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Cap and Dividend: How to Curb Global Warming While Protecting the Incomes Of American Families

James K. Boyce & Matthew Riddle

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POLITICAL ECONOMY RESEARCH INSTITUTE

Gordon Hall
418 North Pleasant Street
Amherst, MA 01002

Phone: 413.545.6355
Fax: 413.577.0261
peri@econs.umass.edu
www.peri.umass.edu

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HOW TO CURB GLOBAL WARMING WHILE PROTECTING THE INCOMES OF AMERICAN FAMILIES

James K. Boyce & Matthew Riddle

Political Economy Research Institute
University of Massachusetts, Amherst

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ABSTRACT

This essay examines the distributional effects of a "cap-and-dividend" policy for reducing carbon emission in the United States: a policy that auctions carbon permits and rebates the revenue to the public on an equal per capita basis. The aim of the policy is to reduce U.S. emissions of carbon dioxide, the main pollutant causing global warming, while at the same time protecting the real incomes of middle-income and lower-income American families. The number of permits is set by a statutory cap on carbon emissions that gradually diminishes over time. The sale of carbon permits will generate very large revenues, posing the critical question of who will get the money. The introduction of carbon permits – or, for that matter, any policy to curb emissions – will raise prices of fossil fuels, and have a regressive impact on income distribution, since fuel expenditures represent a larger fraction of income for lower-income households than for upper-income households. The net effect of carbon emission-reduction policies depends on who gets the money that households pay in higher prices. We find that a cap-and-dividend policy would have a strongly progressive net effect. Moreover, the majority of U.S. households would be net winners in purely monetary terms: that is, their real incomes, after paying higher fuel prices and receiving their dividends, would rise. From the standpoints of both distributional equity and political feasibility, a cap-and-dividend policy is therefore an attractive way to curb carbon emissions.

Key words: Global warming; fossil fuels; climate change; carbon permits; cap-and-dividend; cap-and-auction; cap-and-trade.

JEL codes: H22, H23, Q48, Q52, Q54, Q58

EXECUTIVE SUMMARY

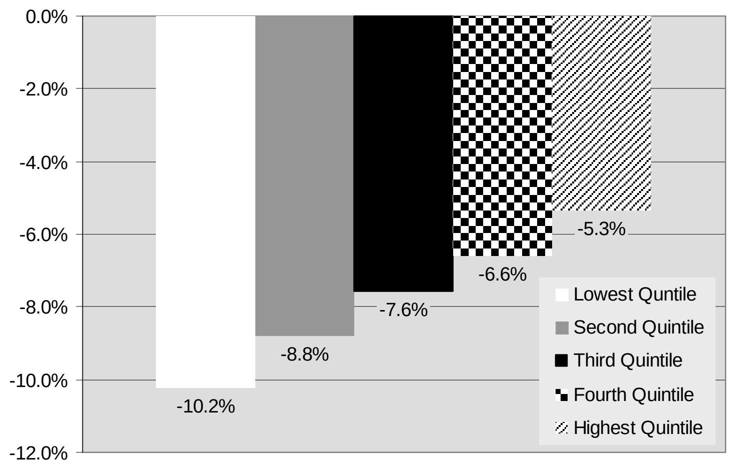
Policies to curb emissions of carbon dioxide – the main cause of global warming – will inevitably raise the prices of fossil fuels: coal, oil, and natural gas. The resulting price increases will reduce the real incomes of American families, striking hardest at those who can afford it least: lower-income households for whom fuel costs represent a higher fraction of their expenditures. The political feasibility of U.S. efforts to curb carbon emissions may hinge on whether policies are designed to protect middle-class and poor families from these adverse income effects.

A “cap-and-dividend” policy offers a simple and practical way to do this. The policy would auction carbon permits – rather than giving them free-of-charge to historic polluters – and then return all or most of the revenue to American families on an equal per person basis. Families who consume lower-than-average amounts of fossil fuels come out ahead, receiving more in dividends than they pay in higher prices. Those who consume more-than-average amounts pay more.

The policy has three basic steps:

- *First,* U.S. carbon emissions are capped at a level that gradually declines over time. One widely discussed target is to reduce emissions 80% below their current level by the year 2050.
- *Second,* based on the cap in a given year, permits are auctioned to firms that bring fossil carbon into the economy (whether through domestic extraction or imports). The supply of permits in a given year is fixed by the cap; their price depends on the demand for them.
- *Third*, revenue from the sale of permits is deposited into a trust fund and paid out equally to every woman, man, and child in the country. In addition, some fraction of the revenue initially may be earmarked for other uses, such as transitional adjustment assistance.

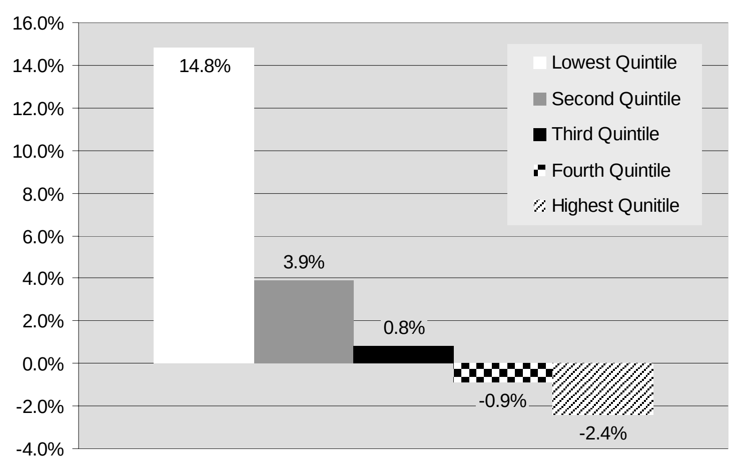
FIGURE A: IMPACT ON FAMILY INCOMES OF A $200/TON CARBON CHARGE



Source: Calculated from Table 7.

This paper calculates the net effects of a cap-and-dividend policy on income distribution in the United States. We estimate that a permit price of $200 per ton of carbon would reduce U.S. emissions by approximately seven percent. The resulting increases in the prices of fossil fuels, and in the prices of goods and services produced with them, would raise the cost of living of the median American family by $1,570 per year. The price increases would represent a larger percentage of family income in poor households than in more affluent households (see Figure A).

FIGURE B: NET IMPACT ON FAMILY INCOMES OF A CAP-AND-DIVIDEND POLICY



Source: Calculated from Table 9.

The revenue from the sale of carbon permits would amount to roughly $200 billion per year. If this revenue is recycled to the public equally, the majority of households receive more in dividends than they pay as a result of higher fossil fuel prices. The net impact ranges from a 14.8% income gain for the poorest 20% of families (and a 24% gain for the poorest 10%) to a 2.4% loss for richest 20% (see Figure B).

Initially earmarking a modest fraction of the carbon revenues for other uses, such as transitional adjustment assistance, could further enhance the appeal of the cap-and-dividend policy. Up to 10% of the carbon revenues can be dedicated to other uses while maintaining positive net benefits for roughly 50% of households. Withholding carbon revenues beyond this threshold would push the net beneficiary share of the population below half.

A cap-and-dividend policy will assert the principle of common ownership of nature's wealth: the right to benefit from our share of the Earth's capacity to absorb carbon emissions is allocated equally to all Americans. It will protect the real incomes of the majority of Americans while curbing global warming and hastening the U.S. economy's transition towards the energy sources of the future. From the standpoints of both distributional equity and political feasibility, a cap-and-dividend policy is therefore an attractive way to curb carbon emissions.

I. INTRODUCTION

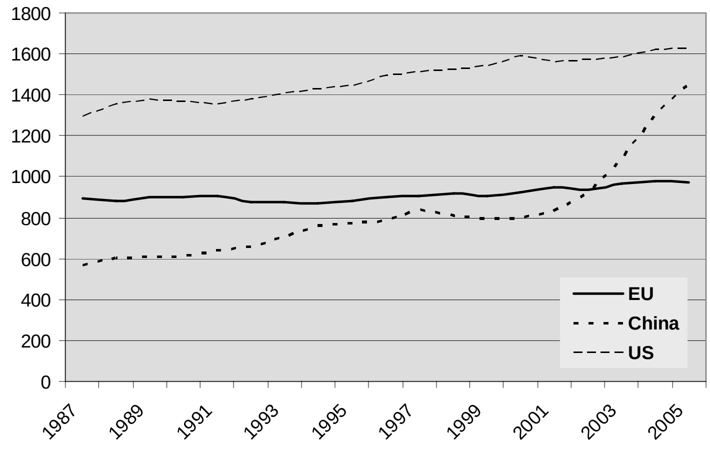
The time is coming when the United States government will enact policies to curb emissions of carbon dioxide and other greenhouse gases, joining the efforts of other nations to confront the historic challenge of global warming. When this happens, a key question – from the standpoints of both fairness and political feasibility – will be how to protect the incomes of American families.

