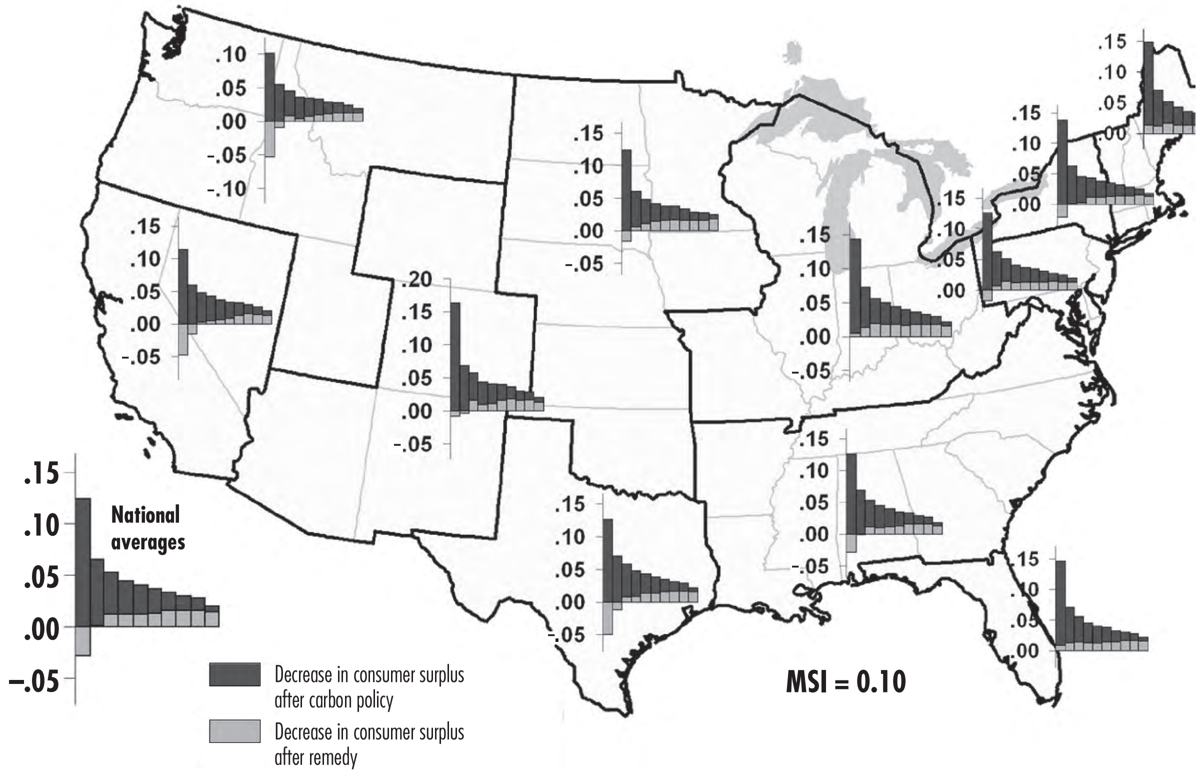
EXCLUSION OF TRANSPORTATION SECTOR FROM THE CO_2 PRICE

The transportation sector is responsible for 32.3 percent of emissions nationally, and the CEX survey data indicate that personal automobile emissions from use of gasoline account for about 21 percent of per capita emissions. Gasoline use

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 behavioral economics literature suggests that consumers are unlikely to factor the expectation of such payments into their short-run energy consumption decisions (Sunstein and Thaler 2008).

22. If no revenue were retained by the government to offset its increase in costs, the dividend would be positive for the bottom five income groups nationwide. However, this would mask the need for increased revenues from other sources, which would also affect family budgets.

Figure 13.5
Cap and Dividend



Note: The vertical axis of the bar chart is the loss in consumer surplus as a share of after-tax income, and the horizontal axis is income decile.
Source: Bureau of Labor Statistics (2008). *Consumer Expenditure Survey Public Use Microdata*, http://www.bls.gov/cex/csxmicro.htm.

is not spread equally around the nation. Table 13.2 illustrates that gasoline use in the West and Southwest is considerably higher than in the Northeast. Furthermore, as illustrated in figures 13.1 and 13.2, transportation expense is not distributed evenly across income groups. The largest expense as a share of income belongs to the lowest income group, and the share decreases as households move up the income ladder.

