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How Do the Costs of Climate Policy Affect Households? The Distribution of Impacts by Age, Income, and Region

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RESOURCES FOR THE FUTURE

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Abstract

This paper explores the near-term effects on household expenditures of legislative cap-and-trade proposals that restrict greenhouse gas emissions. We evaluate optimistic and pessimistic assumptions about the uses of allowance value, compared to relatively predictable results from a cap-and-dividend approach. We find the allocation of emissions allowances is significantly more important to distributional outcomes than the initial costs or regional variation of costs. Older households—age 65 and older—incur relatively less cost than other age groups due to automatic inflation indexing of Social Security. Low-income households spend a larger fraction of earnings on energy than wealthier households; however, the distribution of allowance value and indexing of government programs offset this spending. High-income households fare well because of allowance value that ultimately flows to capital owners. The largest burden as a percentage of income falls on middle-income households, which receive neither low-income rebates nor value through ownership of capital stock.

Key Words: cap-and-trade, allocation, distributional effects, cost burden, equity, regulation, local distribution companies

JEL Classification Numbers: H22, H23, Q52, Q54

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How Do the Costs of Climate Policy Affect Households? The Distribution of Impacts by Age, Income, and Region

Joshua Blonz, Dallas Burtraw, and Margaret A. Walls*

1. Introduction

Several major climate and energy proposals have been introduced before the 111th Congress. These proposals have centered on cap-and-trade programs that would limit emissions of greenhouse gases throughout all sectors of the economy, require firms to hold allowances in order to produce such emissions, and enable trading of allowances. H.R. 2454, introduced by Representatives Henry Waxman (D-CA) and Edward Markey (D-MA), contains cap-and-trade as its central feature and is the only bill to be passed in one house of Congress. Senators John Kerry (D-MA) and Barbara Boxer (D-CA) introduced a similar bill, S. 1733, in September 2009, and it passed out of the Senate Environment and Public Works Committee. Senators Kerry and Joe Lieberman (D-CT) introduced a third bill (not yet assigned a number) in May 2010. All these bills include numerous detailed provisions for allocating emissions allowances across a range of programs and sectors. S. 2879, introduced by Senators Maria Cantwell (D-WA) and Susan Collins (R-ME) in December 2009, takes a much simpler “cap-and-refund” approach in which the government auctions off emissions allowances and returns 75 percent of the revenues in a lump-sum, per-capita fashion to households.

Several previous studies, which we review below, have examined the overall cost of climate policy and distributional impacts for the average household, with some attention to low-income households. No studies to our knowledge have examined the impact on households by other socio-demographic groupings. In this study, we address the consequences of climate policy by age group, combined with the effects by region and income. We focus attention on older households and assess the burden for those households from the cap-and-trade program in the Waxman-Markey bill under alternative interpretations of how the allocation scheme will play

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out. Given the complexity in the bill, how the impacts of various features will filter through to households is very uncertain. To address this uncertainty, we characterize “optimistic” and “pessimistic” scenarios that reflect the effectiveness or economic efficiency consequence of each provision and assess the overall burdens of the policy. We contrast these scenarios with one resembling the Cantwell-Collins proposal. In this scenario, the level of domestic emissions reductions and international offsets (emissions reductions obtained overseas and outside the cap-and-trade program) are scaled to match the outcome under Waxman-Markey so that the proposals can be compared solely on their distributional consequences; hence this scenario is a characterization of cap-and-dividend but not a precise replication of the Cantwell-Collins cap-and-refund proposal. In appendix 3, we contrast this scenario with the Kerry-Boxer proposal under the same assumptions about domestic emissions and international offsets. The Kerry-Boxer proposal yields distributional effects that are relatively similar to those of Waxman-Markey.

We conclude that a wide range of outcomes is possible in the Waxman-Markey framework, depending on the implementation and cost-effectiveness of various allocation provisions in the bill. We examine impacts in 2016, the first year that all the provisions of the proposals would take effect. The annual burden in 2016 for an average household ranges from $138 to $436, depending on whether allocation to particular energy efficiency, technology, and renewable energy programs accelerates the commercialization of these technologies, and whether electric utilities raise marginal prices to customers.[1] By contrast, the outcome under a simpler cap-and-dividend approach aimed at achieving the same emissions target is more predictable—the burden in 2016 for an average household under a full auction with 75 percent of auction revenue returned per capita is estimated to be $235.

We find that low-income households are protected under all the scenarios. In all cases, the allocation of allowances offsets the increase in energy expenditures for an average household in the lowest income quintile, leading to a net gain for low-income households. Under Waxman-Markey, this result is due to the energy rebate entitlement provision for low-income households; under our characterization of a cap-and-dividend policy, the result comes from the progressive nature of per-capita dividends, which give an equal amount to every individual. The cap-and-

[1] Throughout the report, 2006 year dollars are used.

dividend approach is more progressive than Waxman-Markey: it benefits low-income households relatively more than high-income households.

Older households also fare better generally than other households under either Waxman-Markey or a cap-and-dividend scheme. Under the optimistic scenario for Waxman-Markey and under cap-and-dividend, an average household headed by a person age 75 or older is, on net, better off under climate policy than a household headed by someone younger than 75. An average household in the 65–74 category, while not better off, has a lower-than-average burden. In the pessimistic Waxman-Markey scenario, no age groups are net winners, but households in the 65 and older categories have lower average burdens as a percentage of income than the average household. These positive results for older households are due primarily to inflation-indexed Social Security benefits: pricing carbon leads to a general rise in prices for all goods, and Social Security payments increase as a result. Moreover, the energy rebate provisions for low-income households in Waxman-Markey and the progressive nature of the per-capita dividend in the cap-and-dividend policy help protect lower-income older households. An average household age 65 and older in the bottom quintile is a net winner under climate policy in all three cases.

Higher-income households face a relatively small burden as a percentage of income in both Waxman-Markey scenarios, generally because higher-income households consume less carbon as a percentage of their income and allowance values benefit owners of capital, who are predominantly high-income households. Middle-income households do not benefit from allocations that higher income households receive, and have the highest burden as a percentage of income. The cap-and-dividend policy does not have this result owing to its progressive structure for refunding allowance value.

We find small differences in the household burden across regions in all policy scenarios. This holds true for average households and across all age groups. In general, a household's region matters much less than whether the optimistic or pessimistic assumptions play out in Waxman-Markey or whether a cap-and-dividend approach is adopted. In other words, the details and implementation of the policy's allowance allocation scheme are the key factors determining costs of the policy to households.

The benefits of greenhouse gas emissions reductions will accrue in the future as global warming is diminished, but society will begin to pay the costs immediately. This is one of the difficulties that Congress faces in passing climate legislation and a reason why the distribution of costs and allowance value in the first decade of the program is especially important. Outcomes are influenced by uncertain provisions of the proposals, as well as subtle but important elements of existing policies. This analysis explicitly characterizes the most important of these variables to provide a more comprehensive assessment of the distribution of costs across age and income groups than has been available previously.

2. Literature Review

Three government agencies have analyzed the costs of various climate proposals, with the most extensive analysis of H.R. 2454, the Waxman-Markey bill. The studies—by the Congressional Budget Office (CBO), the Environmental Protection Agency (EPA), and the Energy Information Administration (EIA) within the Department of Energy—focus on the overall costs to society of the cap-and-trade program as outlined in the bill for various future years and generally forecast allowance prices, energy prices, gross domestic product (GDP), and other measures of impacts.[2] Of the three, only the CBO assesses distributional impacts across income groups.

Table 2.1 shows the impacts on households and allowance prices in 2020 as forecast in the three studies. It is important to understand that the studies use different methodologies for assessing the impacts on households, and in some cases, not all the details of the methodology are clear. We therefore urge some caution when comparing the numbers.

The CBO calculates a "loss in purchasing power," which equals the estimated costs of complying with the policy minus the compensation through the distribution of allowance value that households would receive as a result of the policy. CBO makes some broad assumptions about how compensation filters to households. While their metric is quite similar to our "household burden," the CBO modeling does not incorporate any impact of allowance allocations on allowance prices (unlike our treatment below). For example, CBO allocates 31 percent of the total value of allowances directly to households—half for low-income energy assistance and half via electricity and natural gas local distribution companies, which are assumed to distribute back to customers. Businesses receive 44 percent of allowance value; CBO assumes that 29 percent goes to shareholders because of allocation to local distribution companies, and the rest goes to trade-exposed industries. Federal, state, and local governments receive 18 percent of allowance value in the CBO study, and the remaining 7 percent of

[2] CBO (2009); EIA (2009a); EPA (2009).

allowance value is sent overseas to fund such projects as reducing deforestation and adapting to climate change.[3]

CBO finds that the average cost per household varies greatly by household income level. It estimates that an average household in the lowest income quintile will see a net benefit of $125, or 0.7 percent of income, while an average household in the highest quintile will experience a cost of $165, or 0.1 percent of income. The middle income quintile will incur the most significant cost of this policy, with an average per-household cost of $310, or 0.6 percent of income.[4]

Table 2.1. Estimated Costs to Households in 2020 from the Cap-and-Trade Program in H.R. 2454

	Average annual net household costs	Average net costs as percentage of income	Allowance price (in $/ton)
CBO (2009)	$160	0.20	$23
EPA (2009)	$105	0.11	$16
EIA (2009a)	$134	N/A	$32

EPA estimates a household's "loss in consumption."[5] Again, this metric is similar to both ours and CBO's, but EPA's methodology is based on the ADAGE computable general equilibrium model. Such models generally incorporate interactions and market linkages in the economy and do a good job at capturing the economy-wide impacts of climate policy, but they usually must rely on rather simplified representations of, for example, household income and consumption patterns. Allowances given to local distribution companies and to industries that are exposed to international competition, as well as many other recipients, are allocated within the general equilibrium model in EPA's analysis. As a result, their distributional effects are subject to the equilibrium found within the model. For example, allowances allocated to electricity local

[3] CBO (2009).

[4] CBO (2009).

[5] EPA (2009).

distribution companies (LDCs) result in lower electricity prices for consumers, as opposed to a transfer to households as in the CBO analysis. Overall, 77.5 percent of the allowances are allocated in this way. The remaining 22.5 percent of allowance value, however, is allocated outside of the ADAGE model, and this value is given directly to households as a lump-sum transfer on a per-capita basis. These allocations to households incorporate allowance value given to programs such as low-income energy-cost assistance and merchant coal generators.

EIA estimates the cost of H.R. 2454 as the average loss of consumption per household.[6] Results are based on their National Energy Modeling System energy–economy model, which predicts a 2020 allowance price of $32 and shows the cost of the policy to be $134 for an average household. The EIA also allocates allowances in the proportions specified by H.R. 2454, such as those given to LDCs and trade-exposed industries. For trade-exposed industries, the EIA assumes allowance value serves to offset a change in the price.

The Congressional Research Service (CRS) compiled an analysis of various estimates of household burdens under H.R. 2454 as part of a detailed look at results—changes in emissions, GDP, allowance prices, and household impacts—from seven different studies. The report focuses on the underlying assumptions and model parameters for each of the studies reviewed. In addition to the CBO, EIA, and EPA studies, the CRS study assesses results from the Heritage Foundation, the National Black Chamber of Commerce, the American Council for Capital Formation and National Association of Manufacturers, and MIT.[7] With the exception of the American Council for Capital Formation–National Association of Manufacturers study, the others obtain estimates of household impacts that are significantly higher than the three studies we discussed above, ranging from $319 to $1,539 per household. CRS emphasizes that the underlying model parameters and structures are quite different across the studies, making comparisons difficult.

Many academic studies over the past two decades have analyzed the distributional impacts of various kinds of energy and environmental taxes and regulations.[8] We glean a few consistent findings from this literature.

[6] EIA (2009a).

[7] CRS (2009).

[8] Parry et al. (2007) review the literature on this topic. Some more recent studies are referenced below.

First, studies find that most energy taxes—gasoline taxes, broad-based taxes based on energy content, carbon taxes, and others—are regressive when analyzed on the basis of annual household income. Because poor households tend to spend a greater fraction of their income on energy than do wealthy households, they are disproportionately harmed by energy taxes. Several studies uphold this finding, including some that consider the indirect consumption of energy through goods and services.[9]

Second, the impact of energy taxes or cap-and-trade schemes can be softened by judicious use of the revenues they generate. Studies have shown that it matters greatly, for example, how allowances are allocated in a cap-and-trade system. Some of the specific findings include the following:

- Giving allowances away for free to industry, based on output, emissions, or some other measure, is generally inefficient and regressive, as the value flows to shareholders who are predominantly in higher-income households.
- Auctioning allowances and returning the revenue in the form of income or payroll tax cuts can improve the overall efficiency of the program, but these options can be regressive, depending on how the tax cuts are implemented.
- Auctioning allowances and giving a lump-sum, per-capita dividend as a rebate to households—the so-called “cap-and-refund” approach found in Cantwell-Collins—is progressive, benefiting low-income households relatively more than higher-income households.[10] Issuing dividends foregoes the efficiency advantage of using revenue to reduce preexisting taxes.[11]

Third, many economists have emphasized the drawbacks of using annual income to assess a household’s ability to bear the burden of a tax or other policy. It has been argued that a measure of “permanent” or “lifetime” income is a better metric than annual income by which to categorize households. Studies that use lifetime income—often proxied by annual consumption

[9] Rausch et al. (2010) are the exception; they find that a portion of costs are borne by the owners of resources and capital and by labor supply, which lessens the regressivity of the policy.