The Clinton administration signed the 1997 Kyoto Protocol, which envisioned a 7% cut in U.S. carbon emissions from their 1990 level by the year 2012. But the Senate refused to ratify the agreement, and when the government of George W. Bush came to power it announced it had "no interest" in the accord.

Political winds in the country are now shifting. At the Group of Eight summit meeting in Germany in June 2007, the Bush administration agreed to re-enter international climate negotiations and to "seriously consider" a European plan to cut greenhouse gas emissions in half by 2050. A legislative proposal unveiled in August 2007 by U.S. Senators Joseph Lieberman and John Warner goes further, calling for a 70% reduction by 2050. It now seems possible, even likely, that the U.S. will adopt a serious emissions-reduction policy early in the post-Bush administration.

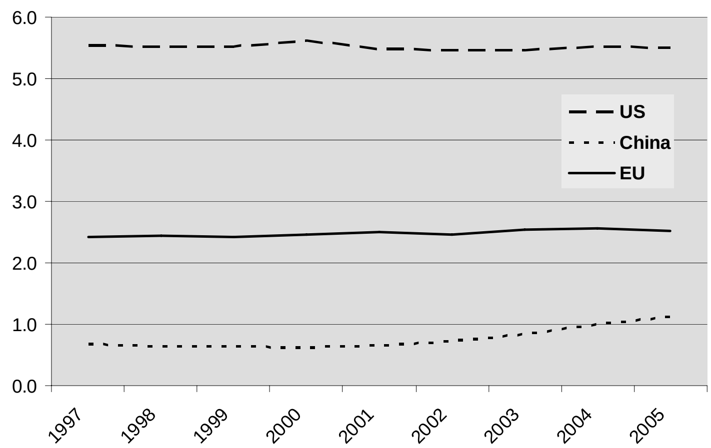
Any policy to curb carbon emissions will raise prices of fossil fuels – coal, oil, and natural gas – and the prices of other goods and services in proportion to the use of fossil fuels in supplying them. These price increases will reduce the real incomes of Americans in general, and low-income and middle-class American households in particular. But for every dollar paid by consumers in higher prices, someone else receives a dollar in additional income. Recycling this money to the public would protect real incomes of the majority of Americans. This paper examines how this can be done by a cap-and-dividend policy that distributes carbon revenues equally to all.

FIGURE 1A: CARBON EMISSIONS OF THE U.S, CHINA, AND EU-15, 1987-2005[1]
(MILLION METRIC TONS)



Source: U.S. Energy Information Administration (2007, Table H.1).

FIGURE 1B: CARBON EMISSIONS PER CAPITA OF THE U.S, CHINA, AND EU-15, 1987-2005
(MILLION METRIC TONS)



Source: U.S. Energy Information Administration (2007, Table H.1).

II. THE CARBON ECONOMY

The United States is the world's top emitter of carbon dioxide (CO_2), the most important greenhouse gas. The burning of fossil fuels in the U.S. released 1.6 billion metric tons (mt) of carbon (5.9 billion mt of CO_2) in 2005. This is 12% more than China, the second-largest emitter, and 65% more than the EU-15 (see Figure 1a).

TABLE 1: CARBON DIOXIDE EMISSIONS BY FUEL SOURCE AND SECTOR, 2004
(MILLIONS OF METRIC TONS OF CO_2)

Fuel Source	Petroleum	Coal	Natural Gas	Other[a]	total	% via electricit
Residential	141.6	695.4	372.8	4.1	1213.9	69.4
Transportation	1902.7	3.8	32.7	0.0	1939.2	0.2
Industrial[b]	465.4	747.4	519.9	3.3	1736.0	38.1
Commercial	88.2	669.0	272.9	3.9	1034.1	77.4
Total	2597.9	2115.6	1198.3	11.3	5923.2	39
(%)	43.9	35.7	20.2	0.2	100	

a. "Other" includes emissions from electricity generation from municipal solid waste and geothermal energy.
b. Industrial emissions from coal include net coke imports.
Source: Calculated from U.S. Energy Information Administration's Historical Data Series. For details, see endnote 2.

In per capita terms, U.S. emissions are five times higher than China's and more than double those of the EU-15 (see Figure 1b).

The composition of U.S. carbon dioxide emissions across fuels and sectors is shown in Table 1. Petroleum accounts for roughly 44% of emissions, coal for 36%, and natural gas for 20%. Electricity generation using these fuels accounts for 39% of the total, with coal-fired plants accounting for more than four-fifths of this amount. Transportation accounts for roughly one-third of total emissions, industry for a further 29%, residential energy use for 20%, and commercial energy use for 18%.

The "carbon footprint" of individual American households – the amount of carbon emissions generated in supplying the goods and services they consume – varies depending on their total expenditure and its composition. Table 2 shows how expenditure patterns varied across households in 2003, ranging from the poorest tenth of the population, whose annual per capita expenditure was under $2,000, to the richest tenth, whose per capita expenditure was close to $30,000.[3]

The carbon content of various categories of consumption items can be calculated from input-output accounts. These provide detailed data on the inputs used by each industry, making it possible to trace the price effects of a change in fossil fuel prices from industry to prices. For this purpose we rely on calculations by Metcalf (1999), updating his measure to reflect 2003 prices.[4] The results are presented in

TABLE 2: CONSUMPTION PATTERNS BY EXPENDITURE DECILE, 2003

Per capita expenditure decile	Per capita expenditure ($)	Average per capita expenditures by consumption category ($)							
		Food	Industrial goods	Services	Electricity	Household fuels	Car fuels	Air transport	Other transport
1	1927	659	225	729	128	52	124	3	8
2	3521	1118	426	1418	227	83	226	11	13
3	4736	1361	638	2001	278	113	304	23	18
4	5991	1621	904	2559	341	144	375	28	19
5	7380	1813	1188	3351	349	164	444	45	27
6	8847	2051	1795	3849	380	186	489	67	30
7	10711	2297	2219	4901	415	211	537	83	46
8	13228	2559	3343	5880	459	214	614	105	54
9	17178	3081	4821	7489	519	273	735	177	83
10	29943	4292	10908	12363	642	334	888	367	149
Total	10346	2085	2647	4454	374	177	474	91	45

Source: Authors' calculations from Consumer Expenditure Survey.

Table 3. As one would expect, the most carbon-intensive categories of consumption are electricity, household fuels (primarily heating oil and natural gas) and car fuels, each of which generates more than two metric tons of carbon per $1000 expenditure. The least carbon-intensive category is services, for which the corresponding figure is 80 kilograms.

TABLE 3: CARBON EMISSIONS PER DOLLAR EXPENDITURE BY CONSUMPTION CATEGORY

Consumption category	**tC per $1000** (2003 dollars)
Food	0.15
Industrial goods	0.14
Services	0.08
Electricity	2.82
Household fuels	2.64
Car fuels	2.08
Air transport	0.56
Other transport	0.30

Source: Calculated from Metcalf (1999); see text for details.

Combining the information in Tables 2 and 3, we can examine the average carbon emissions from U.S. household consumption across the range of per capita expenditure. The results are presented in Table 4. The consumption of the average American, with per capita expenditure of about $10,000, generates approximately 3.7 metric tons of carbon emissions.[5] Direct energy use in the form of car fuels, residential electricity, and household fuels (mainly heating oil and natural gas) accounts for roughly three-fifths of these emissions. Indirect use, via carbon emissions generated in producing other goods and services consumed by the household, account for the remaining two-fifths.

As one might expect, households with higher expenditure generally have bigger carbon footprints. As shown in the final column of Table 4, carbon emissions per person in the richest decile (tenth) of the population are more than double the national average, and more than eight times higher than the lowest decile.

Carbon emissions *per dollar* decline, however, as household expenditure rises. In the top decile, one dollar of expenditure on average generates 0.27 kilograms (kg) of carbon emissions; in the lowest decile the corresponding figure is 0.50 kg. The reason lies in their consumption patterns, as can be seen in Table 3: the poor spend a larger fraction of their household budget on electricity and fuels, while more affluent households spend a larger fraction on services and industrial goods. It so happens that necessities, which account for a larger share of the expenditure of the poor, are more-carbon-intensive than luxuries, which account for a larger share of the expenditure of the well-

TABLE 4: CARBON EMISSIONS BY EXPENDITURE DECILE (METRIC TONS OF CARBON PER YEAR)

Per capita expenditure decile	Per capita expenditure ($)	Average per capita carbon emissions by expenditure category								Total carbon emissions per capita
		Food	Industrial goods	Services	Electricity	Household fuels	Car fuels	Air transport	Other transport	
1	1927	0.10	0.03	0.05	0.36	0.15	0.26	0.002	0.002	0.96
2	3521	0.18	0.06	0.10	0.64	0.23	0.47	0.006	0.004	1.69
3	4736	0.21	0.09	0.15	0.79	0.32	0.63	0.013	0.005	2.21
4	5991	0.25	0.13	0.21	0.96	0.39	0.78	0.016	0.006	2.74
5	7380	0.27	0.17	0.27	0.99	0.46	0.92	0.025	0.008	3.11
6	8847	0.30	0.27	0.32	1.07	0.51	1.02	0.037	0.009	3.53
7	10711	0.34	0.33	0.41	1.17	0.58	1.12	0.047	0.014	4.01
8	13228	0.37	0.50	0.50	1.30	0.59	1.28	0.059	0.016	4.60
9	17178	0.44	0.72	0.64	1.47	0.75	1.53	0.099	0.025	5.66
10	29943	0.59	1.63	1.08	1.81	0.91	1.85	0.206	0.044	8.13
Total	10346	0.31	0.39	0.37	1.06	0.49	0.98	0.051	0.013	3.67

Source: Authors' calculations using data in Tables 2 and 3.

to-do. As a result, carbon emissions rise with household expenditure at a diminishing rate (see Figure 2). As discussed in the next section, this concave relationship has important implications for the distributional effects of public policies to reduce carbon emissions.