Transportation-related emissions ultimately depend on where people live and work. Land use patterns in general are expected to change as a result of climate policy, and they probably will need to change in order to attain long-run emission reduction goals. However, they are unlikely to change by 2015. The demand for gasoline is inelastic in the short run, and the expected reduction in emissions associated with personal transportation would fall by only 2.2 percent in 2015 due to the CO_2 price. Many authors have suggested that important changes in the performance of automobiles as well as changes in personal transportation will depend on other kinds of policy. 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 EU Emissions Trading Scheme, which covers major point source emissions

Table 13.2
Mean Direct Energy Consumption by Region

	Region[a]	States	Electricity (kWh)	Gasoline (gallons)	Natural Gas (tcf)	Heating Oil (gallons)
1	AEV	AL, AR, DC, GA, LA, MS, NC, SC, TN, VA	17,455	970	36	47
2	CNV	CA, NV	8,516	1,049	37	23
3	ERCOT	TX	16,032	1,125	27	16
4	FRCC	FL	15,897	921	3	13
5	MKIO	IL, IN, KY, MI, MS, OH, WV, WI	13,858	973	73	45
6	MPM	DE, MD, NJ, PA	13,101	863	54	133
7	NE	CT, ME, MA, NH, RI	8,676	932	36	353
8	NWP	ID, MT, OR, UT, WA	13,845	932	45	41
9	NY	NY	8,965	802	39	219
10	PPPP	KS, MN, NE, OK, SD	12,562	976	74	27
11	RA	AZ, CO	13,606	905	48	21
	National[b]		13,289	930	42	76

[a] The region names are not acronyms. They are from the North American Electricity Reliability Council, the U.S. Department of Energy, and the authors.
[b] Numbers in this row are not the column averages.
Source: Bureau of Labor Statistics (2008). *Consumer Expenditure Survey Public Use Microdata,* http://www.bls.gov/cex/csxmicro.htm.

totaling roughly 50 percent of total CO_2 emissions in the EU, but which excludes the transportation sector as well as direct fuel use for home heating or cooling.

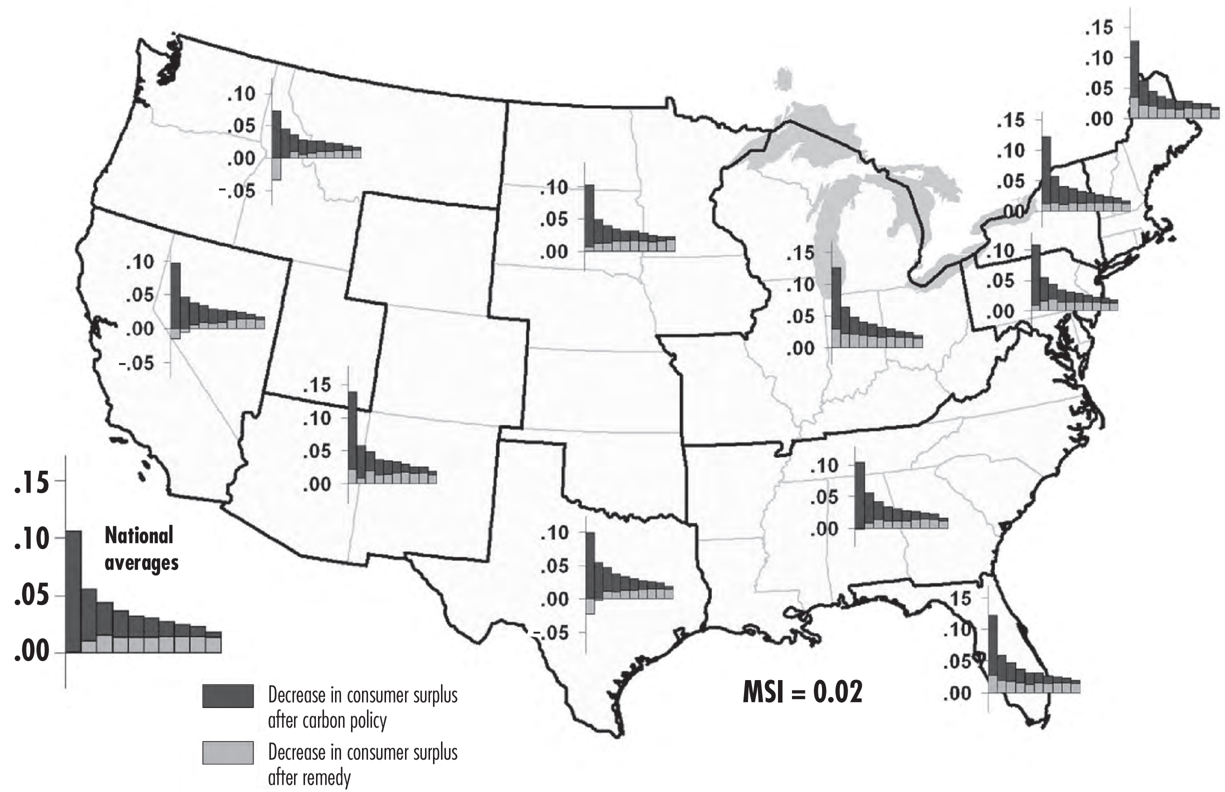
Figure 13.6 illustrates the impact at the regional and national levels of excluding transportation. The revised CAFE standards are assumed to be in place, helping to achieve important emissions reductions compared to 2006 emissions per capita. Nonetheless, exclusion of the transportation sector erodes the emission reductions that otherwise would be expected to occur in the sector. 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 that the allowance price has to rise from \$41.50 $mtCO_2$ under an economy-wide 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. The price of CO_2 allowances goes up to reach the same CO_2 emissions target because this policy does not take advantage of the possibility of achieving emission reductions in the transportation sector. The darker bars in the figure indicate the incidence of the policy before accounting for revenue, measured as the lost consumer surplus as a percentage of income. (As noted previously, the change in consumer surplus is greater than the change in expenditures.) Before accounting for the revenue, the initial incidence of the policy is lower across all income groups, especially across lower-income groups, when transportation is excluded.