[10] Some key studies in this area are Dinan and Rogers (2002), Metcalf (2009), and Parry (2004).

[11] Parry and Williams (2010). However, dividends may be designed to enhance the effectiveness of other programs (Burtraw and Parry (2010)).

expenditures—generally find that carbon taxes and cap-and-trade systems look much less regressive.[12]

Fourth, analysis of the regional impacts of climate policy has been somewhat limited, but some recent studies find that regional differences, at least for households in the middle of the income distribution, appear small. This is particularly true when the analysis includes the full impacts of the policy, including the allocation of allowance value.[13]

3. Description of the Major Climate Policy Proposals

H.R. 2454, the Waxman-Markey bill, is the only legislative proposal to be passed by one house of Congress. The Kerry-Boxer bill in the Senate (S. 1733) and its effective successor, the Kerry-Lieberman bill (number not yet assigned), are similar to Waxman-Markey in their approach to distributing allowance value. The other major bill currently under consideration is the Cantwell-Collins bill, S. 2877. All of these bills include a cap on economy-wide emissions and some form of pricing of emissions allowances, but the Cantwell-Collins proposal is much simpler than the other two because it relies on a government auction of most of the allowances and a subsequent redistribution of revenues back to households using a simple formula. The other two bills give approximately 85 percent of allowances to various programs and sectors using complex allocation schemes that change over time. In the absence of comprehensive legislation, the default mechanism for controlling emissions is a regulatory approach as embodied in the Clean Air Act.

We will describe each approach with special focus on Waxman-Markey, which we analyze and compare with an cap-and-dividend approach similar to Cantwell-Collins.

[12] Fullerton and Rogers (2007) is the seminal study in this area; looking at a range of taxes, they constructed a sophisticated measure of lifetime income using panel data. Most studies do not have such data and must construct proxies in some other way (see Walls and Hanson (1999) for example). Annual consumption is used most often; see Burtraw, Sweeney, and Walls (2009), Grainger and Kolstad (2009), and Metcalf (2009), among others, for distributional impacts of climate policy based on this metric.

[13] For regional analyses, see Boyce and Riddle (2009, 2010), Burtraw, Sweeney, and Walls (2009), and Hassett, Marthur, and Metcalf (2009) .

3.1 Three Legislative Approaches

3.1.1 Waxman-Markey and Kerry-Boxer

Title III of H.R. 2454, the Waxman-Markey bill, sets an annual cap on greenhouse gas emissions that, by 2016, covers approximately 85 percent of all U.S. emissions—from oil refineries; natural gas suppliers; electricity generators; and industries such as cement, paper, iron, steel, and chemicals. The cap gradually becomes more stringent over time. In 2012, the first year the law would go into effect, covered emissions are required to be 3 percent below 2005 levels; by 2020, 2030, and 2050, this figure rises to 17, 42, and 83 percent, respectively. The targets include the opportunity to use domestic and international offsets as a means of compliance, a feature that is expected to play a prominent role in compliance. The cap is met by allocating emissions allowances among the regulated entities; those allowances can then be traded. The bill has approximately 22 separate provisions dealing with allowance allocation.

The Kerry-Boxer bill, S. 1733, is similar to Waxman-Markey in terms of coverage and targets. It sets a slightly stricter cap of 20 percent in 2020, but both bills achieve the same cap by 2050. The Waxman-Markey bill includes a price floor in the auction that represents a minimum price for emissions allowances in the market. The upper price has no limit, but a provision limits the amount that price could increase each year. The Kerry-Boxer bill includes an explicit "price collar" on allowance prices that includes an initial price floor of $11/ton of carbon dioxide (CO_2) and a ceiling of $28/ton; if the ceiling is met, the government will release allowances from a market reserve fund to bring down prices. These reserve allowances must be sold at or above the ceiling price, which increases at 5 percent until 2017 and 7 percent beyond that. The price floor increases at 5 percent for the entire program.

The statutory distribution of allowances across various categories is almost identical in Waxman-Markey and Kerry-Boxer. Kerry-Boxer, having originated in the Senate, set aside allowances for deficit reduction, resulting in somewhat different distributional outcomes than Waxman-Markey.[14] In Kerry-Boxer, approximately 15.75 percent of allowances goes to government for debt reduction, program administration costs, costs of the Market Reserve Fund

[14] Waxman-Markey satisfies the House deficit-reduction provisions by auctioning future year allowances early in the program. While reflected in overall modeling, this provision does not affect 2016 incidence of the policy. Different rules in the Senate require legislation to maintain budget neutrality across the entire life of the measure. As such, the pre-sale of future year allowances does not allow Kerry-Boxer to satisfy budget neutrality. Instead, Kerry-Boxer specifically reserves a portion of all allowances each year for the purpose of maintaing deficit neutrality.

(the reserve of allowances used to prevent price volatility), and other uses. The remaining 84.25 percent is divided in similar proportion to Waxman-Markey, meaning that all other allocations are scaled downward. As an example, 15 percent of allowances are reserved for low-income consumers in both bills, but this allocation represents only 12.64 percent (84.25 percent * 15 percent) of total allowances in Kerry-Boxer because of the initial 15.75 percent of allowance value taken off the top. All other provisions are similarly scaled down.

The bills include a large number of free allowances to residential energy providers—electricity and natural gas LDCs and home heating–oil providers—to try and dampen the rise in prices and lessen the harm to energy consumers. LDCs are regulated retail providers of electricity and natural gas to homes and businesses; they are responsible for billing customers for the full cost of the energy delivered. The Waxman-Markey legislation directs LDCs to use these emissions allowances "exclusively for the benefit of retail ratepayers." Exactly *how* they will pass on the value of the allowances to ratepayers is a matter of debate and an issue we address in the next section. Fully 30 percent of Waxman-Markey allowances go to electricity LDCs, and another 9 percent go to natural gas LDCs.

The bills also include a number of provisions to spur advances in alternative energy and energy efficiency, as well as allocations to international forestry (reducing emissions from deforestation and for degradation, or REDD). These provisions are meant to lower greenhouse gas mitigation costs. If investments in clean vehicle technology, renewable energy, carbon capture and sequestration (CCS), and the like accelerate the commercialization of these technologies, then the costs of the program ultimately would be reduced. Whether this indeed occurs is an open question.

The bills also include industry-specific provisions, most notably allocations to domestic refiners and a relatively large share (14.44 percent in Waxman-Markey; 12.67 percent in Kerry-Boxer) to energy-intensive, trade-exposed industries. The latter industries may lose market share to firms operating in countries without climate policy.

All these bills recognize that some climate change appears to be inevitable and provide funding for adaptation and adjustment. Small amounts of allowances go toward several funds, such as the Natural Resource Climate Change Adaptation Fund, but the bills provide no guidance on how those funds are to be spent. It is also important to note that in later years of the programs, many of the early consumer-protection allocations phase out, leaving more money for deficit reduction and dividends. Many programs, however, continue receiving allocations throughout the program.

3.1.2 Cantwell-Collins

Criticism has been heaped on the 1,400-page Waxman-Markey bill for its length and complexity. In fairness, a portion of the bill addresses energy policy that was sectioned off into different legislation in the Senate approaches under Kerry-Boxer and Kerry-Lieberman. Nonetheless, the Cantwell-Collins bill, S. 2877, offers a starkly different approach. One hundred percent of allowances are auctioned under Cantwell-Collins, with 75 percent of the revenues from the auction returned to individuals as an "energy-security dividend" and 25 percent invested in a Clean Energy Reinvestment Trust Fund. The 75 percent refund is to be distributed as a lump-sum, per-capita payment to every U.S. citizen and is not subject to income taxes. Trust fund expenditures may cover a wide variety of activities: energy efficiency and weatherization programs; agriculture, forestry, and land use projects that sequester carbon; investments in energy research and development; and financial support for low-income households, trade-exposed industry, and climate adaptation. The details of how funds should be divided among these competing uses are unspecified.[15]

This approach offers a number of advantages, as well as potential disadvantages, compared with Waxman-Markey, Kerry-Boxer, and Kerry-Lieberman. The absence of allocations to LDCs, for one thing, is likely to increase the program's efficiency, leading to a lower allowance price and lower overall burden on households (see discussion below and in appendix 1). Omission of the myriad energy technology and efficiency programs reduces uncertainties about the impact of such provisions on the allowance price and overall costs. On the other hand, the energy efficiency and technology programs have the potential to yield significant savings to households if they work well. Under the Cantwell-Collins proposal, the Clean Energy Reinvestment Trust Fund also has the potential to generate savings, but the allocation of value to these items and other competing priorities remains unspecified.

3.1.3 A New Kerry-Lieberman Proposal

In May 2010, Senators Kerry and Lieberman released proposed legislation that takes a generally similar approach with similar coverage and targets as Waxman-Markey and Kerry-Boxer. The bill establishes a cap-and-trade program for electricity sources in 2013 and expands

[15] The trust fund also could be used to cover increased costs to the government from the program. Proponents of Cantwell-Collins emphasize the climate-related (rather than deficit-reducing) uses of the funds, and hence we do not model this allowance value as a means to reduce government costs.

the program to include large industrial sources in 2016. The bill also has similar provisions for industry, most notably allocations to domestic refiners and a relatively large share (15 percent) to energy-intensive, trade-exposed industries. Like Kerry-Boxer, the Senate-based Kerry-Lieberman bill sets aside allowances for deficit reduction, resulting in somewhat different distributional outcomes than Waxman-Markey.

Allowance allocation in Kerry-Lieberman follows the same basic schematic as earlier policies but also borrows somewhat from the ideas of Cantwell-Collins. LDCs in the electricity sector would receive free allocations similar to Waxman-Markey and Kerry-Boxer but based on a slightly changed formula. Under Kerry-Lieberman, LDCs would receive 75 percent of their free allowances based on their historic emissions and the other 25 percent based on their historic electricity sales, compared with the 50-50 split used in the other bills. Kerry-Lieberman has fewer categories across which the allowances are distributed. Funding for REDD and many of the smaller state-level programs is reallocated to transportation infrastructure and efficiency uses. After 2035, Kerry-Lieberman’s allocations look very similar to those of Cantwell-Collins, with all allowances (except for those in the strategic reserve) flowing directly to consumers in the form of rebates. A price collar is specified in the outline, but carbon offset provisions are left for future consideration. The draft includes a “carbon tariff” to deal with international competition. Finally, the senators plan to include several other provisions in the bill: national standards for renewable energy, incentives for nuclear power, offshore oil and gas drilling, and advanced coal and renewables.

The transportation sector would be excluded from the trading program but would be subject to a CO_2 emissions fee calibrated to approximate the price of emissions allowances in the trading program. The revenue from the transportation sector fee, and potentially from a portion of allowances that might be auctioned in the trading program, would be distributed to various purposes, including international programs and energy-efficiency and technology programs that appear in the Waxman-Markey and Kerry-Boxer proposals.

Table 3.1. Net Emissions Reductions among the Four Major Climate Bills

	Percentage of reductions in covered emissions from 2005 levels			
	2012	2020	2030	2050
Waxman-Markey (H.R. 2454)	3	17	42	83
Kerry-Boxer (S. 1733)	3	20	42	83
Cantwell-Collins (S.2877)		20	42	83
Kerry-Lieberman (not yet numbered)	4.75 (begins in 2013)	20	42	83

Note: The Cantwell-Collins domestic reductions goals exclude offsets, which will decrease at an increasing rate per year starting in 2015. The difference between this goal and the covered goal will be made up by other reductions, such as offsets.

3.2 The Clean Air Act

Under the Clean Air Act, the EPA has proposed and finalized rules requiring the reporting of greenhouse gas emissions, an "endangerment finding" that enables and requires the regulation of emissions from mobile sources, and the announcement of new emissions standards for mobile sources. The approach that the EPA will take to regulate stationary sources under the Clean Air Act is uncertain, but in the absence of legislative intervention to prohibit regulation, new regulations are virtually certain. One form of new regulation falls under the preconstruction permitting process, and will affect new and existing sources subject to major modifications. Other potential approaches to regulating existing sources could emerge under the National Ambient Air Quality Standards or the New Source Performance Standards.[16] The regulatory strategy adopted by the EPA will become apparent over the next year.

[16] According to Richardson, Fraas, and Burtraw (2010), the most desirable and likely outcome would be regulation under New Source Performance Standards. Section 111(d) of the Clean Air Act would enable the regulation of existing sources if they have not already been regulated through other parts of the act. This approach could allow for the introduction of technology standards, performance standards, or potentially even an emissions trading program.

4. Modeling Strategy

4.1 Data and Methodology

We base our analysis on U.S. Bureau of Labor Statistics Consumer Expenditure Survey (CE) data from 2004 through 2008. The population sampled in the CE includes 128,973 observations for 50,031 households; an observation equals one household in one quarter. We use these observations to construct national after-tax income quintiles for all states and the District of Columbia, excluding Alaska and Hawaii because they are not included in the electricity model. Our sample for examining regional effects includes 112,306 observations for 43,247 households in 43 states plus the District of Columbia.[17] We aggregate the observations into 11 regions. Appendix 2 shows summary statistics for our sample, by age group and income quintile.