III. THE CASE FOR A CAP-AND-DIVIDEND POLICY

The most reliable way to reduce carbon emissions is to establish a "cap," a limit on the total amount of fossil-fuel carbon that enters the U.S. economy in a given year. The cap can gradually be lowered over time to meet targets for emissions reductions in future years. Based on the cap, a fixed number of annual permits are issued to suppliers of fossil fuels, including both domestic producers and importers. Whether these permits are sold or given away, they represent a claim on a scarce resource – the U.S. share of the biosphere's capacity to absorb and recycle carbon – and as such they have economic value.

The net effect of emission-reduction policies on household incomes depends on:

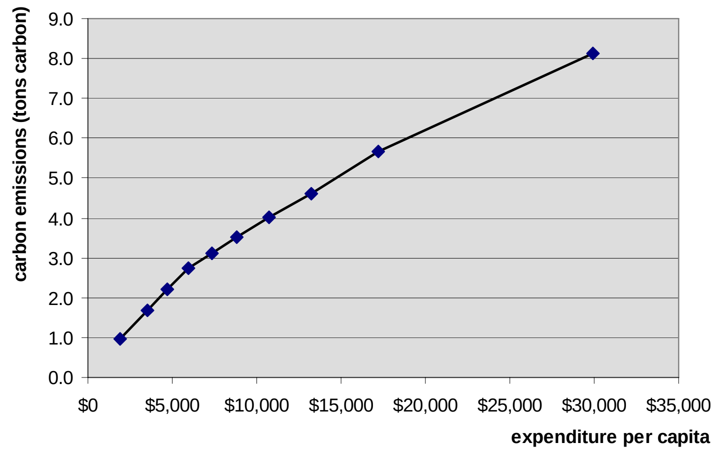
(i) how the household is impacted by higher prices for fossil fuels, and

(ii) how the economic value represented by carbon permits is distributed.

If the permits are given away, a key issue is who gets them. If they are sold, a key issue is who gets the money.

If the permits are given free-of-charge to energy companies – based, for example, on their historic levels of sales of fossil fuels – the result is a windfall gain to these firms, or more precisely, to their shareholders.[6] If the permits are auctioned to the highest bidder and the proceeds are retained by the government, the revenue is similar to that from a tax, and the money can be used to increase government spending and/or cut other taxes. In this paper we analyze a third option, in which the permits are auctioned and the revenue is rebated to the public on an equal

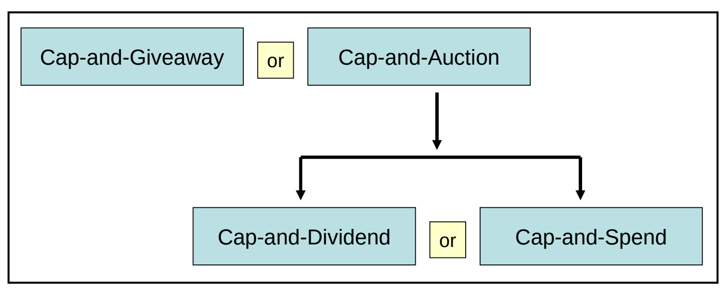
FIGURE 2: CARBON EMISSIONS AND HOUSEHOLD EXPENDITURE, 2003



Source: See Table 4.

per capita basis, a policy sometimes termed a "sky trust" (Barnes 2001).[7] We refer to these three policy options as "cap-and-giveaway," "cap-and-spend," and "cap-and-dividend," respectively (see Figure 3).

FIGURE 3: THREE POLICY OPTIONS FOR CARBON PERMIT ALLOCATION



From open access to common wealth

The enactment of policies to curb carbon emissions is tantamount to the creation of property rights to the sky, or more precisely, to the carbon-absorptive capacity of the biosphere. In the absence of such policies, this is an "open access" resource, in principle freely available to all but in practice disproportionately available to those with the wealth and power to claim it: those who burn the most fossil fuel.[8] Government regulations, carbon taxes, and carbon permits all assert the right to regulate access to this resource, effectively converting it into a form of property.

The question then becomes, who are the rightful owners of this property? If we believe that the gifts of creation are held by all of us in common, rather than being the property of private owners or the government, then the answer is clear: it belongs equally to every woman, man, and child in the country.

A cap-and-dividend policy would transform the U.S. share of the Earth's carbon-absorptive capacity from an open-access resource into the common wealth of all Americans. As a way to curb U.S. carbon emissions, this policy has four attractive features:

- *First,* the cap-and-dividend policy puts into practice the principle of common ownership of nature's wealth: rights to benefit from the carbon-absorptive capacities of the biosphere are allocated equally to all.
- *Second*, the cap-and-dividend policy protects the real incomes of the majority of the population in the face of higher prices for fossil fuels, surmounting a major political impediment to the adoption of policies to curb global warming.
- *Third*, the cap-and-dividend policy results in a progressive redistribution of income, the scale of which depends on the level of the carbon charges and how the carbon intensity of household expenditure varies with income.
- *Fourth,* unlike carbon taxes or a cap-and-spend policy, the cap-and-dividend policy's favorable distributional outcome does not hinge on the willingness and ability of the government to do "the right thing" – however this may be defined – with present and future carbon revenues.[9]

How would a cap-and-dividend policy work?

The cap-and-dividend policy would deposit the revenues from auction sales of carbon permits into a trust fund, an autonomous institution apart from the government budget, akin to the Social Security Trust Fund. These revenues would then be rebated to individuals on an equal per person basis.

Carbon revenues would be most easily collected "upstream," at the mine heads, oil refineries, natural gas pipelines, and ports where fossil fuels enter the U.S. economy. Nationwide there would be roughly 2000 such collection points (Kopp et al. 1999; CBO 2001). The costs of collecting the revenue would represent a very small fraction of the amount collected; the administrative costs of petroleum taxes and excise duties currently range from 0.12 to 0.25% of revenue (Smulders and Vollebergh, 2001, p. 116).[10]

A fixed number of carbon permits would be auctioned (monthly, quarterly, or annually), with the number determined by the national carbon cap at any given point in time. Permit holders would be entitled to bring fossil carbon into the economy within a specified time (say, one year from the date of purchase of the permit). A secondary market in permits could emerge – permit holders who decide not to use their carbon allotment could sell it to others – but with frequent auctions and limited permit life spans, this market would likely be small relative to the total number of permits.

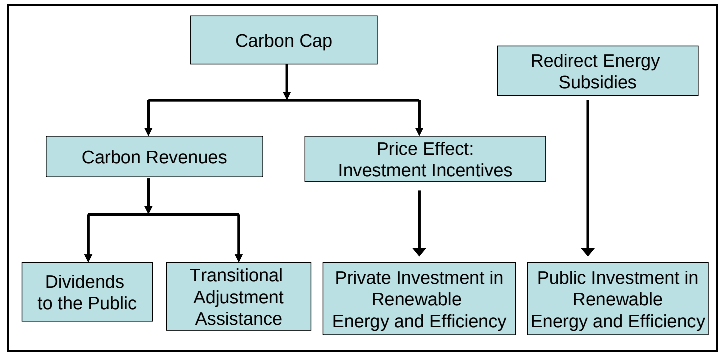
The number of permits issued would diminish over time, as the cap on carbon emissions is gradually tightened. Issuing a fixed number of permits rather than setting a fixed carbon charge (a "carbon tax") would guarantee that the nation's emission-reduction objectives are achieved. The price of the permits would depend on demand and supply. When the economy is booming, for example, higher demand for permits will lead to a higher price than when the economy is sluggish. Similarly, if higher fossil fuel prices and other policies spark rapid improvements in energy efficiency and development of renewable energy sources, the carbon permit price will be lower than if these occur more slowly. In contrast, setting a fixed price instead of a fixed number of permits would allow the quantity of carbon emissions to vary depending on these and other factors. Given the uncertainties as to the extent of emission reductions, the price-setting approach also could be more vulnerable to erroneous forecasts or political manipulations that undermine emission-reduction goals.