The lighter bar indicates the incidence after returning CO_2 revenue to households as dividends on a per capita basis. Although the CO_2 price is greater, the amount of revenue is less than under the economy-wide policy. As before, the government withholds 35 percent of the revenue before returning the rest to households. The figure indicates that the two lowest income groups in every region realize a net gain, or break even, under the policy. At the national level, the modified Suits Index is 0.02, roughly neutral, when the transportation sector is excluded.

Overall, this approach has a large distributional effect. It appears to reduce the regressivity of the climate policy compared to an economy-wide approach, although this depends on what is done with the revenue. This approach may be compelling, since few emission reductions are expected to result from the application of the CO_2 price on gasoline in the short run. However, policy makers should keep in mind the possible hidden costs of the free pass for transportation. Compared to costs of CO_2 emissions elsewhere in the economy, the exclusion of the transportation sector is effectively a subsidy to gasoline use. This may cause people to be less likely to consider the effects of climate change in their personal transportation and land use choices. Furthermore, the subsidy may be sticky; removing it in the future may be even more difficult politically than including transportation in the program from the outset.[23] Finally, our analysis takes place

23. California's Market Advisory Committee (2007) for implementation of the state's greenhouse gas legislation reached a similar conclusion: "If the state chooses to embrace the

Figure 13.6
Excluding Personal Transportation from the CO_2 Price



Note: The vertical axis of the bar charts is the loss in consumer surplus as a share of after-tax income, and the horizontal axis is income decile.
Source: Bureau of Labor Statistics (2008). *Consumer Expenditure Survey Public Use Microdata*, http://www.bls.gov/cex/csxmicro.htm.

prior to the recent substantial increase in gasoline prices and subsequent collapse. The volatility of oil prices may have led consumers and industry to make investments to reduce exposure to price fluctuations and especially sharp increases in the future, but this is not considered in our analysis. To the extent that price increases have already caused people to reduce their gasoline consumption, our estimates might overstate the initial impact of capping CO_2. At the same time, increased prices have probably made excluding the transportation sector more politically popular.

FREE ALLOCATION TO ELECTRICITY CONSUMERS

Free allocation to electricity consumers can be accomplished by allocation to load-serving entities (retail utilities), which would act as trustees on behalf of retail electricity customers. An important question is the basis on which allocation would be made to the load-serving entities. The many options include allocation on the basis of consumption, population, and emissions (or emission intensity of generation). Allocation on the basis of consumption is used to illustrate the policy.

Figure 13.7 illustrates the benefits to electricity consumers. Results are presented only at the national level because there is little variation across regions. The greatest changes occur for the lowest income groups under this policy. Over most of the income range, this approach is fairly neutral, and the Suits Index is reported as –0.08 in the figure.