The model accounts for changes in household costs through direct energy expenditures and the indirect purchase of goods and services.[18] The analysis is focused on 2016, which is the first year that all components of the proposals would come into effect. The stringency of the proposals along with various provisions evolve over time, but our focus on 2016 addresses what we believe are the most salient distributional issues associated with the initial introduction of a price on CO_2 in the economy and the economic transitions that will result. Also, because we use a partial equilibrium analysis to characterize in detail the consequence of the policy, the methodology becomes less valid over a longer time horizon. We assume that the distribution of consumption across regions and income groups would be roughly the same as in our data period (2004–2008), but the level of consumption may change over time. Consumption data are combined with the average carbon contents of goods[19] to estimate the CO_2 content of every household's consumption bundle. The average CO_2 content of household consumption based on the data period is scaled to reflect changes in production and consumption that are predicted by EIA's baseline forecast for 2016 outside the electricity sector.[20] The baseline forecast for the

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[17] The ability to conduct regional analysis is hampered by topcoding—that is, changing or omitting certain characteristics of households to protect their anonymity. Observations scattered around the country; all observations from Iowa, New Mexico, North Dakota, Vermont, and Wyoming do not have state identifiers. As a result, they cannot be associated with regional outcomes. Approximately 17 percent of observations in any given CE data set have the state identifier left blank. In our extracted data, approximately 16 percent of the observations are topcoded.

[18] In the data period, direct energy consumption accounts for 48 percent of CO_2 emissions associated with household expenditures (i.e., excluding government emisisons).

[19] Hassett, Marthur, and Metcalf (2009).

[20] EIA (2009a).

electricity sector is based on Resources for the Future's Haiku electricity market model to enable more detailed analysis. A fuller description of the data and methodology appears in appendix 1.

We use EIA's cost estimate of climate policy outside the electricity sector and Haiku's estimate within the electricity sector to calculate the total burden on households to achieve an emissions reduction target for 2016. These impacts are distributed across regions, age groups, and income groups according to the expenditure patterns revealed in the CE data and the Haiku model. Our measure of household burden captures the loss in well-being experienced by households due to higher energy prices as a result of climate policy, net of any gain earned from the distribution of allowance value. It also captures the effects of changes in government programs and income and payroll taxes that are described below.[21]

4.2 Optimistic versus Pessimistic Outcomes under Waxman-Markey

To illustrate the range of potential impacts on the overall costs of the policy and the distribution of those costs across households, we model two bookend scenarios with respect to the LDC as well as energy efficiency and technology provisions of the Waxman-Markey bill. One scenario is optimistic and the other pessimistic, distinguished by the possibility that uncertain provisions of the bill lead to efficiency-enhancing outcomes or not. It is important to note that the allocation scheme in Waxman-Markey has a number of potential outcomes; we are describing two versions that we feel bound the likely range of outcomes and illustrate the range of possibilities. In describing the results in the next section, we sort out the degree to which these key assumptions affect household burdens.

Table 4.1 shows the full set of assumptions for each provision of Waxman-Markey in our optimistic and pessimistic scenarios. The assumptions do not vary for the adaptation provisions, international programs, and direct allocations to industry. In total, we vary outcomes associated with 43 percent of the allocation between the two scenarios. In both Waxman-Markey scenarios, some percentage of revenue flows to owners of firms, a category that we call shareholders.[22] We

[21]Our household burden is an estimate of the loss in consumer surplus due to higher energy prices, net of the distribution of allowance value. Consumer surplus is a measure of consumer well-being; it is an estimate of how much more a consumer is willing to pay for a good or service over and above what he or she has to pay. It is sometimes useful to think of consumer surplus as "consumer profits." When prices rise, as they would with a carbon cap-and-trade program, this measure decreases. The distribution of allowance value partially offsets this loss and we account for that in our estimate of household burden.

[22] Table 4.1 shows how allocations to merchant coal and domestic refineries flow to shareholders in both Waxman-Markey scenarios.

assume that 90 percent of funds directed to shareholders are captured domestically, with 10 percent of value flowing to international owners.[23] Of the domestic shareholders, the fifth quintile own 77 percent, while the first quintile only owns 1 percent. These allocations are discussed below.

[23] Department of the Treasury (2007).

Table 4.1. Waxman-Markey and Kerry-Boxer Allowance Allocation Summary

Description	Waxman-Markey Percent	Waxman-Markey Section	Kerry-Boxer Percent	Kerry-Boxer Section	Waxman-Markey pessimistic case	Waxman-Markey optimistic case	Cap with 75 percent dividend
Household energy consumption							
Electricity consumers – local distribution companies	30.00	782(a)(1)	25.27	771(a)(1)(A)	Revenue passed through variable portion of bill	Revenue passed through fixed charge, residential consumers respond as if in variable portion	Per-capita dividends
Natural gas consumers – LDCs	6.00	782(b)	5.06	771(a)(2)	Revenue passed through variable charge		
Natural gas consumers – energy efficiency (EE)	3.00	782(b)	2.53	771(a)(2)	Energy rebate programs for the purchase of energy-efficient furnaces and boilers		
Home heating oil and propane consumers – LDCs	0.75	782(c)	0.63	771(a)(3)	Revenue passed through fixed charge		
Home heating oil and propane consumers – EE	0.75	782(c)	0.63	771(a)(3)	Energy rebate programs for the purchase of energy-efficient furnaces and boilers		
Low-Income consumers							
Energy refunds for low-income consumers	15.00	782(d)	12.64	771(b)(2)	Direct rebates to low-income household		Per-capita dividends
Industry							
Merchant coal units/ long-term contract generators	5.01	782(a)(1)	4.22	771(a)(1)(A)	Shareholders		Per-capita dividends
Domestic fuel production	2.25	782(j)(1 & 2)	1.90	771(a)(4)(A-C)	Shareholders		Per-capita dividends
Trade vulnerable industries	14.44	782(e)	12.67	771(a)(5)&(d)(5)	Trade exposed industries react to pre-tax industry fuel prices		
Adaptation and adjustment							
Climate change worker adjustment assistance fund	0.50	782(k)(1)	0.42	771(b)(5)	Per-capita dividends		
Domestic adaptation	0.90	782(L)(1)	0.75	771(a)(15 & 16)			
Health adaptation	0.10	782(L)(2)	0.08	771(b)(6)			
National resources climate change adaptation fund	1.00	782(m)(1 & 2)	0.52	771(b)(7)			
Supplemental agriculture/agricultural incentives program	0.14	782(u)	-	-			
International programs							
REDD (international forestry reductions)	5.00	781(a)	4.21	771(C)(1)	No benefit		Per-capita dividends
International clean technology deployment	1.00	782(o)(1)	0.84	771(a)(13)			Per-capita dividends
International adaptation	1.00	782(n)(1)	1.09	771(a)(14)&(d)(8)			Per-capita dividends
Energy efficiency, energy research and development, tech development, renewables							
Deployment of carbon capture and storage technology	1.75	782(f)	1.47	771(a)(6)	No benefit	Abatement at $50/ton	Per-capita dividends
Clean vehicle technology	3.00	782(i)(1)	2.53	771(a)(8)&(b)(3)	No benefit	Abatement at $75/ton	Per-capita dividends
Energy innovation hubs	0.45	782(h)(1)	0.38	771(a)(11)	No benefit	Electricity energy efficiency programs- efficiency savings to households based on reduced electricity consumption along with CO_2 reductions	Per-capita dividends
Advanced energy research	1.05	782(h)(2)	1.05	771(a)(12)	No benefit		Per-capita dividends
Renewable energy and energy efficiency programs	0.05	782(g)(3)	0.50	771(d)(6)	No benefit		Per-capita dividends
Energy efficiency, renewables and low-income- small LDCs	0.50	782(a)(2)	0.92	771(a)(1)&(d)(7)	No benefit		Per-capita dividends
Investment in energy efficiency and renewable energy	3.25	782(g)(1)	2.46	771(a)(9)	No benefit		Per-capita dividends
	3.25	782(g)(1)	2.46		No benefit	Abatement at $34/ton	Per-capita dividends
Supplemental renewable energy	0.14	782(u)	1.24	771(b)(9)&(d)(3)	No benefit	Abatement at $34/ton	Per-capita dividends
Energy efficiency in building codes	0.50	782(g)(2)	0.42	771(a)(10)	Implementation of improved building codes		
Transportation greenhouse gas reduction	-	-	1.88	771(b)(10)&(d)(4)	No benefit	Abatement at $75/ton	Per-capita dividends
Other							
Deficit reduction	-	-	10.00	771(d)(2)	Used to offset higher government energy costs		
Market stability reserve fund	-	-	2.00	771(d)(9)	No benefit		Per-capita dividends
Total	100.77		100.78				
Economy-wide cap of 5,482 million metric tons of carbon dioxide equivalent							

4.2.1 Energy Efficiency, Rewable Energy, and Energy Technology Investments

A number of provisions allocate allowance value to programs addressing some portion of the climate problem, but how or how well these programs would work is uncertain. For allowance value directed to energy efficiency and technology development, in the pessimistic scenario we assume that these activities and investments have no benefit.[24] In the optimistic scenario, we assume that these programs are effective in achieving the goals, but the challenge is to identify what those accomplishments might entail. We assume that investments in energy efficiency achieve emissions reductions at a cost of $53.50/ton. Compared with other estimates of the cost of emissions reductions and our estimated allowance prices, the cost per ton for reductions that could be achieved through energy efficiency are relatively expensive. However, these investments also reduce spending on electricity and lower equilibrium electricity prices, providing a substantial economic benefit to households, which we account for in the model. For other technology development provisions, based on the literature (see appendix 1), we assume in the optimistic case that CCS, renewable energy, and clean-vehicle technology provides CO_2 emissions reductions at costs of $50/ton, $34/ton, and $75/ton, respectively.

4.3 Other Important Policy Variables

Several other aspects of existing policies and new ones proposed under the Waxman-Markey legislation have an important effect on the distribution of costs. The most important are described here. Appendix 1 provides further detail on the modeling approach.

4.3.1 Low-Income Energy Rebate Program

H.R. 2454 and S. 1733 allocate 15 percent and 12.64 percent, respectively, of allowance value to compensate low-income households for changes in their household expenditures. However, unlike other aspects of allocation, this provision is a means-tested entitlement program that is funded from general revenues, so that actual payments

[24] The revenue collection from introducing a price on CO_2 and associated expenditures on programs would have employment effects and would entail a transfer within the economy, even if the government uses the allowance value for various expenditures that have no benefit. Since our model does not account for changes in employment or gross domestic product, effectively we assume a full-employment economy, and there is no macroeconomic change from the collection of revenue via climate policy or the use of the allowance value.

may vary from the intended percentage. In the early years, including our model year 2016, we estimate the claim will be about 3 to 5 percent of total allowance value, depending on the allowance price and other factors we model. This implies that some allowance value in that year will be unspent and will return to general revenues, which triggers an accounted-for reduction in revenue requirements from the income tax.[25]

4.3.2 Indexing to Inflation

The introduction of a price on CO_2 raises the cost of using energy as well as the prices of all goods and services. Various government programs that are indexed to inflation are affected. Using the EIA's estimate of growth in the Urban Consumer Price Index (CPI) due to climate policy, we inflate the benefits received by households from three major programs: the Earned Income Tax Credit, veterans' benefits, and Social Security.[26] To account for the increased revenue requirement for the first two programs, we assume a proportional increase in income tax payments. For the third program, we assume an increase in the payroll tax rate.[27]

Another important way inflation affects households is through the automatic indexing of income tax brackets to inflation. As the price index increases, income tax brackets will increase and some households will drop to a lower marginal (and average) tax rate. We calculate the effect of this indexing across the income distribution. Indexing of tax brackets leads to lower revenues for the government, which we assume are offset by a proportional increase in income tax payments.

4.3.3 Allocation to Energy-Intensive, Trade-Exposed Industries

H.R. 2454 and S. 1733 allocate 14.44 percent and 12.67 percent, respectively, of allowances to energy-intensive, trade-exposed industries. The purpose of this allocation is to protect industry from unfair competition with economies that do not control their CO_2

[25] We assume proportional reductions in income tax payments. In later years under Waxman-Markey, the elibigility is expected to increase and may even exceed 15 percent of allowance value.

[26] We use EIA's (2009a) estimate of the Urban CPI from the Waxman-Markey Core Scenario. The magnitude of inflation does not change across our scenarios. Inflation would affect other programs, including food stamps and Supplemental Security Income, but we exclude them because the magnitude of the benefit is small or its distribution cannot be extracted from the CE data. An increase in military pensions could be more important, but we also exclude this effect because of insufficient data.

[27] The wage base that determines the upper limit on wage income eligible to for the payroll tax is indexed to average national wages, which we assume do not change.

emissions. The magnitude of the allocation is calculated on the basis of direct energy use, embodied CO_2 emissions, and indirect changes in cost associated with changes in electricity prices. Free allocation on an updating output basis has the effect of an output subsidy that offsets the cost of emissions allowances. Consequently, goods and services from these industries would experience a smaller increase in product prices than they would in the absence of this provision. The EIA model and our own estimates capture the effect of this provision, although the allowance value allocated does not vary across scenarios. Households benefit from this rebate by experiencing a smaller price increase on average on their bundle of goods.

4.3.4 International Programs and Emissions Offsets

EIA's estimated emissions level under the policy provides the emissions target, which we hold constant across scenarios.[28] The contribution of offsets to the emissions target varies across policies affecting the electricity LDCs, one of the policy variables described above, but is held constant for the other variables.