Revenues from the sale of carbon permits would be paid out equally to every man, woman, and child in the country. One way to distribute these dividends would be to issue "Sky Trust cards" that could be used at automatic teller machines (ATMs) to withdraw cash. If permit auctions are held quarterly, the balances in every individual's account would be topped up quarterly, too. As with bank accounts, individuals could check their balances online, as well as at the ATM. The administrative costs of issuing Sky Trust cards would be no greater than the current cost of issuing Social Security cards; in fact, after the initial distribution to existing holders of Social Security cards, the two operations could be combined.

In the case of children, an alternative way to distribute carbon revenues would be to accumulate their dividends in individual development accounts (IDAs) until they reach the age of eighteen. They could withdraw funds as they enter adulthood, perhaps with rules or incentives to encourage investment in further education or purchases of homes or businesses.

The introduction of carbon permits would alter relative prices throughout the economy. Fossil fuels, and goods and services whose supply relies heavily on them, would become more expensive, strengthening incentives to invest in energy efficiency and non-fossil energy sources. The energy investment playing field, which is currently tilted in favor of fossil fuels by the implicit subsidy resulting from free use of the Earth's finite capacity to recycle emissions, would become more level. The playing field could be further leveled by ending the explicit government subsidies currently given to fossil-fuel industries in the form of tax breaks and royalty-free access to public lands. Redirection of subsidies to public investment in energy

FIGURE 4: CAP-AND-DIVIDEND POLICY



efficiency and renewable energy would complement the stimulus to private investment arising from the realignment of relative prices.

The redirection of private investment is crucial for any strategy to curb global warming. The Intergovernmental Panel on Climate Change (2007, p. 13), which foresees future energy investments totaling more than $20 *trillion* worldwide between now and 2030, observes that limiting global carbon emissions to 2005 levels by 2030 "would require a large shift in the pattern of investment, although the net additional investment required ranges from negligible to 5-10%."

As documented below, a cap-and-dividend policy would protect the real incomes of the majority of American families in the face of rising fossil fuel prices. But households and communities that currently depend on employment in fossil fuel-intensive industries, such as coal mining, would nevertheless see income losses. To protect these vulnerable sectors, a fraction of the revenue from the sale of carbon permits could be earmarked initially for transitional adjustment assistance. For example, Barnes (2001) proposes a transition fund that initially would recycle 25% of the revenue and gradually be phased out over a ten-year period.

Figure 4 summarizes the basic features of a cap-and-dividend policy: cap carbon emissions; auction permits to bring fossil carbon into the economy; distribute revenues from permit sales to the public, with a fraction initially earmarked for transitional adjustment assistance; realign incentives for private investment; and redirect government subsidies to public investments in energy efficiency and renewable energy.

In the next section, we analyze how a cap-and-dividend policy would affect the distribution of income in the United States. Before doing so, we briefly review prior studies on the distributional impacts of higher fossil fuel prices and carbon revenue recycling.

Distributional impact of higher fossil fuel prices

Carbon emission-reduction policies – whether in the form of regulations, carbon taxes, or caps and permits – will raise the price of fossil fuels, at least in the foreseeable future. The increased price is the flip side of reduced use. The higher cost of coal, oil, and natural gas in turn alters relative prices of goods and services throughout the economy in proportion to the carbon embodied in their production and distribution. In the end, the price increases are passed along to consumers (although producers may absorb part of the cost via lower profit margins, a possibility to which we return below).

The result of higher prices, in terms of absolute dollars, is that those who consume more fossil fuels directly in the form of energy, and indirectly in the form of other goods and services whose supply uses fossil fuels, pay more. Since the rich generally consume more of most things than the poor, they pay more (although how much any specific household pays depends on its consumption decisions). Relative to total expenditure, however, the poor pay more as noted above. This means that carbon emission-reduction policies have a regressive impact on income distribution – unless coupled with revenue-recycling policies that protect the real incomes of the poor and middle classes.

Based on the data in Table 4, for example, we can calculate that a $200/ton price for carbon would translate into a $215 rise in the cost of living for the average person in poorest decile, equivalent to more than 10 per cent of annual expenditure. The cost of living in richest decile would rise by $1,475 per person, but this would be equivalent to less than 5 per cent of annual expenditure.

Previous studies have reached similar conclusions. The U.S. Congressional Budget Office (CBO), in an analysis of the distributional impacts of carbon permits, estimated that the price effects would reduce real incomes in the lowest quintile of the income distribution by 3.3%, almost twice the 1.7% reduction in the highest quintile (CBO 2000, p. 21). In a follow-on study, Dinan and Rogers (2002, p. 212) report an even sharper disparity: reductions of 6.6% and 1.7% for the poorest and richest quintiles, respectively. In estimates based on a higher carbon price, Barnes and Breslow (2003, p. 144) report the cost for the lowest decile to be equivalent to 16.8% of income, whereas the cost for the top decile is equivalent to 2.5% of income.

Studies in other industrialized countries generally support the conclusion that carbon charges are regressive – taking a bigger slice in percentage terms from low-income households than from high-income households – or, at best, distributionally neutral or mixed. An analysis by Symons et al. (1994) found that a carbon tax in the United Kingdom would be "severely regressive." In Canada, Hamilton and Cameron (1994) concluded that a carbon tax would be "moderately regressive." Cornwell and Creedy (1996) likewise found that a carbon tax in Australia would be regressive. Symons et al. (2000) reported regressive effects in Germany, France, and Spain, a mixed effect in the UK, and a neutral effect in Italy. Klinge Jacobsen et al. (2003) and Wier et al. (2005) found that Denmark's existing carbon taxes are regressive, and Brännlund and Nordström (2004) reported that increases in carbon taxes in Sweden would be regressive.[11] Summarizing studies from a number of OECD countries, Cramton and Kerr (1999, p. 261) conclude: "The weak regressivity of carbon regulation appears to hold across countries and modeling techniques."[12]

Carbon revenue recycling

When consumers pay higher prices for goods and services, in proportion to the fossil carbon embodied in them, a great deal of money changes hands. The net effect of carbon charges depends crucially on where this money goes.

Recognizing that carbon charges could generate annual revenues of "tens or hundreds of billions of dollars," the U.S. Congressional Budget Office (2000) compared two methods of allocating carbon emission allowances: selling them through an auction, or giving them away free-of-charge to the energy companies that produce and import fossil fuels. The CBO also compared two methods of revenue recycling: reducing corporate taxes or rebating an identical lump-sum amount to each household. The only policy mix found to have a progressive distributional effect was the "sky trust" combination of permit sales and lump-sum redistribution of the revenues.[13] In this case, the regressive effect of fossil-fuel price increases was outweighed by the progressive effect of equal payments to each household. With a carbon charge of $100/ton, the CBO estimated that after-tax incomes in the lowest quintile of the income distribution would rise by 1.8%, while those of the top quintile would decrease by 0.9%. In an extension of the CBO analysis, Dinan and Rogers (2002) reported somewhat stronger redistributive impacts: a 3.5% rise in incomes for the lowest quintile, coupled with a 1.6% decline for the top quintile.[14]

Both of these studies assumed that carbon charges create "deadweight losses" by reducing fossil fuel consumption (and also, in the Dinan and Rogers study, by lowering real returns to labor and capital and thereby reducing factor supplies). For example, when consumers curtail fuel consumption in response to higher prices, they experience welfare losses in the form of "the discomfort associated with keeping their house cooler in the winter or the loss in satisfaction that would result from canceling a vacation because of high gasoline prices" (CBO 2003, p. 3). The studies add these losses to the monetary costs borne by consumers in the form of higher prices for the fossil fuels that they continue to consume.

Neither study accounted, however, for the welfare *gains* that would result from reduced use of fossil fuels. These include benefits from the mitigation of climate change and "co-benefits" from reduced emissions of other pollutants, including airborne particulates and sulfur dioxide, that are released by burning fossil fuels.[15] Yet the rationale for policies to reduce carbon emissions is precisely that the welfare gains to society exceed the welfare losses. A comprehensive analysis of the welfare impacts of carbon emission-reduction policies would allocate these gains across households, too. In the absence of such an accounting, the incorporation of "deadweight losses" from carbon caps gives a misleading picture of net effects: it counts the cost of reducing carbon emissions without counting the benefits.

The effect of this one-sided treatment of welfare effects is that the total costs of carbon charges (from higher prices plus "deadweight losses") exceed the total amount of revenue to be recycled (from higher prices alone). This understates the cap-and-dividend policy's positive impact on incomes of low-income households, and overstates its negative impact on those of high-income households.

In this paper, we adopt the simpler – and, in our view, more appropriate – procedure of estimating the monetary impacts of carbon charges and revenue recycling alone, without attempting to incorporate other welfare effects. Barnes and Breslow (2003) followed this procedure in a third analysis of the distributional impact of a cap-and-dividend policy.[16] They find that the bottom decile would receive a net benefit equal to 5.1% of income, while the top decile would bear a net loss of 0.9%. Roughly 70% of the population sees net gains, getting more back in dividends than they pay in higher fuel prices. Insofar as public policy is guided by majority rule, this augurs well for the political feasibility of a cap-and-dividend policy for curbing carbon emissions.