Despite its advantages, free allocation to consumers has a deleterious effect on the efficiency of the program. The electricity sector uses more of the overall emission target because the lower electricity price leads to greater emissions. When electricity prices do not rise, consumers invest less in improving end-use efficiency. In effect, allocation to consumers is a subsidy to electricity consumption that raises the overall cost of the program. The Haiku electricity model accounts for this with endogenous price formation and price responsive demand functions. Because consumers do not see higher prices, the reductions necessary elsewhere in the economy increase. Compared to the central policy case (cap and dividend), total emissions in the electricity sector rise by 6 percent under load-based allocation. Consequently, the allowance price increases above that in the central policy case to \$46.56, and this is reflected in the overall incidence of the policy. Government is assigned 35 percent of the CO_2 revenue, and the portion outside the electricity sector is returned as a per capita dividend.

Allocation to load-serving entities on the basis of consumption 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, and allocation on the basis

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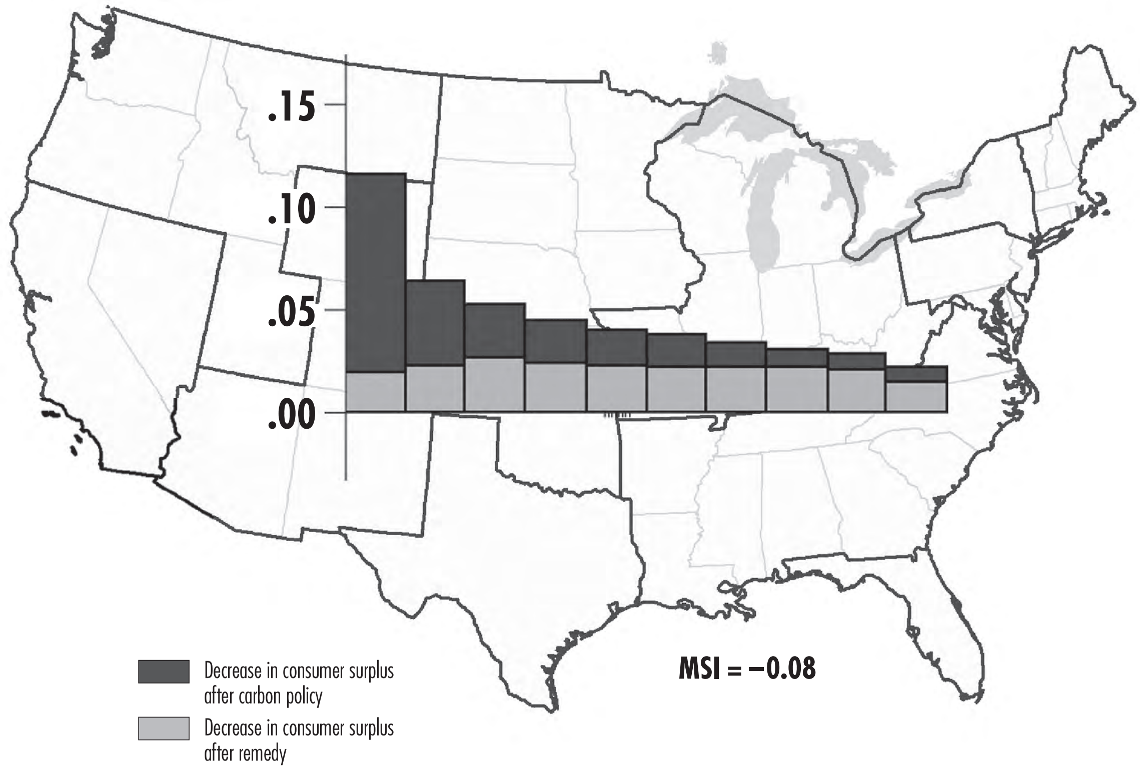
fundamental principle of comprehensive coverage, it should strive to incorporate that principle from the outset, when the cost of doing so is relatively low. This would reduce uncertainties about whether this sector will ever be included, and establish an efficient architecture for the cap-and-trade program to grow in stringency over time."

Figure 13.7
Free Allocation to Consumers (Load-Serving Entities) in the Electricity Sector



Note: The vertical axis of the bar chart is the loss in consumer surplus as a share of after-tax income, and the horizontal axis is income decile.
Source: Bureau of Labor Statistics (2008). *Consumer Expenditure Survey Public Use Microdata*, http://www.bls.gov/cex/csxmicro.htm.