A share of allowance value is directed to three international programs aimed at forestry, clean-technology deployment, and adaptation. These programs will not have a direct effect on domestic compliance costs, but they could have an important indirect effect on the cost of international offsets. We assume that these programs are in place, and we do not vary this assumption across our scenarios.[29]

International and domestic offsets have different effects on households. International offsets are assumed to come into the program at the allowance price, and the profit from providing offsets flows abroad.[30] However, domestic offsets are modeled differently because domestic firms capture this profit. Although the distribution of the

[28] Both the EIA and Haiku models solve for aggregate intertemporal emissions targets and an intertemporal equilibrium that include potential changes in banking and the purchase of offsets. The models vary to a small degree with respect to emissions obtained in 2016. To hold constant the emissions in that year, we scale the results across scenarios. This introduces a small inconsistency in the aggregate intertemporal emissions reductions achieved over the modeling horizon but does not affect the distributional issues that are our focus in this report.

[29] Stevenson and Purvis (2010) argue that the international programs have a potent effect in building capacity and lowering the cost of international offsets, such that the value of these programs provides benefits that are greater than if the revenue were returned directly to households. Our offset supply curves taken from EIA assume these programs are in place.

[30] If an international offset can be provided at $5, but the clearing price is $20, the international provider of that offset captures the $15 (rent) while the U.S. firm does not.

profits from providing domestic offsets is unknown, we model profits as being split 50-50 between firm owners and per-capita dividends.[31]

4.3.5 Keeping the Government Budget Whole

In addition to the changing expenditures and revenues described above, changes in energy prices affect the government's own costs. Emissions associated with federal, state, and local governments' use of energy account for 14 percent of national emissions. Changes in expenditure requirements or revenue for government will affect the budget in the short run or debt in the long run. To achieve a full, balanced-budget accounting of these changes, we adjust federal income tax payments proportionally (or payroll taxes where appropriate) among households according to their tax burden in the baseline, thereby preserving current distributional patterns associated with tax burden at the federal level.[32] The Kerry-Boxer bill, which we analyze in appendix 3, includes specific allocation to offset budget deficits caused by the policy.

5. Results

The impacts on households from climate policy to achieve emissions reductions identified in the Waxman-Markey bill vary considerably across the legislative approaches and assumptions about implementation of those proposals. We estimate that the average household burden in 2016, accounting for changes in expenditures due to higher energy prices and the distribution of allowance value according to the bills, ranges from $138 in our optimistic version of Waxman-Markey to $436 in the pessimistic scenario. The cap-and-dividend policy lies in the middle at $235. As a percentage of annual household income, these amounts are relatively small across the board: 0.23 percent for the optimistic Waxman-Markey scenario, 0.39 percent for cap-and-dividend policy, and 0.73 percent for the pessimistic Waxman-Markey scenario.

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[31] In practice, some portion of the foreign profits accrue to U.S. households through ownership of equity, and some portion accrues abroad. We ignore these offsetting factors.

[32] One potentially important caveat is that the federal government has the smallest share of total (federal, state, and local) government CO_2 emissions. State and local revenue sources differ substantially from the federal level; therefore, those branches of government can be expected to make up revenue shortfalls through increases in, for example, sales and property taxes. We lack the resources for a full accounting at the state and local levels in this study.

The distribution of these burdens by income quintile, age group, and region of the country varies across the three scenarios as well, but some general conclusions hold across the three scenarios.

First, the magnitudes of burden for most households vary importantly with implementation of the bill. The average household in the pessimistic case experiences a burden more than three times larger than in the optimistic case.

Second, low-income households are protected under all three scenarios. In all three, households in the bottom income quintile could realize a slight gain on average from climate policy—that is, increased expenditures from higher energy prices could be more than offset by the distribution of allowance value and indexing of government programs. The degree of progressivity varies across the three scenarios, but in all cases the poorest households are, on average, the best protected.

Third, older households fare better than average households in all cases. The oldest households—those with a household head older than age 75—are harmed the least; under an optimistic scenario for Waxman-Markey and under the cap-and-dividend approach, those households enjoy a net gain.

Fourth, high-income households do well under the Waxman-Markey scenario, partially owing to rebates that flow to owners of capital. This leaves middle-income households, which receive neither the low-income rebates nor benefits as owners of capital, bearing the largest burden as a percentage of income. The cap with 75 percent dividend option distributes allowance value on a per-capita basis and therefore does not follow this pattern.

Finally, for most categories of households there are differences across regions, but these differences are less important than the differences across policy scenarios. We turn next to some more specific findings by income quintile, age group, and region.

5.1 Distributional Impacts by Income Quintile and Age Group

Table 5.1 shows average household burdens by income quintile for the two versions of Waxman-Markey and the cap with a 75 percent dividend. The top half of the table shows the losses in dollars, the bottom half as a percentage of income. The rows labeled “all” show the average household burdens across all households.

The numbers show clearly what we reported above: the average household in the lowest income quintile is better off under climate policy, be it the Waxman-Markey approach or a cap-and-dividend option. The cap with 75 percent dividend provides the largest benefit—$86 in 2016, nearly 1 percent of annual income—but all three scenarios show gains for that lowest income group. In the cap-and-dividend case, the gain is the result of the per-capita rebate of allowance value, which is proportionately more beneficial to low-income households. In the Waxman-Markey scenarios, the gain is primarily a result of the energy rebate programs for low-income households.

Table 5.1. Household Burden by Income Quintile per Household for Three Cap-and-Trade Scenarios

Income quintile	Household average income	Waxman-Markey optimistic case	Waxman-Markey pessimistic case	Cap with 75 percent dividend
		2006 dollars/year		
1	11,610	-24	-15	-86
2	26,842	77	239	-35
3	44,074	186	442	106
4	68,620	296	641	307
5	140,280	138	820	840
All	59,569	138	436	235
		Percentage of income		
1	11,610	-0.21%	-0.13%	-0.74%
2	26,842	0.29%	0.89%	-0.13%
3	44,074	0.42%	1.00%	0.24%
4	68,620	0.43%	0.93%	0.45%
5	140,280	0.10%	0.58%	0.60%
All	59,569	0.23%	0.73%	0.39%
Allowance price		($12.82 mt/$CO_2$)	($23.32 mt/$CO_2$)	($18.57 mt/$CO_2$)

Note: mt/CO_2=metric ton of carbon dioxide.

The cap-and-dividend option is more progressive than the Waxman-Markey policy under either the optimistic or pessimistic case—that is, the household burden as a percentage of income rises with the level of income. The Waxman-Markey policy is progressive through the third or fourth quintile, but the average household in the top quintile sees a smaller loss as a percentage of income than the average household in the fourth quintile. In the optimistic scenario, the average household in the top quintile experiences only 0.10 percent loss of income, resulting from the assumption that commercial and industrial electricity consumers see an increase in the variable portion of their electricity bills but a drop in fixed charges owing to the pass-through of the value of allowances by the LDCs. This scenario is efficient in that the price of electricity increases with climate policy, encouraging conservation and carbon reductions. However, the value of allowances flows through to those businesses' shareholders, who are primarily in the highest income groups.

Table 5.2 shows the average household burdens by age group, in dollar terms and as a percent of income. Households under age 65 bear most of the burden of climate policy under the Waxman-Markey option, averaging about 0.26 percent of household income in the optimistic case and about 0.77 percent in the pessimistic case. All three age groups below age 65 experience larger-than-average household burdens. In the cap-and-dividend option, households in the 40–64 age range experience larger-than-average losses, while other age groups are below average. Households in the 75+ age group are net winners under the optimistic Waxman-Markey scenario.

Table 5.2. Household Burden (2006 Dollars) by Age Group per Household for Three Cap-and-Trade Scenarios

Age group	Household average income	Waxman-Markey optimistic case	Waxman-Markey pessimistic case	Cap with 75 percent dividend
		2006 dollars/year		
Under 39	54,828	154	433	130
40–49	74,348	178	569	305
50–64	69,453	181	517	413
65–74	44,983	50	271	164
75+	30,791	-26	105	16
All	59,569	138	436	235
		Percentage of income		
Under 39	54,828	0.28%	0.79%	0.24%
40–49	74,348	0.24%	0.77%	0.41%
50–64	69,453	0.26%	0.74%	0.59%
65–74	44,983	0.11%	0.60%	0.36%
75+	30,791	-0.08%	0.34%	0.05%
All	59,569	0.23%	0.73%	0.39%
Allowance price		(\$12.82 mt/CO_2)	(\$23.32 mt/CO_2)	(\$18.57 mt/CO_2)

Note: mt/CO_2=metric ton of carbon dioxide.

Tables 5.3 and 5.4 break down the impacts on older households by showing average household burdens by income quintile for households in the three top age groups: 50–64, 65–74, and 75 and above.[33] Table 5.3 shows the results in dollar terms and table 5.4 as a percentage of income. The tables indicate that the low-income elderly do better than average elderly households, which in turn do better than average households over all age groups. In fact, households whose head is at least 65 years old in the lowest income quintile enjoy a net household gain in all three scenarios. The gain for low-income elderly households is larger than the gain for all households in the lowest income quintile (table 5.1) under Waxman-Markey. However, this pattern does not hold for a cap-and-dividend approach, where the low-income elderly do not benefit as much as low-income households on average. This is primarily a result of the per-capita nature of the rebate in that policy option; older households receive a smaller rebate because they are smaller on average.

[33] For a fair comparison across the tables, quintiles are defined nationally for the entire population, as in tables 5.1 and 5.2. Note that the average incomes listed in tables 5.3 and 5.4 for each quintile are the averages for older households, not the national average across all households reported in tables 5.1 and 5.2.

Table 5.3. Household Burden (2006 Dollars) for Older Households by Income Quintile for Three Cap-and-Trade Scenarios

Income quintile	Household average income	Waxman-Markey optimistic case	Waxman-Markey pessimistic case	Cap with 75 percent dividend
		Age group		
		50–64	**50–64**	**50–64**
1	11,611	6	19	-22
2	27,006	131	297	76
3	44,445	221	467	223
4	68,729	321	648	423
5	145,373	158	840	984
		Age group		
		65–74	**65–74**	**65–74**
1	12,415	-44	-38	-41
2	26,385	32	203	7
3	43,657	110	358	146
4	68,338	149	468	286
5	136,980	57	711	898
		Age group		
		75+	**75+**	**75+**
1	12,646	-73	-75	-61
2	25,861	-20	138	-52
3	42,893	17	237	26
4	66,689	105	416	238
5	127,897	2	592	716

Households in the 50–64 age range, on the other hand, bear a much larger portion of the burden. Across all three policy scenarios, these households have burdens that are higher than average for their quintile, regardless of the specific quintile. For example, a household in the 50–64 age group in quintile 3 incurs an average loss of $223, or 0.5 percent of income, under the cap-and-dividend policy, compared with only $26, or 0.06 percent of income, for a household age 75 or older, and $106, or 0.24 percent of income, for an average household in quintile 3. The sharp contrast with elderly households is partially due to fewer households in this range receiving Social Security (and its corresponding indexed benefits), and various other consumption behaviors.

Table 5.4. Household Burden (2006 Dollars) as a Percentage of Income for Older Households by Income Quintile for Three Cap-and-Trade Scenarios

Income quintile	Household average income	Waxman-Markey optimistic case	Waxman-Markey pessimistic case	Cap with 75 percent dividend
		Age group		
		50–64	**50–64**	**50–64**
1	11,611	0.05%	0.17%	-0.19%
2	27,006	0.49%	1.10%	0.28%
3	44,445	0.50%	1.05%	0.50%
4	68,729	0.47%	0.94%	0.62%
5	145,373	0.11%	0.58%	0.68%
		Age group		
		65–74	**65–74**	**65–74**
1	12,415	-0.36%	-0.30%	-0.33%
2	26,385	0.12%	0.77%	0.03%
3	43,657	0.25%	0.82%	0.33%
4	68,338	0.22%	0.68%	0.42%
5	136,980	0.04%	0.52%	0.66%
		Age group		
		75+	**75+**	**75+**
1	12,646	-0.58%	-0.59%	-0.48%
2	25,861	-0.08%	0.53%	-0.20%
3	42,893	0.04%	0.55%	0.06%
4	66,689	0.16%	0.62%	0.36%
5	127,897	0.00%	0.46%	0.56%

The cap-and-dividend policy is strongly progressive for older households, as shown for all households in Table 5.1. The average household burden as a percentage of income rises from -0.48 percent for the lowest income quintile in the 75+ age group to 0.56 percent for the highest income quintile. For the 65–74 age group, the loss rises from -0.33 percent of income up to 0.66 percent. The 50–64 age group also has a progressive distribution ranging from -0.19 percent to 0.68 percent, with a higher average burden throughout. The Waxman-Markey progressivity results for older households are similar to those in table 5.1 for all households. For both Waxman-Markey scenarios, the burden as a percentage of annual household income peaks in the third or fourth quintile.