IV. DISTRIBUTIONAL IMPACTS OF A CAP-AND-DIVIDEND POLICY

In this section we provide new estimates of the impacts of a cap-and-dividend policy on the distribution of income in the United States, taking into account both the impact of higher prices on consumers and the recycling of carbon revenue via equal per capita dividends.

Apart from using more recent data for these calculations, our analysis differs from prior studies in several respects. We stratify households on the basis of expenditure rather than income, on the grounds that expenditure is a better proxy for lifetime income. Since households differ in size, we use expenditure per person rather than expenditure per household, on the grounds that this is a better measure of relative income. In addition to our baseline estimate of the net impact of a cap-and-dividend policy, the next section examines how the results change when some fraction of the carbon revenue is allocated initially to other uses, such as transitional adjustment assistance. In the appendix, we also show how the results are affected if we assume that some fraction of the cost of carbon permits is absorbed by producers via lower profit margins, instead of being entirely "passed through" to consumers.

What price for carbon?

The amount of money that will be generated by the sale of carbon permits depends on both the quantity of permits sold and their price. The quantity is set by the carbon emission cap. The price depends on the price elasticities of demand for fossil fuels, which translate changes in quantity into changes in prices.

No one can be certain as to the precise magnitude of these elasticities, particularly in the long-run when induced technological changes are taken into account. The Intergovernmental Panel on Climate Change (2007, p. 19), for example, reports that carbon prices of $20-295 per ton ($5-80 per ton of CO_2) in the year 2030 would be consistent with a trajectory for eventual stabilization of atmospheric concentrations in the year 2100. This wide price range illustrates why setting a cap on the quantity of permits and letting market forces determine their price is preferable to setting a price on permits (or levying a carbon tax) and letting market forces determine the quantity of emissions. If our central aim is to meet a timetable for emissions reductions, fixing the quantity guarantees that we will hit the target. Fixing the price does not.

While we do not know the precise magnitude of the price elasticity of demand for fossil fuels, we do know that it is inelastic, particularly in the short run; that is, the percentage change in price exceeds the associated percentage change in quantity demanded. With a price elasticity of -0.2, for example, a 2% reduction in quantity requires a 10% increase in price. This means that the lower the quantity of emissions permitted under the cap (and the higher the price of the permits), the greater the total amount of revenue.

We base the calculations that follow on a permit price of $200 per ton of carbon (tC). This is near the middle of the range of carbon price scenarios used in the literature reviewed by Barnes and Breslow (2003, pp. 142-3). It is also close to the initial price of $180/tC ($50/tCO_2) that a recent study by the MIT Joint Program on the Science and Policy of Global Change reckons is needed to achieve an 80% reduction in emissions by the year 2050, with the price gradually rising to $730/tC by that year (Paltsev et al., 2007). While the price we use for our calculations affects the magnitudes of costs and benefits, it does not affect their distributional pattern across households: if the permit price were higher, then the costs, dividends, and net benefits would rise; if the price were lower, they would be smaller.[17]

Table 5 shows how a $200/tC charge would change energy prices, assuming the cost to be entirely passed through into the price to end-users. Price increases for gasoline, heating oil, and natural gas are in the 20-30% range. The price of coal rises much more steeply due to its

TABLE 5: IMPACTS OF $200/TON CARBON CHARGE ON FOSSIL FUEL PRICES

Fuel	Price (2006) a	Carbon charge	Price increase
Gasoline	$2.53/gallon	$0.53/gallon	21%
Heating oil	$2.42/gallon	$0.71/gallon	29%
Natural gas (residential)	$13.76/1000 cu. ft.	$3.26/1000 cu. ft.	24%
Coal (delivered to electric utilities)	$31.22/short ton	$116/short ton	371%
Electricity	9.45 cents/kwh	3.68 cents/kwh	39%

Note: a. Coal and electricity prices refer to the year 2005.
Sources: Price data from U.S. Energy Information Administration (EIA). For each individual fuel reference, see endnote 17.

relatively low price and high carbon content, and electricity prices rise by nearly 40%.

To calculate how these price increases impact households, we use the data on consumption patterns and the carbon content of goods and services reported in Tables 2 to 4. To incorporate the response of consumers to changes in relative prices, we use estimates drawn from other studies of the price elasticities of demand for the various consumption categories.[18] These are reported in Table 6.

TABLE 6: PRICE ELASTICITIES OF DEMAND

Consumption category	Price elasticity of demand
Food	0.6
Industrial goods	1.3
Services	1
Electricity	0.2
Natural gas	0.2
Heating oil	0.27
Car fuels	0.26
Air transport	0.25
Other transport	0.25

Note: Short-run own price elasticities of demand.

We estimate that a $200 per ton carbon charge would reduce U.S. emissions by approximately 7%. Put differently, if a cap on annual carbon emissions is set at 7% below current levels, and the corresponding number of carbon permits is auctioned to fossil fuel suppliers, we estimate that the market price for these permits will be approximately $200/tC. At this price, the total amount of revenue generated by permit sales is $198 billion per year.[19]

Baseline scenario

In Table 7, we present the distributional impacts of a cap-and-dividend policy, with the entire cost of carbon permits passed through to consumers and the entire revenue from the sale of permits recycled to the public in the form of equal per capita dividends. The amount per person that households pay in higher prices is reported in the "charge" column. This amount rises with per capita household expenditure, from $215/person/year in the poorest decile to $1,475/person/year in the richest decile.

The dividend is the same across all households: $678 per person. For the bottom six deciles, this exceeds the amount paid in higher prices; for the top four deciles the charge exceeds the dividend. In other words, roughly 60% of Americans come out ahead in sheer monetary terms from the cap-and-dividend policy, while 40% pay more in higher prices than they get back in their share of the dividends. The poorer the household, the larger the net benefit; the richer the household, the larger the net cost. The policy increases net incomes in the poorest decile by 24.0%, while net incomes in the richest decile decline by 2.7%.

These estimates are decile averages. But for any individual household, the net impact of the cap-and-dividend policy depends on its consumption pattern and how much it responds to changing relative prices by shifting from more carbon-intensive to less carbon-intensive consumption. Any household that curtails its direct and indirect consumption of fossil fuels to a level below the national average comes out ahead, receiving more money in dividends than it pays in higher prices, regardless of its expen-

TABLE 7: DISTRIBUTIONAL IMPACT OF A CAP-AND-DIVIDEND POLICY
(BASED ON A CARBON CHARGE OF $200/TC, WITH 100% RECYCLING TO INDIVIDUALS)

Per capita expenditure decile	Per capita expenditure ($)	Average household size	Per capita incidence ($)			As percentage of expenditures		
			Charge	Dividend	Net benefit	Charge	Dividend	Net benefit
1	1927	3.4	215	678	463	11.2%	35.2%	24.0%
2	3521	3.3	338	678	341	9.6%	19.3%	9.7%
3	4736	3.2	424	678	254	9.0%	14.3%	5.4%
4	5991	2.7	514	678	164	8.6%	11.3%	2.7%
5	7380	2.6	576	678	102	7.8%	9.2%	1.4%
6	8847	2.5	649	678	30	7.3%	7.7%	0.3%
7	10711	2.3	732	678	-53	6.8%	6.3%	-0.5%
8	13228	2.1	837	678	-158	6.3%	5.1%	-1.2%
9	17178	2.0	1024	678	-346	6.0%	3.9%	-2.0%
10	29943	1.8	1475	678	-797	4.9%	2.3%	-2.7%

Source: Authors' calculations (see text for details).

diture decile. The policy rewards "good behavior" – reductions in carbon emissions – across the income spectrum.

Cap-and-dividend versus cap-and-giveaway

The cap-and-dividend distributional outcome differs radically from what would happen under a cap-and-giveaway policy in which carbon permits are distributed free-of-charge to fossil-fuel firms. Both policies would increase the prices of fossil fuels, and of other goods and services in proportion to the use of fossil fuels in their supply, but instead of capturing the "rent" from permit sales and rebating it to the public on an equal per person basis, the cap-and-giveaway policy would generate windfall profits for fossil-fuel firms. These profits would flow to shareholders in the form of higher dividends and capital gains, benefiting households in proportion to their ownership of corporate stock. In the words of a U.S. Congressional Budget Office report (2007. p. 2), a giveaway strategy "would transfer income from energy consumers – among whom lower-income households would bear disproportionately large burdens – to shareholders of energy companies, who are disproportionately higher-income households."[20]

Data on the distribution of stock ownership by income decile are presented in Table 8.[21] Stock ownership is concentrated in upper-income households, with the top tenth owning nearly 65% of the total, and the top two-tenths owning 77%. Using these figures, we can approximate the distributional effects of a cap-and-giveaway policy.[22]

Table 9 summarizes distributional outcomes under these two policy scenarios. In contrast to cap-and-dividend, the cap-and-giveaway policy results in a regressive redistribution of income and imposes net costs on the majority of American households: the bottom nine deciles pay more as a result of higher fuel prices than they receive in stock dividends and capital gains. The contrast between the distributional outcomes of the two policies is depicted graphically in Figure 5, with the deciles combined into quintiles for simplicity.