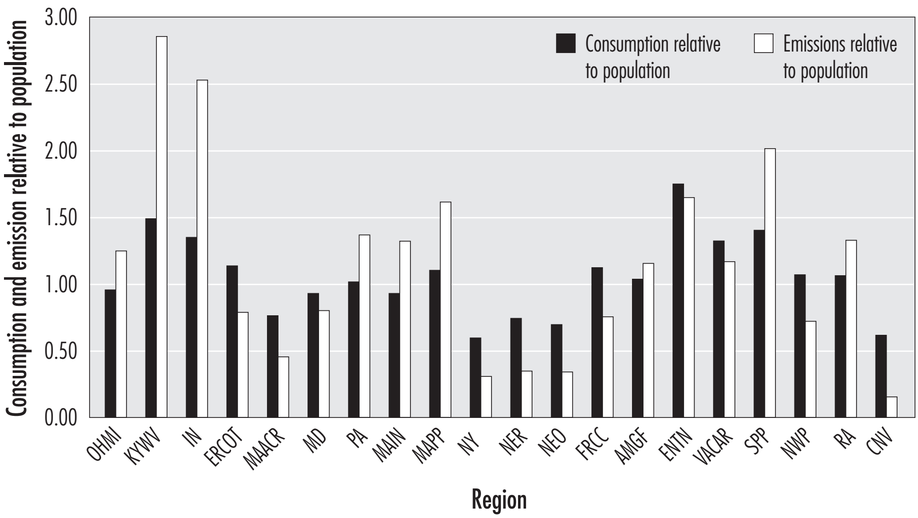
of emissions. The alternatives could double or halve the allocation to electricity consumers on a regional basis.

Figure 13.8 illustrates these three approaches with two comparisons for the 20 regions represented in the Haiku electricity model that are mapped into the 11 regions in this analysis. One approach compares allocation on the basis of consumption to allocation on the basis of population; the second approach compares allocation on the basis of emissions relative to allocation on the basis of population. California and Nevada at the far right of the figure provide an interesting example. Allocation on the basis of consumption reduces the allowances going to load-serving entities by nearly half compared to allocation on the basis of population. This reflects the relatively low electricity consumption per capita in the region, the result of three decades of conservation programs. Allocation on the basis of emissions would be even more dramatic, reducing the allowance value going to electricity consumers by 80 percent compared to allocation on a per capita basis because of the relatively low emitting mix of generation technology in the region. On the other hand, coal-intensive regions would benefit tremendously from allocation on the basis of emissions.

ADDITIONAL OPTIONS WITH VARIED EFFECTS

We also investigate other options, including free allocation to emitters, reduction in income taxes, and investment in end-use efficiency (Burtraw, Sweeney, and

Figure 13.8
Apportioning Allowances to Load-Serving Electricity Companies



Note: The region names are not acronyms. They are from the North American Electricity Reliability Council, the U.S. Department of Energy, and the authors.

Walls 2008). These alternatives lead to a wider array of values for the modified Suits Index, indicating that they have significant effects on the distribution of costs across income groups at the national level. These effects are most concisely illustrated through the calculation of a modified Suits Index, which is shown in table 13.3. The greater the value of the index, the more progressive the policy.

The three policies examined in detail in this chapter are relatively neutral from a distributional standpoint. By contrast, the two most regressive policies are free allocation to emitters, which has a modified Suits Index of –0.39, and the use of revenue to reduce income taxes, which has a modified Suits Index of –1.32. The latter value results because we assume a proportional reduction in taxes paid across all income groups. However, tax reform is not necessarily regressive. Burtraw, Sweeney, and Walls (2008) explore other approaches, including a reduction in the payroll tax and expansion of the earned income tax credit.

The policy scenarios also have significantly different effects across regions of the country. For example, cap and dividend, which has a Suits Index that is slightly progressive, yields more progressive outcomes in the western states than in the Midwest, Florida, and the Northeast. Excluding the transportation sector from the program is moderately progressive at the national level, but there is considerable variation in the impact across regions. This policy benefits lower-income households in the West, but remains moderately regressive in parts of the Northeast and Southeast.