Table 5.5. Increase in Average Social Security Payments for Elderly Households by Income Quintile as a Result of Indexing Social Security Benefits to Inflation

Income quintile	Household average income	Annual dollars	Percentage of income	Household average income	Annual dollars	Percentage of income
	65–74			75+		
1	12,415	$88	0.71%	12,646	$98	0.79%
2	26,385	$138	0.52%	25,861	$150	0.57%
3	43,657	$139	0.32%	42,893	$155	0.36%
4	68,338	$130	0.19%	66,689	$152	0.22%
5	136,980	$97	0.07%	127,897	$145	0.11%
All	44,983	$120	0.27%	30,791	$128	0.29%

Indexed Social Security payments play a large role in easing the burden of climate policy on older households. As energy prices rise, the CPI increases, and Social Security payments rise along with it. These payments accrue to households age 65 and older that are receiving those benefits, while the costs are assumed to be borne by younger, working households through the payroll tax (see Appendix 2). These transfers are included in the household burden reported above. Table 5.5 breaks out the increase in Social Security payments for the two older age groups by income quintile.[34] As the bottom row shows, the average household in the 65–74 age group earns $120 in extra Social Security income as a result of climate policy. Compared with the average household burdens shown in table 5.2, we can see that this extra payment is important in offsetting the costs of climate policy. The average loss for these households would have been $170 per year rather than $50 in the Waxman-Markey optimistic case, $391 rather than $271 in the pessimistic case, and $284 rather than $164 in the cap-and-dividend scenario. Similar effects are shown for the age 75+ households.

For lower-income older households, indexed Social Security matters even more. As table 5.5 shows, the extra payment amounts to 0.71 percent of income for the average age 65–74 household and 0.79 percent of income for the average age 75+ household. The

[34] Our modeling represents the effect of indexing as invariant to choice of policy scenario, thus the same benefit is earned in each case. In reality, with different allowance prices and different impacts on energy prices, the three options may have different impacts on the CPI and thus on Social Security payments. We are unable to account for those impacts, as we take our CPI prediction from EIA analysis of Waxman-Markey. The basic message—that indexing makes a big difference to the net burden—still applies, but the effect would be bigger in the pessimistic case because it has a higher allowance price and thus presumably a bigger impact on the CPI.

payment has a strongly progressive effect for these older groups: the payment as a percentage of income decreases as income rises.

5.2 Distributional Impacts by Region

Members of Congress and some interest groups pay special attention to the differential impacts of climate policy on particular states or regions of the country. Whether cap-and-trade programs affect households in one region more than another, however, depends on a complicated mix of electricity market structure, consumption patterns across regions—including fuel consumption and consumption of other goods and services—and the allowance allocation scheme. For example, households in a certain region do not necessarily bear a heavier burden just because the region has relatively more energy-intensive industries. The regional household burden is usually divorced from the location of industries, because those industries produce products sold and consumed across the country and have shareholders who live outside the region. In addition, coal-fired power produced in one region may be exported to another. It is also important to keep in mind the sheer magnitude of the allowance value relative to impacts from higher energy prices (see figure A1.1); how that value is distributed across households in different income groups and to a lesser extent across regions are the key factors in determining the ultimate burden.

Table 5.6 shows the average household burdens in 11 regions of the country for all households and for the two oldest age groups. The table also includes the average loss for households for whom the regional identifier is missing, called "topcoded households" in the table. As we stated above, the differences across regions are relatively small, particularly for average households across all age groups.[35] For example, the loss for an average household in the pessimistic Waxman-Markey scenario is 0.73 percent of income; this ranges from 0.66 percent in the Southeast to 0.86 percent in the Plains—differences of only 0.07 to 0.13 percent of income. For an average household, region matters much less than the implementation of the Waxman-Markey allocation scheme. The difference between the pessimistic and optimistic scenarios, for an average household, is 0.50 percent of income (0.73 percent versus 0.23 percent).

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[35] As we previously explained, we are unable to assign the topcoded observations to individual regions. We show the average household burdens for these observations in table 5.6 to highlight that they are generally smaller than for the nation on average. The reported regional averages have a small upward bias.

Beyond the relatively minor regional differences, it is difficult to draw any other strong conclusions from the findings in the table. Comparing average household burdens for all age groups, households in the Plains region consistently fare the worst. However, this is not the case for older households. The Mountain region is the worst for households in the 65–74 age group, while no consistent pattern shows up for the 75+ group. Older households in the Southeast incur the lowest household burdens as a percentage of income for the optimistic and cap-and-dividend cases and the second-lowest for the pessimistic case. Overall, though, these differences are quite small, both for older households and for households of all ages.

Table 5.6. Household Burden (2006 Dollars) for Elderly Households as a Percentage of Income By Region for Three Cap-and-Trade Scenarios

Region	Waxman-Markey pessimistic case			Waxman-Markey optimistic case			Cap with 75 percent dividend		
	Age group								
	65–74	75+	All	65–74	75+	All	65–74	75+	All
Southeast	0.46%	0.11%	0.66%	0.05%	-0.19%	0.23%	0.21%	-0.15%	0.34%
California	0.59%	0.42%	0.69%	0.09%	-0.05%	0.16%	0.29%	0.07%	0.32%
Texas	0.62%	0.43%	0.82%	0.12%	-0.01%	0.26%	0.41%	0.18%	0.42%
Florida	0.63%	0.27%	0.71%	0.16%	-0.08%	0.24%	0.32%	-0.01%	0.34%
Ohio Valley	0.64%	0.36%	0.76%	0.16%	-0.05%	0.28%	0.47%	0.11%	0.49%
Mid-Atlantic	0.58%	0.41%	0.69%	0.04%	-0.08%	0.17%	0.33%	0.10%	0.43%
Northeast	0.71%	0.52%	0.75%	0.12%	-0.10%	0.17%	0.41%	0.08%	0.47%
Northwest	0.54%	0.36%	0.74%	0.11%	-0.01%	0.32%	0.35%	0.12%	0.35%
New York	0.69%	0.44%	0.67%	0.09%	-0.18%	0.07%	0.46%	0.19%	0.35%
Plains	0.74%	0.43%	0.86%	0.25%	0.03%	0.37%	0.52%	0.13%	0.59%
Mountains	0.76%	0.33%	0.79%	0.27%	-0.03%	0.31%	0.61%	0.04%	0.43%
Topcoded Households	-0.11%	-0.13%	-0.06%	-0.06%	0.00%	-0.03%	-0.06%	-0.13%	-0.03%
National	0.60%	0.34%	0.73%	0.11%	-0.08%	0.23%	0.36%	0.05%	0.39%

5.3 Understanding the Differences in the Optimistic and Pessimistic Scenarios

The average household burdens are quite different between the Waxman-Markey optimistic and pessimistic scenarios. The primary reasons for the differences lie in assumptions about LDC behavior, the efficacy of investments in clean-energy technologies and renewables, and the payoff from electricity energy efficiency. We disentangle the degree to which these three provisions contribute to the differences between the optimistic and pessimistic outcomes using the Shapley value concept.[36] The Shapley value calculates the marginal contribution of each provision within each possible combination of provisions that distinguish the optimistic and pessimistic scenarios. The result is in a unique estimate of the percentage of the difference across the three scenarios that is attributable to each policy element of those scenarios. Table 5.8 shows the Shapley values for the allowance price in the last row of the table and the values for the average household burden in the penultimate row. Above that are the Shapley values for each age group's household burden.

Table 5.7. Shapley Values by Income Quintile per Household for LDC Behavior, Technology Provisions, and Electricity Energy Efficiency Programs

Age group	Waxman-Markey pessimistic case	Percentage Reduction in Household Cost Due to: LDC Billing Behavior	Technology Programs	Electricity Energy Efficiency Programs	Waxman-Markey optimistic case
Under 39	$433	4%	23%	73%	$154
40–49	$569	14%	21%	65%	$178
50–64	$517	15%	25%	60%	$181
65–74	$271	2%	32%	66%	$50
75+	$105	0%	30%	70%	-$26
All	$436	10%	24%	66%	$138
		Percent Reduction in Allowance Price			
Allowance Price	($23.32 mt/$CO_2$)	26%	48%	26%	($12.82 mt/$CO_2$)

Notes: LDC=local distribution companies; mt/CO_2=metric ton of carbon dioxide.

The electricity energy efficiency provisions are responsible for most of the differences between the optimistic and pessimistic household burdens for all age groups. They account for 66 percent of the difference between the average loss of $436 in the pessimistic case and $138 in

[36] Roth (1988).

the optimistic case. This result is consistent across age groups, ranging only from 60 percent for the age 50–64 households to 73 percent for those under age 39. The efficiency provisions provide savings through multiple mechanisms. Because less electricity is generated, other sectors of the economy do not need to work as hard to reduce emissions; this lowers the allowance price and reduces overall costs, similar to the way the technology provisions work, as previously discussed. But the efficiency provisions have additional impact. These provisions, by improving the efficiency of buildings, appliances, and equipment, directly reduce household electricity purchases and expenditures; this is additional to reductions spurred by higher prices. This benefit to households explains why the optimistic assumptions for the efficiency provisions have a large impact on household burdens but a more modest impact on the allowance price: the assumptions for these programs account for only 26 percent of the difference in allowance price in the optimistic and pessimistic cases.

The assumptions about allocation to LDCs account for only 10 percent of the difference in household burden for average households in the pessimistic and optimistic cases. This small impact on household burdens is due to the fact that changing from pessimistic to optimistic assumptions for the allocation to LDCs only reallocates allowance value from a less efficient to more efficient use. By contrast, the pessimistic case for the technology and electricity efficiency provisions assumes that all revenue for those provisions is lost, while the optimistic case assumes productive use of the revenues. The LDC provisions produce slightly different results by age group: they account for a greater share of the difference in pessimistic and optimistic outcomes for households in the 40–49 and 50–64 age groups but a very small share of the differences for households in other age groups.

6. Conclusion

CO_2 emissions are ubiquitous, and consequently, policies to restrict these emissions will affect household expenditures in diverse ways. In this study, we examined three versions of an economy-wide CO_2 cap-and-trade system and evaluated the distribution of the burden placed on households by income quintile, age group, and region of the country.

We modeled in detail two versions of the Waxman-Markey legislation, which vary according to implementation of the complex allowance allocation scheme in the bill, and a third, more predictable approach that relies largely on a government auction coupled with per-capita dividends as payment back to households. We calculated the average burden for households by income group, age group, and region, assuming outcomes that can be anticipated for the year

2016. Our measure of burden is an approximation of consumer surplus loss net of the allowance value distributed back to households according to the policy alternatives.

We find that the average household burden ranges from $138 per household in our optimistic version of Waxman-Markey to $235 in the cap-and-dividend approach to $436 in the pessimistic version for Waxman-Markey. As a percentage of average annual household income, these amounts are all relatively small: 0.23 percent for the optimistic Waxman-Markey case, 0.39 percent for cap-and-dividend, and 0.73 percent for the pessimistic Waxman-Markey case.

Our distributional analyses yielded five main findings. First, the implementation of the bill is an important determinant of most household burdens. All households face a lower burden in the optimistic case compared to their pessimistic case burden.

Second, poorer households are protected under all three scenarios. Households in the bottom income quintile could realize a slight gain, on average, from climate policy—increased expenditures from higher energy prices could be more than offset by the distribution of allowance value and indexing of government programs. This result is due to the Low-Income Energy Rebate Program in the Waxman-Markey bill and the per-capita rebate in the cap-and-dividend option. The energy rebate program phases out quickly as income rises; households in the middle part of the second income quintile fare worse because they no longer qualify for the rebate.

Third, older households—those older than age 65—are harmed less by climate policy than other age groups. The low-income elderly are further protected, with the first quintile always experiencing net gains. Many of these comparatively low burdens can be attributed to the automatic indexing of Social Security to inflation, which provides an average household headed by an elderly person approximately $124 of additional income. Low-income elderly households receive additional protection from the Low-Income Energy Rebate Program.

Fourth, higher-income households receive relief from allocations that flow to owners of capital in the Waxman-Markey cases. This results in the largest burden as a percentage of income falling on households in the middle of the income distribution. These households do not benefit from programs targeted at the lowest income households, nor do they receive many of the benefits of allocations that accrue to shareholders who are concentrated in the higher-income households.

Fifth, regional differences do exist across regions, but they are less important than the differences across policy scenarios. In sum, the details and implementation of the allowance allocation scheme are the key factors determining costs of the policy to households.

The possible range of outcomes depends on the performance of various climate-related programs and assumptions about the behavior of electricity consumers. The optimistic and pessimistic implementations of Waxman-Markey serve as bookends for this range of outcomes. It is important to note that the difference between optimistic and pessimistic cases within a demographic group is frequently larger than the differences between demographic groups. Electricity energy efficiency programs—among the recipients of allowances in the Waxman-Markey bill—are the most important cost-saving measure, responsible for 66 percent of the difference between the optimistic and pessimistic cases. These results reinforce that how allowance value is spent is usually more important than the initial demographic characteristics and initial household burdens. It also points to the effectiveness of electricity energy efficiency as a cost-containment measure and reinforces the importance of effective implementation and monitoring of climate-related programs under Waxman-Markey.

The uncertainty surrounding household outcomes in Waxman-Markey can be easily contrasted with the relative certainty of a cap-and-dividend scenario. The scenario we investigate is modeled after the approach proposed in the Cantwell-Collins bill but is calibrated with different provisions, including emissions targets that match the Waxman-Markey cases. It is difficult to predict how the Waxman-Markey legislation might be implemented; the optimistic and pessimistic cases provide possible bookends, with the relatively predictable cap-and-dividend approach likely falling between the two. The cap-and-dividend scenario eliminates much of the uncertainty associated with allowance allocation, and its strongly progressive nature effectively compensates low-income households without a complex means-tested programs.

Although the changing climate is a long-term problem, public policy tends to have parochial and short-term concerns, especially with respect to the distribution of costs. Therefore, the estimated impacts on households in the next decade may play an especially important role in the prospects of climate policy. We find that the most vulnerable groups of the population are not harmed, and the distribution of costs across groups does not seem to pose an insurmountable challenge in the design of policy. Nonetheless, we also show that choices over provisions of possible legislation can have an important effect on some groups and on the overall cost of the policy.