TABLE 8: DISTRIBUTION OF STOCK OWNERSHIP

Per capita income decile	Stock ownership	Share of total stock
1	7437	0.8%
2	4564	0.5%
3	8697	0.9%
4	16069	1.7%
5	23066	2.4%
6	40296	4.2%
7	54571	5.7%
8	67427	7.0%
9	116542	12.1%
10	626335	64.9%

Source: Calculated from 2004 Survey of Consumer Finances.

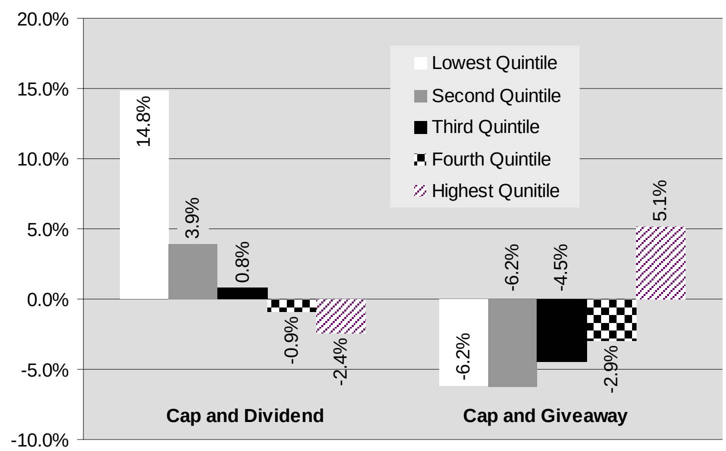
TABLE 9: CAP-AND-GIVEAWAY VERSUS CAP-AND-DIVIDEND

Per capita expenditure decile	Per capita expenditure ($)	Household size	Cap-and-Giveaway		Cap-and-Dividend	
			Net benefits per capita ($)	As % of total expenditures	Net benefits per capita ($)	As % of total expenditures
1	1927	3.4	-91	-4.7%	463	24.0%
2	3521	3.3	-244	-6.9%	341	9.7%
3	4736	3.2	-309	-6.5%	254	5.4%
4	5991	2.7	-355	-5.9%	164	2.7%
5	7380	2.6	-377	-5.1%	102	1.4%
6	8847	2.5	-342	-3.9%	30	0.3%
7	10711	2.3	-336	-3.1%	-53	-0.5%
8	13228	2.1	-360	-2.7%	-158	-1.2%
9	17178	2.0	-231	-1.3%	-346	-2.0%
10	29943	1.8	2645	8.8%	-797	-2.7%

Based on a carbon charge of $200 per tC.
Source: Authors' calculations (see text for details).

In the absence of revenue recycling, the price increases arising from a carbon cap that yields a $200/tC permit price would raise the cost of living of the median American family by about $1,570 per year.[23] It is unlikely that the public would welcome such belt-tightening, particularly if they see the money going from their pockets into windfall profits for energy companies. Whether the public would be much happier if the money instead went to the government, as would occur with a cap-and-spend policy (or a carbon tax) is an open question. In contrast to these other policies, cap-and-dividend protects the real incomes of middle-class and low-income households. The political implications of these differences among policy outcomes should be evident.

FIGURE 5: CAP-AND-DIVIDEND VERSUS CAP-AND-GIVEAWAY



Source: Calculated from Table 9..

Five caveats

Like all models of the distributional impacts of public policies, the estimates presented in Table 7 rest on a number of simplifying assumptions. We want to note five caveats in particular: (i) the assumption that the cost of carbon permits is passed through fully to consumers, rather than part of the cost being absorbed by producers via lower profit margins; (ii) the assumption of constant price elasticities of demand across expenditure deciles; (iii) the omission of welfare effects from our calculations; (iv) the omission of fossil fuel uses not tied to household consumption; and (v) the omission of sectoral employment impacts.

"Pass-through" to consumers. Studies of environmental policies – whether in the form of regulations, pollution taxes, or marketable pollution permits – typically assume that the costs these policies impose on firms are fully passed through to consumers in the form of higher prices. We have followed this conventional practice. It is plausible, however, that some fraction of the costs of carbon permits will be absorbed by producers via reduced profits – a possibility that may help to explain why producers often oppose environmental protection policies.

One reason why some firms might not shift the entire cost of carbon charges forward to consumers is that they are competing with other firms that are not equally impacted by the charges. Production costs of firms using less carbon-intensive technologies will rise less than those of firms in the same industry that use more carbon-intensive technologies.[24] To defend their market shares, the latter may trim profit margins rather than increasing prices to consumers enough to cover the full cost of their carbon permits. The ability of firms to absorb permit costs would be enhanced if they have been earning above-normal profits (for example, due to oligopolistic market power).

Households would bear the cost of any profit squeeze in proportion to their ownership of corporate stock. As noted above, this is highly unequal. Less-than-100% pass-through therefore would reduce the regressivity of carbon charges and enhance the progressivity of a cap-and-dividend policy. In the Appendix, we report calculations on distributional outcomes based on varying assumptions as to the actual extent of pass-through.

Constant price elasticities. In our calculations we assume that all households respond identically to price changes; that is, the price elasticity of demand does not vary across the expenditure spectrum. But there are plausible reasons to think that price elasticities may vary with income. For example, lower-income households may tend to respond more strongly to higher prices than upper-income households: with less money, they have a stronger incentive to economize.[25] In one of the few empirical studies of this question, West and Williams (2004) find that the lower-income households are more responsive to changes in the price of gasoline: in the poorest quintile they estimate the price elasticity of demand to be -0.73 (in other words, a 10% price rise leads to a 7.3% decline in demand), whereas in the richest quintile the price elasticity is only -0.18. If this pattern could be generalized, it would imply that our estimates overstate the impact of carbon charges on lower-expenditure households and hence understate the progressivity of a cap-and-dividend policy.[26]

Welfare effects. Our calculations refer only to the real-income effects of carbon charges and revenue recycling. As noted above, we do not attempt to take into account the positive and negative welfare effects arising from reduced use of fossil fuels. But it bears repeating that the underlying rationale for policies to curb carbon emissions is that the benefits of doing so outweigh the costs. In an analysis of welfare effects that excludes benefits from reduced global warming, De Canio (2007) concludes that the distribution of carbon revenues has much stronger effects on household incomes than the macroeconomic effects of the carbon cap, and that an egalitarian distribution of carbon revenues "will improve the material well-being of a majority of the agents, even without taking into account the environmental benefits of the emissions reductions."

Our analysis also does not take into account the diminishing marginal utility of income, the eminently plausible proposition that a dollar is worth more to a poor person than to a rich one. A cap-and-dividend policy would transfer dollars from richer households, where the marginal utility of a dollar is relatively low, to poorer ones, where the marginal utility of a dollar is relatively high. The incorporation of such "interpersonal comparisons" into a welfare-based accounting of distributional impacts would further reinforce the progressivity of the cap-and-dividend policy's outcome.

Non-household users of fossil fuels. The Consumer Expenditure Survey (CEX) data on which we rely for our calculations omit non-household end-users of fossil fuels and other goods and services. According to the national income accounts (NIA), consumption represented 71% of U.S. GDP in 2003 (the remaining items are investment, net exports, and government spending).[27] This is fairly close to the ratio of our CEX-based measure of carbon emissions reported in Table 4 (3.67 mt/person/year) to total

U.S. emissions reported in Figure 1b (5.46 mt/person/year).[28]

Carbon permits will raise prices to non-household end-users, too. For simplicity, we have omitted these from our calculations of both revenue and dividends, but the distributional outcome is not greatly affected by the omission. Assuming that carbon charges associated with investment are passed to consumers in the same way as variable input costs, the inclusion of investment would simply increase the magnitudes of revenue and dividends without altering substantially the distributional pattern of net benefits.[29] Since carbon permit charges are levied on exports but not imports, omission of trade effects leads to a modest understatement of net benefits to U.S. households: part of the revenue rebated to them comes from foreign consumers, while the permit charges do not raise import prices.[30]

In the case of government, there are two ways to offset the impacts of higher fossil-fuel prices on real expenditure while providing the governments with an incentive to improve energy efficiency and shift to alternative energy sources. The first is to earmark a share of total carbon revenues to be directly recycled to federal, state and local governments, according to a formula based on their expenditures. Assuming this share equals what they pay in increased costs as a result of higher fossil-fuel prices, our calculations of net benefits would be unaffected. The second option is to dividend all of the carbon revenue to households, and let governments recoup their higher costs through taxation. Assuming this is accomplished through progressive taxes, this would enhance the progressivity of net benefits from the cap-and-dividend policy.