While the case for equity across income groups is straightforward, inter-regional equity is somewhat complicated. To the extent that some regions have enacted policies to reduce their carbon footprint, one can make the case that their citizens deserve the relative benefits that incentive-based policies would bring them. On the other hand, there is considerable resource and lifestyle heterogeneity across regions, and some states do not have the resources to reduce their carbon consumption quite as easily. Despite the ambiguity of the merits of inter-regional equity, the relative burden of climate policy across regions will shape political considerations as such policies come to fruition.

Table 13.3
Modified Suits Index

Scenario	Modified Suits Index		Equilibrium Allowance Price ($2006\$/mtCO_2$)
	After CO_2 Price	Including Revenue	
Cap and Dividend	–0.19	0.10	$41.52
Exclude Transportation Sector	–0.19	0.02	$42.83
Load-Based Allocation	–0.18	–0.08	$46.56
Reduce Income Taxes	–0.19	–1.32	$41.52
Free Allocation to Emitters	–0.19	–0.39	$44.85
Invest in Efficiency	–0.19	0.05	$36.87

An additional trade-off faced by policy makers is the design of policy that is more efficient versus one that achieves desirable distributional outcomes. This analysis indicates that using revenues to reduce preexisting taxes, which public finance economists suggest is the most efficient approach, can have deleterious distributional consequences. On the other hand, some approaches that would ease the burden on specific economic activities, such as personal transportation and electricity use, have negative efficiency consequences. Table 13.3 illustrates the range of allowance prices required to meet the same climate goal under these various approaches. All other things being equal, a higher permit price will correspond to a greater marginal burden of compliance in the covered sectors.

We examine a fairly stringent climate policy with a CO_2 price of \$41.50 in 2015, which can range from \$36.87 to \$46.56 over the policies we consider. The lowest-cost options for reducing carbon emissions lie in the electricity sector; thus, the highest allowance price across the policy cases occurs with free allocation to electricity consumers because it removes the CO_2 price from the electricity price, leading to higher electricity consumption and emissions from this sector. A similar outcome occurs with free allocation to emitters in regions of the country with regulated electricity prices, but not in regions with market-based prices. In both cases, the higher allowance price relative to cap and dividend indicates that more reductions and greater costs are realized in other sectors of the economy. In contrast, direct investments in energy efficiency in the electricity sector yield the lowest overall allowance price. In each case where allowance value is dedicated to meet specific distributional goals within one sector, it constitutes a subsidy to that sector or the exclusion of another sector. This implies a violation of the law of one price in climate policy, which is a fundamental tenet of economic efficiency. When a resource, good, or service attracts a different price in different parts of the economy, efficiency is undermined because resources are not consistently allocated to their highest-valued use. The violation of the law of one price raises the overall social cost of achieving climate goals, even if it addresses distributional concerns.

How Might State-Level Interests Shape Climate Policy?

Although climate change is a long-run problem, climate policy takes shape with a more immediate political dynamic. Delivering compensation or finding ways to alleviate disproportional burdens of the policy seems especially important in the early years of climate policy. If all politics are local, then the local and regional effects of policy may be fundamentally important to building the political coalition necessary to enact climate policy.[24] Just as at the national level, policies on

24. There are regional differences in the pattern of benefits as well as costs. Deschênes and Greenstone (2007) estimate interstate differences that are striking, with California agriculture losing around \$1 billion annually and Pennsylvania gaining about half that much due to a changing climate.

climate change at the local level will be driven in part by interests not necessarily related to climate change.

STATE-LEVEL STRATEGIC INTERESTS

Responsiveness to local and regional interests arguably may improve the policy outcome in general or may be essential to achieving any policy outcome, but it seems unlikely to enhance the efficiency of the policy. For a firm with a scope of operations that spans multiple jurisdictions, regulatory standards that vary substantially among regions would impose larger compliance costs than would regulations with relatively cross-regional uniformity. Given that, variations in greenhouse gas policies at the state level may result in higher compliance costs than would policies implemented on the national or even international level. Standards not only may be different, but they may also be inconsistent with requirements in other states. A regulatory standard in one state may encourage the use of a particular energy source, while another state's standard may specifically prohibit it. A power company selling into both markets would face significant managerial and technological costs in satisfying the joint but inconsistent requirements. Navigating this regulatory maze can place a substantial burden on commerce between jurisdictions, imposing hidden costs on consumers.

For example, several states took steps to promote the use of in-state coal (usually high-sulfur coal) to comply with Title IV of the 1990 Clean Air Act amendments. The promotion of in-state coal inevitably raised costs, but it was consistent with policies that promoted economic development in the state. In-state economic development historically has been a common focus of state public utility commissions and is sometimes even part of their charter in state constitutions (Arimura 2002; Bohi 1994; Burtraw 1996; Rose 1997; Sotkiewicz 2002).