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Appendix 1. Background on Modeling Strategy

The average CO_2 content of household consumption based on U.S. Consumer Expenditure Survey (CE) data from 2004–2008 is scaled to reflect production and consumption that are predicted by EIA's baseline forecast (in the absence of climate policy) for 2016 outside the electricity sector[37] and the forecast of RFF's Haiku electricity market model inside the electricity sector.

Figure A1.1 illustrates the mechanism of placing a price on CO_2 emissions through the introduction of a cap-and-trade policy. The horizontal axis in the graph represents 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 (MAC) curve. The electricity sector MAC is generated from the Haiku model, whereas abatement behavior for the rest of the economy, excluding the electricity sector, is taken from the EIA analysis of the Waxman-Markey bill, H.R. 2454.[38] The EIA MAC curve is combined with the Haiku electricity MAC curve to model economy-wide abatement behavior. Using this economy-wide curve, an endogenous allowance price (represented by the height of the rectangle) is calculated such that emissions in our model match capped levels in 2016 under climate policy (17 tons of CO_2 equivalent), as estimated by EIA.[39]

The triangular area under the marginal cost curve up to the emissions target is the cost of resources used to achieve emissions reductions. The rectangle represents the value of emissions allowances generated by the trading program (number of allowances multiplied by the price per allowance). EIA's analysis of H.R. 2454 provides an estimate of the aggregate burden—that is, the two areas shown on the graph—along with a breakdown of this burden among sectors. We treat the electricity sector separately, using the Haiku model to obtain changes in emissions due to the CO_2 price. All other sectors' reductions and costs are assumed to match EIA.

Household goods are divided into two categories: direct and indirect. Direct goods are fuels consumed by households, such as electricity, natural gas, fuel oil, and gasoline. Indirect goods are all other purchases by households, such as food, services, durable goods, and automobiles. Direct electricity price and demand changes, along with the carbon content of

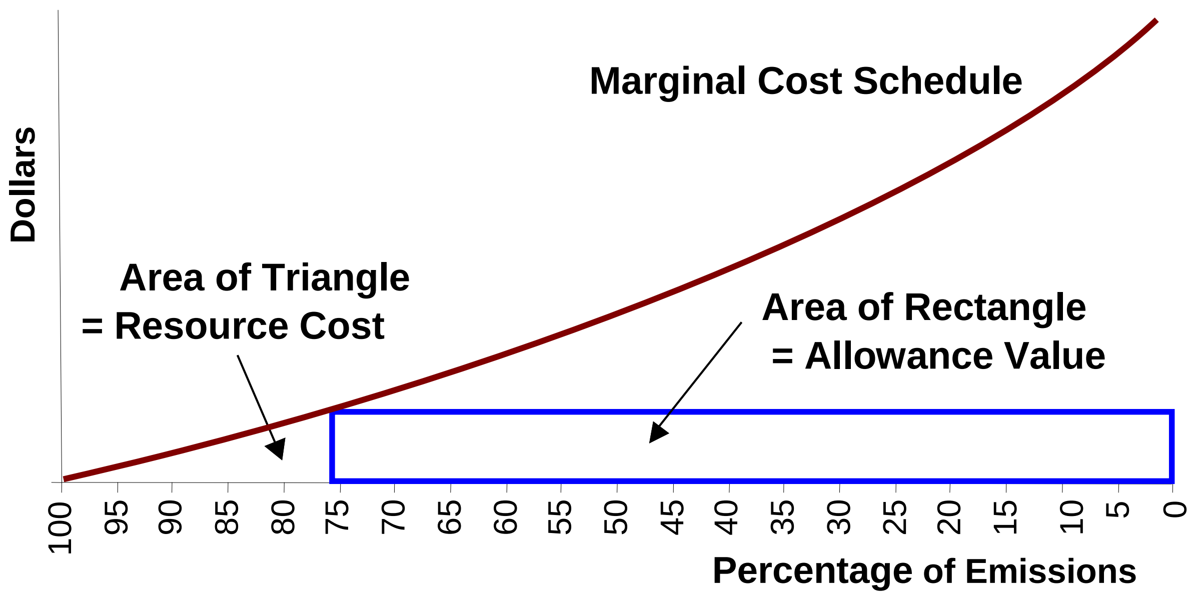
[37] EIA (2009a).

[38] EIA (2009a).

[39] http://www.eia.doe.gov/oiaf/servicerpt/hr2454/excel/hr2454cap.xls (accessed September 9, 2009)

electricity, are taken from Haiku results. The other direct emissions and abatement are from EIA. Indirect goods emissions are divided into two parts, non-electricity emissions and electricity emissions. Indirect non-electricity emissions and abatement behavior are assumed to match EIA estimates. Indirect electricity emissions and abatement behavior are taken from Haiku estimates of electricity use by the commercial and industrial (nonresidential) sectors.

Figure A1.1. Resource Cost and Allowance Value



To calculate the distribution of losses across regions and households, we use baseline emissions intensities and own-price elasticities along with consumption expenditure and price increases.[40] These data provide a first-order indication of the relative change in burden across various consumption categories resulting from the introduction of a price on CO_2. This distribution of losses is then scaled proportionately across categories of consumption to match the changes predicted by EIA and Haiku to generate an initial household burden. This calculation explicitly assumes that the initial change in household welfare in our model equals the sum of the resource cost and the allowance value estimated by EIA and Haiku. This approach also rests on

[40] An own-price elasticity is the percentage change in consumption given a 1 percent change in the price of a good. Direct electricity does not use own-price elasticities since Haiku provides detailed, regional demand changes. Own-price elasticities and baseline emissions intensities are taken from Burtraw, Sweeney, and Walls (2009).

the implicit assumption that producers pass all costs through to consumers and bear none of the costs themselves, which is approximately true in the short run, when demand is relatively inelastic. As a result, our estimate of the initial household burden outside the electricity sector for the average household matches EIA's estimate of abatement cost, including allowance cost.

After initial household burdens are calculated, allowance value is distributed based on scenario dependent allocation schemes. This refunded allowance value is subtracted from the initial household burden, along with changes in transfers due to inflation driven changes in taxes and government benefit programs, to calculate a net household burden. This measure of welfare loss under climate policy constitutes the sum of the resource cost triangle plus the allowance value that does not find its way back to households.

As noted, we use the Haiku electricity market model in place of EIA's forecast for the sector. The Haiku model reports price changes that are somewhat different across regions and slightly lower on average than those of EIA. Using Haiku in place of the EIA electricity model preserves substantial detail with respect to regions and customer classes and allows for the various treatments of customer classes and allocation scenarios that we discuss below. The Haiku model solves for electricity market equilibria in 21 regions of the country that are mapped into the 11 regions used for the distributional analysis. The electricity model accounts for price-sensitive demand, electricity transmission between regions, system operation for three seasons of the year (spring and fall are combined), and four times of day, and changes in demand and supply-side investment and retirement over a 25-year horizon.[41] The Haiku model also captures differences in the regulatory environment across regions and allows us to model different behavioral assumptions corresponding to fixed and variable charges for residential, commercial, and industrial customers.[42] The model calculates a national baseline–emissions rate of 0.602 tons of CO_2 per megawatt-hour for 2016 in the absence of any climate policy.

One important limitation of our methodology is the use of partial equilibrium modeling for what is fundamentally a general equilibrium problem. The partial equilibrium approach allows us greater flexibility in manipulating institutional representation in the model and much greater attention to detail, but important feedbacks within the economy are lost to the analysis—

[41] Paul, Burtraw, and Palmer (2009).

[42] The 48 contiguous states and the District of Columbia are included in the electricity modeling, but as noted, five states (Iowa, New Mexico, North Dakota, Vermont, and Wyoming) are dropped when calculating effects on households at the regional level because of topcoding. However, national estimates always include these five states.

for example, the hidden costs associated with introducing new regulatory costs to the economy. A second limitation has to do with the actual schedule of opportunities for energy efficiency and technology. Under each of our scenarios that assume optimistic or pessimistic outcomes, we assume a constant return to scale for these endeavors. In fact, efficiency or technology could exhibit increasing cost, but it could alternatively exhibit decreasing costs through learning by doing and other factors. Moreover, examining these technological possibilities on a piecewise basis rather than in an integrated technological model introduces the opportunity for double-counting emissions reductions opportunities. While concerns about returns to scale arguably introduce bias in any direction, the possibility for double-counting is likely to bias our cost estimates downward. In any case, these issues provide one more illustration of the uncertainty associated with implementing a complex policy such as Waxman-Markey.

A.1.1 Allocation to Local Distribution Companies

If LDCs used allowance value to reduce rates, consumers would perceive electricity as relatively less expensive and make relatively fewer efforts to improve end-use efficiency as a consequence. Modeling indicates that this scenario this could raise allowance prices and overall cost because greater emissions reductions would have to be achieved elsewhere in the economy.[43] Some have suggested that LDCs should instead preserve price increases that would be expected under an auction of allowances and return the allowance value to consumers as a refund or apply it against the fixed-cost portion of energy bills. However, unless LDCs were to segregate the refund from the monthly bill, consumers likely would equate a smaller bill with less expensive energy, which would have the same effect as using the allocation to reduce prices. The options are complicated further because LDCs may choose to use different methods for different classes of customers.

In the modeling, we do not vary the effect of allocation to natural gas LDCs. With respect to the electricity LDC allocations, in the pessimistic scenario we assume the allowance value flows to all classes of customers—residential, commercial, and industrial—via a reduction in the variable electricity rates on monthly bills. As we explained above, consumption is higher as a consequence of the subsidy to electricity prices, so the allowance price and overall costs of the policy are higher in this case; this is the sense in which the assumption is pessimistic. In the optimistic scenario, we assume that fixed charges are reduced for industrial and commercial

[43] Burtraw, Walls, and Blonz (2009); Paul, Burtraw, and Palmer (2009).

customers. However, we assume this remains infeasible for residential customers. A review of current billing practices and state public utility commission behavior suggests that significant hurdles exist to implementing this kind of pricing (a reduction in the fixed portion of the electricity bill) by 2016.[44] One prominent reason is that in almost no case does the fixed portion of costs appear as a separate line item on bills for residential customers, and even when it does appear separately, it is recovered almost entirely through volumetric charges.

Furthermore, it is unclear how residential customers would respond even if it were possible to return allowance value to them through fixed payments. Many observers have suggested that residential customers are unlikely to understand and respond in an economically rational way to an increase in the variable rate (marginal cost) by reducing consumption if their overall bill is reduced. Nonetheless, industrial and commercial electricity consumers might have greater sophistication and ability to distinguish between the fixed and variable parts of their bill, and thus we evaluate this possibility in our optimistic case with respect to the allocation to LDCs. If industrial and commercial customers recognize a reduction in the fixed cost but not the price, then in a competitive market, the rebate would not affect the price they charge their own customers for the goods and services they provide. The benefit of the rebate would not be passed on through lower product prices but instead would accrue to owners of the firms. Hence, for these customers, we assume that the refund flows through to shareholders.

An important aspect of allocation to electricity LDCs is the basis for determining apportionment among LDCs. The formula embodied in H.R. 2454 distributes allowances to electricity LDCs with weights based half on (historic) emissions and half on (an updated measure of) electricity output.

A.1.2 Energy Efficiency, Renewable Energy, and Energy Technology Investments

The energy efficiency, renewables, and technology development provisions also generate highly uncertain outcomes. McKinsey & Company has argued that a great deal of “low-hanging fruit” is available for reducing energy use and CO_2 emissions.[45] Its study and several replicas[46]

[44] Burtraw, Walls, and Blonz (2009).

[45] McKinsey & Company (2007).

[46] Sweeney and Weyant (2008).

identify MAC curves for reducing CO_2 emissions that show engineering cost estimates for a variety of energy-saving options in production and consumption.

Estimates of the cost of reducing electricity consumption in the optimistic scenario are based on advocates' claim that spending resources on energy efficiency programs can overcome institutional or market barriers, and in effect can accomplish cost-effective investments that households cannot or do not make for themselves.[47] A large survey of the energy efficiency literature estimates that investments in efficiency have reduced electricity use at a payoff of about 2.8 cents per kilowatt-hour (kWh) of electricity saved (2002 dollars).[48] However, subsequent studies characterize this as a very optimistic estimate. Using improved statistical methods, one study estimates an average cost of 6.2 cents per kWh (2007 dollars) saved in previous programs.[49] The researchers speculate that incremental spending by utilities that had low previous levels of spending could achieve savings at half the incremental cost of previous programs. Accounting for the possibility of improved program design and expansion to new regions of the country that provide low-cost opportunities, we use the estimate of 2.8 cents per kWh[50] as an optimistic forecast of the average cost-effectiveness of future investments in efficiency across the nation. We apply an average emissions intensity of electricity generation in the country of 0.000523 tons CO_2 per kWh of generation as forecast by the Haiku model in the baseline to arrive at an optimistic estimate of $53.50 as the cost per ton of avoided emissions resulting from energy efficiency investments.[51]

The studies on which we based our optimistic estimates for the technology development provisions estimate the cost per ton of CO_2 emissions reduced when particular technologies or alternative fuels are used in place of the conventional option.[52] For example, one study estimates the cost of abating CO_2 emissions through the use of carbon capture and sequestration (CCS), both for a first-of-a-kind plant and a mature technology plant in 2030, using a range of cost estimates from several previous studies.[53] The researchers conclude a first-of-a-kind plant is

[47] Cowart (2008).