Employment effects. Finally, our calculations do not include the short-run impacts of carbon emission-reduction policies on employment. These include both negative impacts on fossil fuel-based sectors of the economy and positive impacts on other sectors, notably those involving alternative energy sources. Since the shift in relative prices raises labor demand in some sectors while lowering it in others, there is no obvious reason to expect a substantial impact on aggregate employment. But insofar as alternative energy sectors are more labor-intensive than fossil-fuel industries – and there is some evidence that this is the case – the change may generate net increases in employment, particularly if investments are channeled into communities with high unemployment rates.

Labor does not move costlessly across industries and sectors, however. As we have noted, workers in fossil fuel-intensive industries could experience income losses as a result of policies that curtail carbon emissions. These adverse impacts could be offset by the provision of transitional adjustment assistance to the affected households and communities, an issue to which we turn in the next section. It is worth noting, however, that this issue arises with any public policy to reduce carbon emissions, not only a cap-and-dividend policy. Indeed, from the standpoint of displaced workers, cap-and-dividend at least has the advantage of offsetting the impact of higher fossil fuel prices on their real incomes, in the absence of which they would face a double blow from price effects as well as employment impacts.

V. EARMARKS FOR NON-DIVIDEND USES

In this section we examine how the distributional outcome of a cap-and-dividend policy would differ if part of the revenue from carbon permits is earmarked initially for other uses, such as transitional adjustment assistance, rather than being entirely recycled as individual dividends.

The baseline results reported above assumed that all of the carbon revenues are recycled to individuals in the form of equal per capita dividends. It is possible, however, that policy makers will decide to earmark part of the revenue from the sale of carbon permits for other uses, particularly during the first few years of the policy's im-

TABLE 10: EFFECT OF WITHHOLDING CARBON REVENUES FOR OTHER USES

Per capita expenditure decile	Per capita expenditure ($)	Net benefit/expenditure with different withholding percentages					
		0%	5%	10%	15%	20%	25%
1	1927	24.0%	22.3%	20.6%	18.9%	17.2%	15.5%
2	3521	9.7%	8.7%	7.8%	6.8%	5.9%	5.0%
3	4736	5.4%	4.7%	4.0%	3.3%	2.6%	1.9%
4	5991	2.7%	2.2%	1.6%	1.1%	0.5%	0.0%
5	7380	1.4%	0.9%	0.5%	0.0%	-0.4%	-0.9%
6	8847	0.3%	0.0%	-0.4%	-0.8%	-1.2%	-1.5%
7	10711	-0.5%	-0.8%	-1.1%	-1.4%	-1.8%	-2.1%
8	13228	-1.2%	-1.5%	-1.7%	-2.0%	-2.2%	-2.5%
9	17178	-2.0%	-2.2%	-2.4%	-2.6%	-2.8%	-3.0%
10	29943	-2.7%	-2.8%	-2.9%	-3.0%	-3.1%	-3.2%

Source: Authors' calculations.

plementation. For example, part of the revenue might be devoted to transitional adjustment assistance for workers and communities that suffer employment losses as a result of the reduced production and consumption of fossil fuels.

Other possible uses of carbon revenues include spending on public goods (such as investments in renewable energy), cuts in other taxes, and what might be termed transitional adjustment assistance to corporations (for example, via give-aways of a fraction of the carbon permits free-of-charge). Each of these may have its own attractions on political grounds, but there are economic and political costs to devoting more than a modest share of carbon revenues to them for reasons explained below.

The effects of withholding carbon revenues for other uses are shown in Table 10. We vary the percentage withheld from zero to 25% in five percentage-point increments, to show the sensitivity of our results to alternative assumptions. As the percentage earmarked for other uses goes up, net benefits to households go down and the percentage of households who come out ahead (in purely monetary terms) decreases. Whereas the bottom six deciles receive positive net benefits when 100% of the revenue is distributed in individual dividends (our baseline scenario, reproduced in the first column), only the bottom half receive positive net benefits with 10% of the revenue earmarked for other uses. With 20% earmarked for other uses, only the bottom four deciles come out ahead.

Note that these results refer only to the net impact of higher fossil fuel prices and individual dividends, without taking into account the distributional effects of other uses of carbon revenues. The latter would depend, of course, on precisely what these other uses are. If the other uses benefit lower-income and middle-income households, their losses from lower dividends could be offset and the distributional progressivity of the overall result possibly enhanced. On the other hand, if the other uses primarily benefit upper-income households, this would reduce their losses and diminish the progressivity of the policy mix.

In our view, there are good economic and political reasons to minimize the extent of non-dividend uses of carbon revenues:

- *First,* the scale of other uses must be limited if we are to meet the central policy goal of reducing carbon emissions while protecting the real incomes of lower-income and middle-income households. We regard income protection as a crucial ingredient of climate policy: any policy that instead puts the economic burden on the poor and middle class risks a political backlash that could fatally undermine public support for curbing carbon emissions.

- *Second,* greater investment in energy efficiency and renewable energy sources will be induced by raising the price of fossil fuels and eliminating the implicit subsidy these now receive by virtue of the zero-pricing of carbon emissions. Such investment could – and, we believe, should – be boosted further by redirecting explicit subsidies from fossil fuels to renewables. Currently, federal subsidies for the fossil-fuel industry in the form of tax breaks and royalty-free access to public lands are worth $24 billion per year (Andrews, 2007).[31] Reorienting these would dramatically increase federal support for energy efficiency and renewables without tapping the revenue from sales of carbon permits.
- *Third,* every dollar of revenues that is devoted to other uses is deducted equally from the dividends of all Americans, rich and poor alike. In other words, it is equivalent to a head tax: by taking a fixed amount from each person, it takes a higher percentage of income from the poor than from the rich. In effect, this would be one of the most regressive taxes in the country, a retreat from the principle of using progressive taxation to fund social expenditures.
- *Fourth,* using carbon revenues to make an equivalent cut in payroll taxes – as former vice-president Al Gore has advocated – would fail to protect the real incomes of lower-income and middle-income population who do not pay these taxes, including the elderly, the disabled and the unemployed.[32] It would also tie the future of Social Security and Medicare to a funding source that ultimately will shrink as the transition to a post-fossil fuel economy moves forward.
- *Finally,* if carbon revenues are used to finance government expenditures or tax cuts, there is no guarantee as to what these uses will turn out to be. Instead of a cut in payroll taxes, for example, we could see a cut in corporate income taxes; indeed, this is the alternative to the cap-and-dividend policy that was analyzed in the CBO studies. Instead of financing expenditures on renewable energy or mass transit, we could see increased government spending on subsidies for fossil fuel corporations. We live with the administrations we have, not necessarily those we want. A policy in which the revenues are dedicated to individual dividends comes as close as possible to building a "locked box" that is not vulnerable to political vicissitudes in future years.

VI. CONCLUSIONS

A cap-and-dividend policy would combine an effective means to curb U.S. carbon emissions from burning fossil fuels with protection of real incomes of lower-income and middle-income Americans from the consequences of higher fossil fuel prices.

Any policy that reduces carbon emissions will raise the prices of fossil fuels: higher prices are the handmaiden of lower demand. Higher prices for oil, coal, and natural gas will mean higher prices for goods and services produced with them. As documented in this study, these higher prices will hit the real incomes of lower-income and middle-income households harder than those of upper-income households.

But higher prices for fossil fuels are only one side of the story. The other side is summed up by the question, "Who gets the money?" If the money is recycled to the public on an equal per capita basis, via cap-and-dividend, the impact of the emissions-reduction policy on the distribution of incomes is transformed: lower-income and middle-income households come out ahead in monetary terms, both absolutely and relative to upper-income groups.

A cap-and-dividend policy has three basic steps:

- *First,* U.S. carbon emissions are capped at a level that gradually declines over time. For example, if we reduce emissions at a rate of 4% per year starting in 2010, we will cut emissions to 20% of their 2010 level by the year 2050.

- *Second,* based on the cap in a given year, permits are auctioned to firms that bring fossil carbon into the economy (whether through domestic extraction or imports). The supply of permits in a given year is fixed by the cap; their price depends on the demand for them.
- *Third,* the revenue from the sale of permits is deposited into a trust fund and paid out to all individuals on an equal per person basis. In addition, some fraction of the revenue initially may be earmarked for other uses, such as transitional adjustment assistance.

A cap-and-dividend policy has several attractive features. It asserts the principle of common ownership of nature's wealth: rights to benefit from the U.S. share of the Earth's capacity to absorb carbon are allocated equally to all Americans. It protects the real incomes of the majority of the population, overcoming a crucial political hurdle to the adoption of effective policies to curb global warming. It results in a progressive redistribution of income, a result that does not hinge on the propensity of present and future governments to use the revenues for egalitarian purposes.

At a permit price of $200 per ton of carbon, the annual revenue from the sale of permits would amount to roughly $200 billion. If this revenue is recycled to individuals equally, the majority of households will receive positive net benefits: their dividends exceed the amount they pay as a result of higher fossil fuel prices. The net impact ranges from a 2.7% loss for the richest 10% of households to a 24.0% gain for the poorest 10%. This "baseline scenario" assumes that 100% of the cost of carbon permits is shifted to consumers. If the extent of pass-through to consumers is less than 100%, and some of the cost is absorbed via lower profit margins, then the distributional progressivity of the outcome is enhanced and the percentage of American families who come out ahead increases.