Another example is the geographic limitation of existing renewable energy programs, which raises the cost of achieving specific penetration rates for renewables. Palmer and Burtraw (2005) found that state-level renewable energy portfolio standards aimed at achieving fairly stringent goals appear virtually impossible to achieve in many areas of the nation without incurring large costs for new capabilities in biomass or solar technologies. According to the authors, other areas could achieve less expensive generation from renewables and export renewable energy credits. Nonetheless, all the states that have pursued renewable policies have limited geographic tradability of renewable credits in order to attempt to promote local economic development.

The architecture of a national cap and trade program could take a variety of forms. As described above, sectors could be regulated in different ways and in fact could function under separate regulations. A possibility that mirrors the development of the NOx budget program, for example, might give states the latitude to choose whether various sectors would be in or out of a national CO_2 trading program. A state's decision to exclude a sector from the national trading program may not only benefit local interests but also harm other states. This illustrates a strategic dynamic to the decisions that might be left to states, and that characterize interests that will influence the design of a national trading program.

We construct a reduced-form model of idiosyncratic state and regional interests built on the CEX survey data by modeling a representative agent who might be thought of as an average voter—not necessarily the median voter—in each region. We hold the emission target discussed above constant and calculate the CO_2 price that would be necessary under various scenarios. This exercise is simplified compared to that described above; here we calculate CO_2 expenditures for each agent by multiplying the price times the emissions embodied in consumption at the price necessary to achieve the emissions target; we use linear estimates of the change in emissions that occurs in response to a change in the price; and we do not calculate consumer surplus changes.[25] We focus exclusively on the first-order estimate of the change in expenditures associated with the introduction of the CO_2 price, and the disposition of revenues after accounting for 35 percent of revenues that is always siphoned off to maintain a balanced government budget.

FREE ALLOCATION TO ELECTRICITY CONSUMERS

One possible outcome would be for states to retain authority to allocate some portion of emissions allowances. The natural way for this to occur is for emissions allowances to be apportioned originally to states, perhaps for only some sectors, as occurred under previous emissions trading programs. As noted earlier, the Lieberman-Warner proposal delegates 22 percent of allowances to states, with 9 percent to the electricity sector, specifically designated as allocation to load-serving entities on behalf of consumers, and other value potentially available to the electricity sector at the state's discretion. The 2002 Jeffords bill would have allocated two-thirds of emissions allowances to the states for determination of allocation by trustees. It would be plausible for the decision to be left to the state public utility commissions, which would act as trustees on behalf of consumers.

We model apportionment of emissions allowances for the electricity sector, which effectively directs that portion of value of the CO_2 revenue to the state, which in turn decides how to direct it further. We assume that an auction with per capita dividends is implemented at the federal level for other parts of the economy. The payoffs for individual states consider two options: (1) auction to the electricity sector with value returned as a per capita dividend; and (2) allocation for free to load-serving entities on behalf of consumers, thereby effectively subsidizing electricity consumption.

We define payoffs for the representative agent in each state or region as net CO_2 expenditures equal to payments for CO_2 emissions allowances minus the dividend received. Under allocation to load-serving entities, the electricity price does not increase to reflect the value of CO_2 emissions. There are still significant

25. We also do not account for the different number of persons per household, which is relevant when accounting for revenue returned on a per capita basis.

emission reductions in the electricity sector, but they are less than would occur under an auction. In effect, the allowance value is used to subsidize the electricity price, and the dividends are reduced accordingly. Another effect is that more emissions reductions have to occur in other sectors, which pushes up the CO_2 price and associated costs in other sectors. States and regions have different levels of emissions associated with economic activity in various sectors, so the decision will have dissimilar effects across states.

Table 13.4 reports the estimated net expenditures for each region under five different scenarios. Column 1 describes the emissions cap with a nationwide auction for all sectors and with dividends returned on a per capita basis. The scenario in the second column gives special consideration to the electricity sector, where allowances for the sector are apportioned to the states, all states separately auction the allowances, and households receive 65 percent of the allowance value as dividends. Compared to an auction at the national level, this federalist approach for the electricity sector preserves the value of the emissions allowances for each region, providing a sort of compensation for emission-intensive regions.