[48] Gillingham, Newell, and Palmer (2004).

[49] Arimura, Newell, and Palmer (2009).

[50] From Gillingham, Newell, and Palmer (2004).

[51] For comparison, EIA (2009b) indicates that average emissions intensity in 2010 is 0.000558 tons CO_2 per kWh.

[52] These studies are Al-Juaied and Whitmore (2009), Kammen et al. (2009), and McKinsey & Company (2007)and.

[53] Al-Juaied and Whitmore (2009).

likely to have an abatement cost of \$100 to \$150 per metric ton CO_2 avoided, while a mature technology plant is likely to have an abatement cost of \$30 to \$50 per metric ton. Another group of researchers estimate the cost per ton of emissions reduced in a range of scenarios for plug-in hybrid and electric vehicles compared with conventional gasoline vehicles.[54] And as we explained above, McKinsey & Company has cost and effectiveness estimates for a range of technologies and scenarios.[55] Based on findings in these studies, we assume in the optimistic case that CCS, renewable energy, and clean-vehicle technology provide CO_2 emissions reductions at costs of \$50/ton, \$34/ton, and \$75/ton, respectively.[56]

A.1.3 Indexing to Inflation

Benefits delivered through several existing programs are calibrated to changes in the CPI. Social Security and veterans' benefits are tied to the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W). Tax parameters are tied to the Consumer Price Index for All Urban Consumers (CPI-U). We use the CPI-U, which is virtually indistinguishable from the CPI-W over the short-time horizon of this study, to examine changes in both spending programs and taxes.

Earned Income Tax Credit (EITC): The EITC initially grows with a taxpayer's earned income until it reaches a maximum benefit, and then is phased out as household income grows further. The income ranges over which the EITC is phased in and out are indexed to inflation, and as a result the maximum benefit is also indexed to inflation. Consequently, indexing gives higher benefits to recipients who qualify along with extending eligibility to some additional households. This is modeled explicitly (see figure A.1.2).

Veterans' Benefits: Households that currently receive veterans' benefits see an increase equal to the inflation factor, which we model explicitly (see figure A.1.3). Veterans' benefits are a very small portion of the average household's income. In total, this program is less important than either the EITC or the Social Security program. Note that these benefits do not include

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54 Kammen et al. (2009).

55 McKinsey & Company (2007).

56 We do not solve with any specific introduction date for any of the technology development provisions, and they may not be deployed in 2016. Instead, we assume that some of these technologies will reduce cumulative emissions targets over the lifetime of the cap-and-trade policy and, consequently, 2016 allowance prices through the banking mechanism.

retirement income for military personnel, which we are unable to model for lack of data. Most important, indexed military pensions would likely be increased and further reduce the average burden on retired citizens.

Social Security: Social Security benefits are indexed annually to the cost-of-living adjustment. We adjust all Social Security benefits by the inflation factor and adjust the payroll tax to account for the change in the revenue requirement for the program (see figure A.1.4).

Indexation of Tax Brackets: Tax brackets are automatically indexed to inflation to prevent bracket creep as prices increase. The inflation caused by climate policy represents an increase in prices, without a corresponding general increase in the nominal wage. Because the brackets would shift up but incomes would not, the real tax revenue that the government collects would decrease. For example, consider a hypothetical marginal tax rate of 25 percent for an income bracket of $30,000–$50,000 and 30 percent for $50,000–$70,000. If the CPI increased by 1 percent, the automatic indexing would increase these brackets to $30,300–$50,500 and $50,500–$70,700, respectively. Imagine a household that earns $50,250. Before the automatic indexation of taxes, the household would pay the 30 percent marginal rate on that last $250. However, after the automatic indexation, a household on the margin of the tax brackets would pay only 25 percent on the last $250. This constitutes a $12.50 loss in revenue for the government, while this household would experience higher after-tax income.

To approximate this effect, we use average tax rates by decile for 2005. We adjust the decile income breaks for each average tax rate by the inflation factor. Any household from the decile above that falls into the adjusted range for average taxes would face the average tax rate of the lower decile. Consequently, households on the margin see a reduction in their tax payments, and the government sees a corresponding decrease in revenue.

To make up for the need for additional government revenue, average tax rates on households are increased proportionately. This is accounted for in calculating the net household loss (see figure A.1.5).

A.1.4 Keeping the Government Budget Whole

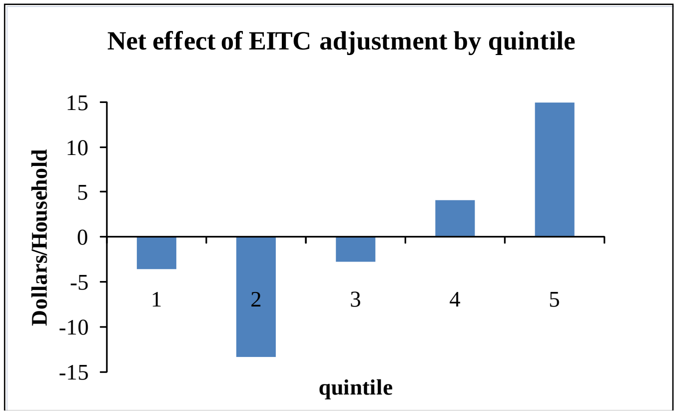
Government revenues and expenditures are affected in several ways. Where expenditures or tax revenues are affected through indexing to inflation, the change in the government's budget is accounted for and revenues are adjusted through proportional changes in the average income tax (or payroll tax in the case of Social Security benefits). Government will see an increase in expenditures associated with its own use of energy, which we assume to be associated with 14 percent of allowance value. A potentially important limitation is that we associate all changes in government costs with the federal government, when in fact a majority of government direct energy expenditures occur at the state and local level. We adjust average income taxes to account for the difference between this increase in costs and revenues dedicated to government expenditures under the various policy proposals. The assumption that government will raise taxes instead of cutting services is strong, with important distributional consequences. Service cuts would more likely harm low-income households, and higher-income households would pay for income tax increases. The Congressional Budget Office does not allocate 13 percent of allowance value from the allowance allocation to cover government costs, thereby avoiding an explicit assumption about the distributional consequence of increases in government costs.[57] Nonetheless, a strong assumption is implicit and understates the complexity of the allowance allocation scheme. It also constitutes an explicit assumption that the 13 percent will not be used for the purposes for which it is allocated in the legislation.

One aspect that we do not model with respect to government revenue is the "Congressional Budget Office haircut." This feature of legislation requires that enough revenue be withheld to offset the decreases in direct tax revenue as a result of climate policy. The details are complex and differ between House and Senate proposals. Waxman-Markey, which originated in the House, has relatively lax provisions about budget neutrality. Since it is the main bill analyzed in this report, we decided not to model the haircut provisions in Kerry-Boxer. Instead, we use funds set aside for deficit neutrality to directly pay for the increase in government's energy expenditures, as discussed above.

[57] CBO (2009).

Figure A1.2. Net Household Burden (2006 Dollars) by Income Quintile and Age Group per Household due to Automatic Indexation of Earned Income Tax Credit (EITC) Benefits

	Average income	Change in EITC benefits	Increase in income taxes to offset gain in EITC benefits	Net effect of EITC adjustment
Quintile				
1	11,610	-4	0	-4
2	26,842	-15	1	-13
3	44,074	-5	3	-3
4	68,620	-1	5	4
5	140,280	0	15	15
Age group				
Under 39	54,828	-9	4	-5
40–49	74,348	-6	7	1
50–65	69,453	-2	6	4
65–74	44,983	-1	3	2
75+	30,791	-1	2	1
All	59,569	-5	5	0



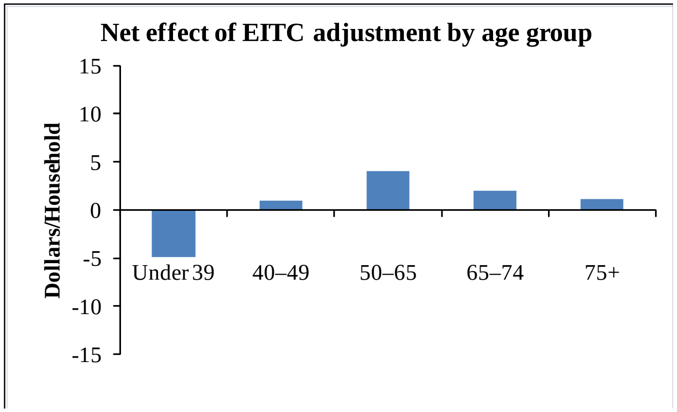
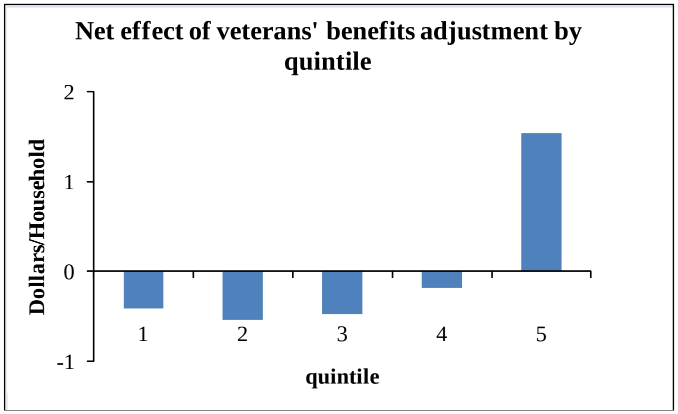


Figure A1.3. Net Household Burden (2006 Dollars) by Income Quintile and Age Group per Household due to Automatic Indexation of Veterans' Benefits

	Average income	Change in veterans' benefits	Increase in income taxes to offset gain in veterans benefits benefits	Net effect of veterans' benefits adjustment
Quintile				
1	11,610	0	0	0
2	26,842	-1	0	-1
3	44,074	-1	0	0
4	68,620	-1	1	0
5	140,280	-1	3	2
Age group				
Under 39	54,828	0	1	0
40–49	74,348	-1	1	0
50–65	69,453	-1	1	0
65–74	44,983	-1	1	0
75+	30,791	-1	0	-1
All	59,569	-1	1	0



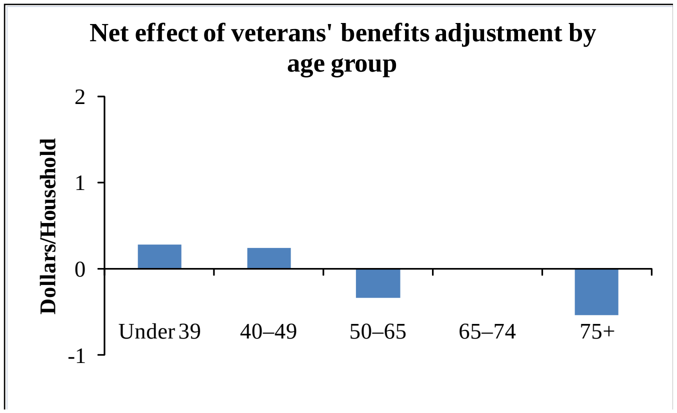
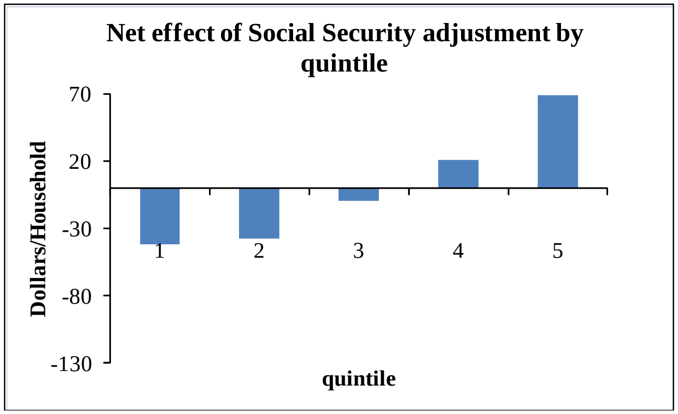


Figure A1.4 Net Household Burden (2006 Dollars) by Income Quintile and Age Group per Household due to Automatic Indexation of Social Security Benefits

	Average income	Change in Social Security benefits	Increase in payroll taxes to offset gain in Social Security benefits	Net effect of Social Security adjustment
Quintile				
1	11,610	-45	3	-42
2	26,842	-52	14	-38
3	44,074	-38	28	-10
4	68,620	-26	47	21
5	140,280	-18	87	69
Age group				
Under 39	54,828	-3	39	37
40–49	74,348	-7	51	44
50–65	69,453	-25	43	18
65–74	44,983	-133	13	-120
75+	30,791	-132	4	-128
All	59,569	-36	37	1