For example, AEV in the first row includes a large portion of the Southeast and has a relatively large amount of coal-fired generation. The representative

Table 13.4
Net CO_2 Expenditures by Region (2006 Dollars)

Region[a]	Economy-wide Nationwide	Apportionment to States for Electricity Sector	Load-Based Allocation in AEV	Load-Based Allocation in AEV, MKIO, MPM, PPPP	Load-Based Allocation Nationwide
AEV	387	269	162	176	206
CNV	147	225	229	250	282
ERCOT	192	199	207	219	207
FRCC	197	202	207	222	209
MKIO	503	354	353	248	282
MPM	417	320	319	247	281
NE	294	343	334	377	400
NWP	160	241	245	263	301
NY	158	211	214	233	249
PPPP	281	338	324	357	396
RA	185	233	221	251	269
CO_2 Price (2006\$/ mtCO_2)	41	41	42	46	48

[a] The region names are not acronyms. They are from the North American Electricity Reliability Council, the U.S. Department of Energy, and the authors.

agent in this region receives a larger share of the allowance value when all the value from the electricity sector associated with emissions in the region is kept in the region through apportionment. Compared to a nationwide auction, net expenditures in AEV fall from $387 to $269 per capita. On the other hand, the second row illustrates the California/Nevada region, which has relatively low CO_2 emissions associated with electricity consumption. Here, net expenditures increase from $147 to $225 per capita. The bottom row of the table indicates that there is no change in the CO_2 price; that is, we do not identify an efficiency consequence.[26] Rather, the shift in expenditures among regions is a zero-sum game associated with the assignment of value.

Apportionment to states gives them the discretion to decide differently about how to allocate allowances. The third column illustrates the incentives for the AEV region to use allocation to load-serving entities instead of an auction. Net expenditures in the region fall significantly to $162 per capita. Net expenditures fall in some other regions because they achieve more value from the change in per capita dividend than they pay due to the higher allowance price. However, as the bottom row indicates, the allowance price increases to $42, indicating an overall efficiency consequence from AEV's decision to subsidize electricity consumption.

Column 4 illustrates the outcome when MKIO (much of the Midwest), MPM (the mid-Atlantic), and PPPP (the Great Plains) also decide to allocate to electricity consumers. The movement of these regions as a group erodes AEV's gains. It also further increases the electricity price to $46, imposing costs on other regions and the nation as a whole.

Each region individually has an incentive to move to free allocation to electricity consumers. Column 5 indicates that when all regions do this, the electricity price rises to $48, with efficiency consequences for the nation as a whole. The strategic relationship takes the form of a multiplayer prisoner's dilemma. The individually rational choice of each state or region leads to a collective outcome that is less advantageous from the perspective of efficiency than is a coordinated allocation using an auction at the federal level. Nonetheless, because the distributional consequence of a nationwide auction is severe for regions with emission-intensive electricity use, political considerations may lead to a less-efficient outcome.

Conclusions

Emissions trading is an important policy innovation that promises to dramatically reduce the overall cost of climate policy. The formation of a formal emissions allowance market for CO_2 would create a new asset of enormous value. How that value is distributed in the economy will be important to the long-term

26. The allowance price in this simulation differs slightly from that achieved earlier with a more complete model.

impact of efforts to address climate change. Even if the benefits of climate policy dramatically outweigh the costs, the distributional impact of a market for CO_2 could have much bigger economic effects on many households than will the environmental consequences of a changing climate.

State governments are often thought to be better able to address distributional considerations than is the national government because decision makers are more proximate to affected constituencies. This might suggest that states should play a central role in the architecture of climate policy as it is conceived at the federal level. The precedent in most previous environmental regulation places state governments in the primary role of implementing policy. The introduction of national markets for CO_2 emissions allowances by the federal government would represent a significant appropriation of authority and significant economic value from what has previously been the domain of states.

The wide variety of consumption patterns across the nation lead to differences in the incidence of climate policy across regions and across income groups. As a consequence, states not only have concerns about distributional impacts, but also have strategic interests in the design of national climate policy. These interests may be an important influence on the architecture of national policy. If authority for important decisions such as allocation of emissions allowances is delegated to the states, these interests could play a prominent role because of strategic relationships among the states. As is often observed, the devolution of authority is a two-edged sword. States may be better suited to address idiosyncratic distributional concerns, but state-level decisions can also unleash a dilemma that causes overall costs for the nation as a whole to increase.

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