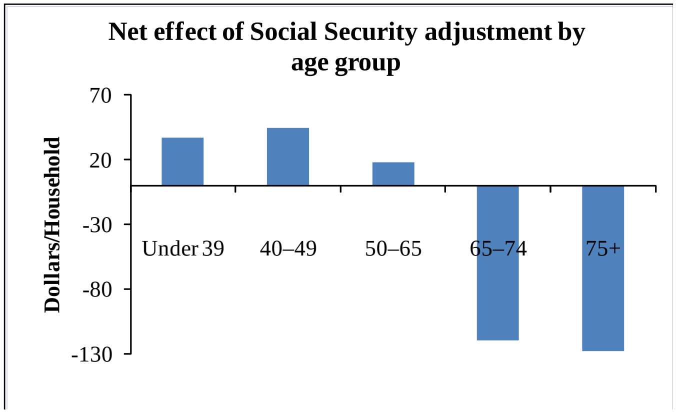
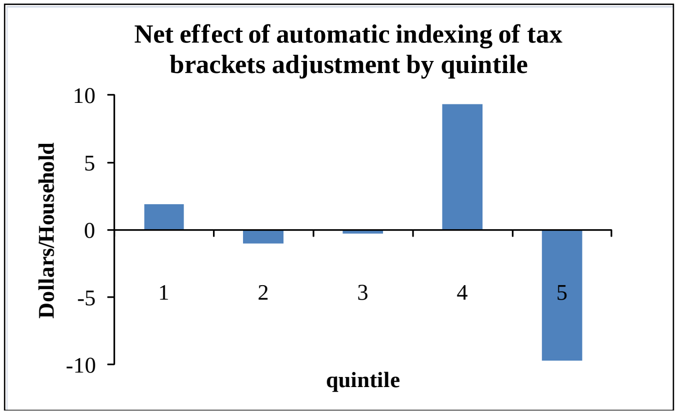
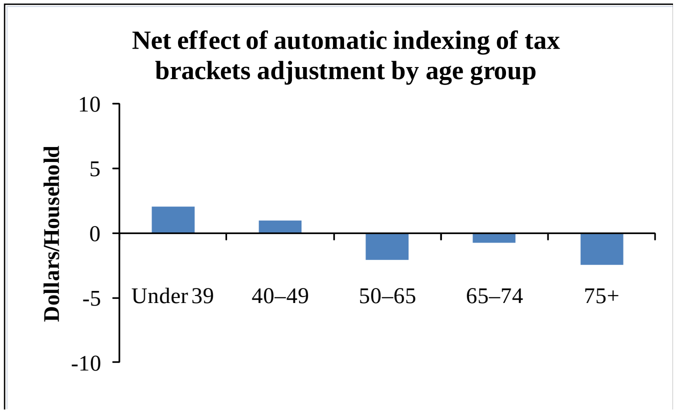


Figure A1.5. Net Household Burden (2006 Dollars) by Income Quintile and Age Group per Household due to Automatic Indexation of Income Tax Brackets

	Average income	Change in welfare from automatic indexing	Change in income taxes to offset gain in automatic indexing of tax brackets	Net effect of automatic indexing of tax brackets adjustment
Quintile				
1	11,610	0	2	2
2	26,842	-11	10	-1
3	44,074	-23	23	0
4	68,620	-36	45	9
5	140,280	-147	137	-10
Age group				
Under 39	54,828	-38	40	2
40–49	74,348	-59	60	1
50–65	69,453	-56	54	-2
65–74	44,983	-30	30	-1
75+	30,791	-19	17	-2
All	59,569	-45	45	0





Appendix 2. Summary Statistics

	Household income	Household wages	Household size	Observations	Direct energy expenditures: Electricity	Gasoline	Natural gas	Fuel oil	Total direct energy	Indirect costs (other spending)	Social Security	Earned Income Tax Credit	Veterans' benefits
Quintile													
1	$11,268	$4,312	1.71	26,687	$779	$912	$280	$81	$2,052	$16,612	$4,767	$392	$44
2	$26,798	$17,577	2.22	26,687	$1,043	$1,607	$390	$112	$3,152	$24,796	$5,548	$540	$79
3	$44,054	$35,171	2.59	26,688	$1,192	$2,191	$464	$126	$3,972	$33,707	$4,085	$133	$101
4	$68,603	$59,568	2.95	26,687	$1,359	$2,754	$552	$165	$4,829	$44,865	$2,874	$33	$113
5	$140,277	$123,545	3.25	26,688	$1,726	$3,411	$772	$220	$6,130	$71,217	$1,979	$15	$116
Age group of head of household*													
Under 39	$53,305	$50,076	2.91	43,091	$1,064	$2,192	$389	$77	$3,721	$35,391	$277	$413	$51
40–49	$73,345	$68,438	3.14	28,283	$1,419	$2,699	$557	$160	$4,836	$44,475	$773	$246	$96
50–64	$68,414	$57,408	2.29	34,900	$1,348	$2,393	$559	$168	$4,468	$42,388	$2,740	$97	$147
65–74	$44,062	$17,576	1.91	13,818	$1,210	$1,697	$525	$176	$3,608	$34,704	$14,242	$73	$62
75+	$29,843	$5,230	1.59	13,345	$978	$932	$472	$200	$2,581	$27,037	$14,058	$42	$92
All	$58,201	$48,035	2.57	133,437	$1,220	$2,175	$491	$141	$4,027	$38,240	$3,851	$223	$91

Notes and definitions

*Head of Household — Defined as Consumer Expenditure Survey (CE) "Reference Person" : The first member mentioned by the respondent when asked to "Start with the name of the person or one of the persons who owns or rents the home."

Social Security — Defined by question asked in CE "What was the amount of the last Social Security or Railroad Retirement payment received?"

Veterans' Benefits — Defined by question asked in CE "What was the total amount of income from workers' compensation or veterans' benefits, including education benefits, but excluding military retirement, received by ALL consumer unit members? "

Earned Income Tax Credit - Values calculated by authors

Appendix 3. Analysis of Kerry-Boxer

In this appendix, we analyze the Kerry-Boxer bill, S. 1733. This bill is similar in many ways, including the overall distributional outcome, to the Waxman-Markey bill (H.R. 2454) examined in detail above. The coverage of emissions under Kerry-Boxer is similar to Waxman-Markey and includes 75 percent of all greenhouse gas emissions in the United States. Kerry-Boxer requires slightly greater emissions reductions by 2020, but by 2050 its emissions goal is equivalent to that of Waxman-Markey. Both bills provide an unlimited opportunity for emissions banking; consequently, the cumulative emissions reductions target over the 38-year period starting in 2012 plays the primary role in determining the path of emissions reductions that will be achieved in the intervening years. In our study year of 2016, the difference in expected emissions reductions is small, and the expected allowance prices for that year are similar.

We analyze the Kerry-Boxer bill using a set of optimistic and pessimistic assumptions described in table 4.1. Several provisions are similar to those in the Waxman-Markey bill, and we employ analogous assumptions with respect to outcomes. In a few cases, provisions have changed. The distributional effects across income quintiles under this set of assumptions are reported in table A3.1.

The optimistic case under Kerry-Boxer results in an allowance price of $12.99/ton of CO_2, or $0.17 (1.3 percent) greater than the allowance price under Waxman-Markey (compare with table 5.1). However, the cost for the average household is $1 (0.8 percent) lower than Waxman-Markey. This is a result of the different offset and banking outcomes under the two bills, due to different rules governing the maximum allowable provision of offsets in different years. The Kerry-Boxer optimistic case allows for greater domestic offsets, resulting in a greater use of offsets overall (with a small reduction in international offsets). We assume that the profits from producing domestic offsets flow to U.S. households. Half these funds are credited to all households on a per-capita basis, and half are split proportionately among households according to their shareholder-equity ownership. The profits from the sale of international offsets are assumed to flow abroad rather than accrue to U.S. households. Consequently, the expansion of domestic offsets under the Kerry-Boxer bill lowers the average cost to U.S. households.

The pessimistic case is a bit more straightforward. The Kerry-Boxer bill results in an allowance price that is $0.87 lower than comparable assumptions under Waxman-Markey and an average household burden that is $22 lower. This follows from the same preferential treatment of domestic offsets that was relevant in the optimistic case.

The distribution across income quintiles also is similar in the two bills. The biggest differences occur in the highest income quintile, which does relatively better under the Kerry-Boxer bill. One reason is that half the profits from the sale of domestic offsets return to shareholder-equity owners, who are disproportionately represented in the top income quintile.

Assigning the burden of increased government energy costs also plays a role in why the highest income quintile does relatively better under the Kerry-Boxer bill. We assume that the increase in the cost of government's direct energy purchases is equal to 14 percent of total allowance value, and in Waxman-Markey, we collect this revenue through a proportional increase in the income tax. Like Waxman-Markey, the Kerry-Boxer bill ignores changes in costs associated with government's own energy purchases; however, it explicitly withholds 10 percent of all allowances in 2016 (increasing to 22 percent in 2030 and 25 percent in 2040) to address the change in government revenues associated with an expected decrease in taxable activities. As noted in appendix 1, because changes in taxable activities are treated differently in rules for legislation proposed in the House and Senate, we ignore this issue to facilitate an even comparison of the proposed legislation. In the analysis of the Kerry-Boxer bill, we explicitly assign the 10 percent of allowances held out for deficit reduction to pay for the increase in government energy costs, which reduces the amount of revenue that must be raised through an increase in the income tax. Overall, this reassigns revenue that previously flowed to allocations in Waxman-Markey and directs it to offset taxes mostly borne by high-income households. This can be observed in the approximately 13 percent reduction in the net household burden for the highest income quintile from Waxman-Markey to Kerry-Boxer. This 13 percent difference exists in both the optimistic and pessimistic cases.

Table A3.2 illustrates the distributional consequences of the Kerry-Boxer bill for the average household across age groups. The incidence across age groups has the same shape and varies only slightly in magnitude based on the overall costs of the two bills. One factor contributing to this similarity is that our analysis of the bills does not differ with respect to the influence of indexing of Social Security payments to account for changes in the cost of living.

Table A3.3 illustrates the effect across income quintiles for groups ages 50 and older. Table A3.4 reports these results as a percentage of income. For the 50–64 age group, which may be paying the greatest attention to retirement planning, the results are largely unchanged between these bills. In this group, the burden as a percentage of income is slightly lower for the lowest and highest income quintiles under Kerry-Boxer. This appears to be the result of the increased use of domestic offsets under Kerry-Boxer, as mentioned above. The results for the 65–74 age group are almost identical across the income distribution under the two bills, and similarly for the 75 and older age group. However, the top income quintile does better in both the optimistic and pessimistic cases under Kerry-Boxer. In the optimistic case, the gains for the top decile outweigh the costs, creating an increase in welfare.

Table A3.1. Net Household Burden (2006 Dollars) by Income Quintile per Household for Two Kerry-Boxer Scenarios

Income quintile	Household average income	Kerry-Boxer optimistic case	Kerry-Boxer pessimistic case
		2006 dollars/year	
1	11,610	-26	-18
2	26,842	84	250
3	44,074	192	448
4	68,620	295	627
5	140,280	120	713
All	59,569	137	414
		Percentage of income	
1	11,610	-0.23%	-0.16%
2	26,842	0.31%	0.93%
3	44,074	0.44%	1.02%
4	68,620	0.43%	0.91%
5	140,280	0.09%	0.51%
All	59,569	0.23%	0.70%
Allowance price		(\$12.99 mt/CO_2)	(\$22.45 mt/CO_2)

Note: mt/CO_2=metric ton of carbon dioxide.

Table A3.2. Net Household Burden (2006 Dollars) by Age Group per Household for Two Kerry-Boxer Scenarios

Age group	Household average income	Kerry-Boxer optimistic case	Kerry-Boxer pessimistic case
		2006 dollars/year	
Under 39	54,828	150	414
40–49	74,348	175	537
50–64	69,453	180	488
65–74	44,983	53	264
75+	30,791	-24	102
All	59,569	137	414
		Percentage of income	
Under 39	54,828	0.27%	0.75%
40–49	74,348	0.24%	0.72%
50–64	69,453	0.26%	0.70%
65–74	44,983	0.12%	0.59%
75+	30,791	-0.08%	0.33%
All	59,569	0.23%	0.70%
Allowance price		(\$12.99 mt/CO_2)	(\$22.45 mt/CO_2)

Note: mt/CO_2=metric ton of carbon dioxide.

Table A3.3. Net Household Burden (2006 Dollars) for Elderly Households by Income Quintile for Two Kerry-Boxer Scenarios

Income quintile	Household average income	Kerry-Boxer optimistic case	Kerry-Boxer pessimistic case
		Age group	
		50–64	**50–64**
1	11,611	5	18
2	27,006	141	311
3	44,445	229	474
4	68,729	320	634
5	145,373	140	729
		Age group	
		65–74	**65–74**
1	12,415	-45	-40
2	26,385	43	219
3	43,657	119	367
4	68,338	148	453
5	136,980	40	607
		Age group	
		75+	**75+**
1	12,646	-74	-77
2	25,861	-10	151
3	42,893	24	241
4	66,689	104	400
5	127,897	-20	489

Table A3.4. Net Household Burden (2006 Dollars) as a Percentage of Income for Elderly Households by Income Quintile for Two Kerry-Boxer Scenarios

Income quintile	Household average income	Kerry-Boxer optimistic case	Kerry-Boxer pessimistic case
		Age group	
		50–64	**50–64**
1	11,611	0.04%	0.16%
2	27,006	0.52%	1.15%
3	44,445	0.51%	1.07%
4	68,729	0.47%	0.92%
5	145,373	0.10%	0.50%
		Age group	
		65–74	**65–74**
1	12,415	-0.36%	-0.32%
2	26,385	0.16%	0.83%
3	43,657	0.27%	0.84%
4	68,338	0.22%	0.66%
5	136,980	0.03%	0.44%
		Age group	
		75+	**75+**
1	12,646	-0.58%	-0.61%
2	25,861	-0.04%	0.58%
3	42,893	0.05%	0.56%
4	66,689	0.16%	0.60%
5	127,897	-0.02%	0.38%