Allowing a modest fraction of the carbon revenues to be earmarked initially for other uses, such as transitional adjustment assistance, could further enhance the political appeal of the cap-and-dividend policy. Our results indicate that up to ten per cent of the carbon revenues can be dedicated to other uses while maintaining positive net benefits for roughly 50% of households; withholding carbon revenues beyond the 10% threshold pushes the net beneficiary share of the population below half.

In sum, a cap-and-dividend policy is a "win-win" option for the majority of Americans, maintaining or increasing real incomes while curbing global warming and hastening the U.S. economy's transition towards the energy sources of the future. Not only is it an attractive policy on environmental, economic, and political grounds; it is, as far as we know, the *only* policy that combines these virtues in a realistic proposal. If the American public engages actively in shaping the nation's climate policies, the cap-and-dividend policy could become not just an attractive idea but a historic breakthrough.

APPENDIX:

Distributional Impact with Less-than-100% Pass-through to Consumers

In this appendix, we examine how the distributional impact of a cap-and-dividend policy would differ if part of the cost of carbon permits is absorbed by producers in the form of lower profit margins, rather than being passed fully to consumers in the form of higher prices.

Little empirical research has been done to ascertain the extent to which the cost of carbon permits will be passed through to consumers. In a recent literature review, Parry et al. (2005, p. 32) remark that "empirical studies on the extent to which the costs of environmental policies are passed forward into higher prices of consumer products would be extremely valuable." Studies on the extent of pass-through of sales and excise taxes have generated mixed results: some studies have found close to 100% pass-through, some have found significantly less, and still others have found "overshifting" in which prices rise by more than the amount of the tax (Fullerton and Metcalf 2004, pp. 1817-1823).[33]

If firms absorb part of the cost of carbon permits via lower profit margins, this has two effects on our calculations. First, it reduces the incomes of households in proportion to their ownership of corporate stock. Second, it translates into a higher permit price and higher total revenues for a given emission cap. (Permit prices rise because the reduction in demand for fossil fuels is a function of the price increases passed through to consumers; total revenues rise because demand is price-inelastic).

To examine the effects of less-than-100% pass-through of carbon charges to consumers, we assume that reductions in corporate profits are distributed amongst households on the basis of stock ownership as reported in Table 8. We vary the share of permit costs absorbed via lower profits from 0% (our baseline scenario) to 25% in five percentage-point increments, to show the sensitivity of the results to alternative assumptions. That is, we allow the percentage of the carbon charge that is passed through to consumers to vary from 75% to 100%.

The results are presented in Table A.1. The first column – with zero charge from profits, or 100% pass-through – shows the net distributional impact of the cap-and-dividend policy as reported in Table 7. Subsequent columns show the distributional impact with rising shares of the permit price coming from corporate profits. As the pass-through to consumers diminishes, net benefits to lower-income and middle-income households increase. Insofar as the carbon charges cut into corporate profits rather than being shifted fully to consumers, our baseline results understate the favorable distributional impacts of the cap-and-dividend policy.

TABLE A.1: IMPACT OF VARYING PERCENTAGE OF CHARGE FROM PROFITS

Per capita expenditure decile	Per capita expenditure ($)	Net benefit /expenditure with different percentage of charge from profits					
		0%	5%	10%	15%	20%	25%
1	1927	24.00%	25.70%	27.60%	29.70%	32.20%	35.00%
2	3521	9.70%	10.60%	11.70%	12.90%	14.30%	15.90%
3	4736	5.40%	6.00%	6.80%	7.70%	8.60%	9.80%
4	5991	2.70%	3.20%	3.80%	4.40%	5.10%	5.90%
5	7380	1.40%	1.80%	2.20%	2.60%	3.20%	3.80%
6	8847	0.30%	0.60%	0.80%	1.10%	1.50%	1.90%
7	10711	-0.50%	-0.30%	-0.20%	0.00%	0.20%	0.50%
8	13228	-1.20%	-1.10%	-1.00%	-0.90%	-0.80%	-0.70%
9	17178	-2.00%	-2.10%	-2.10%	-2.20%	-2.20%	-2.30%
10	29943	-2.70%	-3.30%	-4.10%	-4.90%	-5.80%	-6.90%
Carbon charge (per tC)		$200.00	$210.53	$222.22	$235.29	$250.00	$266.67

Note: Assumes 100% revenue recycling via dividends.
Source: Authors' calculations.

Notes

[1] EU-15 refers to the fifteen member states of the European Union as of 1995. Emissions for Germany prior to German reunification in 1990 are the total for West Germany and East Germany.

[2] Emissions resulting from electricity use are allocated across fuel sources on the basis of total emissions from the electric power sector. Emissions by sector: http://www.eia.doe.gov/emeu/aer/pdf/pages/sec12_5.pdf. Emissions from electricity generation by fuel source: http://www.eia.doe.gov/emeu/aer/pdf/pages/sec12_16.pdf.

[3] The data in Table 2 are drawn from the Consumer Expenditure Survey, conducted quarterly for the U.S. Bureau of Labor Statistics by the Census Bureau. We pooled annual consumption data for households that began participating in the survey from the 3rd quarter of 2002 through the 2nd quarter of 2003.

[4] We calculated separate price impacts for air transport and "other transport" (including trains and mass transit), categories combined in Metcalf's study, using data from the 1992 input-output accounts (Lawson 1997).

[5] The higher per capita emissions shown in Figure 1b (5.5 tC) include carbon emissions from other sources, such as government expenditure, in addition to those associated with household consumption.

[6] This is what happened when the European Union introduced carbon permits for electric power generation and gave them free-of-charge to utility companies. For accounts, see Ball (2006) and Dutzik et al. (2007. p. 22). As Paltsev et al. (2007, p. 5) note, if regulated utility markets were to prevent price rises (and windfall profits), this would dissipate the incentive for consumers to curb consumption.

[7] This is an extension of the 'feebate' concept, whereby fees are paid according to the extent of individual resource use, and the proceeds rebated equally to all use-rights holders. This idea has been applied to a variety of environmental problems; see, for example, Puig-Ventosa (2004). For an early application to gasoline taxes, see Shepard (1976).

[8] The so-called "tragedy of the commons" – in which unrestricted access to a scarce resource leads to its overuse – is more accurately termed the tragedy of open access, since communities often devise rules to protect common-property resources. Open access often leads to a second tragedy, too: those who reap most of the short-run benefits from open access are the wealthy and powerful, while those most severely impacted by the long-run costs are the poor and relatively powerless. For discussion, see Boyce (2002, pp. 7-8).

[9] It is possible to design alternative uses of carbon-charge revenues that are superior, at least in theory, to lump-sum redistribution on efficiency or distributional grounds (see Zhang and Baranzini 2004, pp. 511-2). In practice, however, these alternatives would be subject to the vagaries of fiscal politics. Moreover, Unlike the cap-and-dividend policy, they would not affirm the fundamental principle of equal rights to nature's common wealth.

[10] For discussion of administrative costs, see also Fisher et al. (1998). As the CBO (2001, p. 19) notes, administrative costs would increase if charges were levied not only on fossil fuels, but also on imports of carbon-intensive products (such as aluminum) so as to avoid placing domestic producers at a disadvantage in the absence of similar carbon policies in the exporting countries. Presumably these cost increases would be offset by the additional revenue collected.

[11] A recent study of Italy's carbon tax (Tiezzi 2005) finds that it has a progressive incidence, however, by virtue of the facts that it is designed to hit transport fuels harder than domestic fuel use and that higher-income Italian households were less responsive to higher prices.

[12] In assessing distributional impacts, researchers often stratify households on the basis of expenditure rather than income, on the grounds that expenditure is a better proxy for lifetime income and less subject to transitory shocks. We do the same in this paper. If incidence instead is calculated on the basis of income data, carbon charges generally appear to be even more regressive because expenditure-to-income ratios typically decline as incomes rise. For discussion, see Metcalf (1999).

[13] The give-away option, sometimes referred to as "grandfathering," was the main method adopted when sulfur dioxide emission permits were introduced in the U.S. in the 1990s. Insofar as the resulting windfall profits are taxed, this method generates some government revenue (albeit less than if the permits were sold by auction). In an analysis of the effects of grandfathered carbon emissions permits with profits taxed at the rate of 35%, Parry (2004) likewise finds that the distributional impact is regressive even when coupled with lump-sum redistribution of the revenues recouped by taxation, due to the skewed distribution of profit income.

[14] The stronger distributional effects in the Dinan and Rogers study arise mainly from (i) use of a lower value for average income in the lowest quintile, and (ii) incorporation of an estimated "deadweight loss" in factor markets due to the impact of higher carbon prices on real returns to capital and labor.

[15] For a tool for calculating co-benefits, see Mulholland (2007). For estimates of damages from releases of particulates, sulfur dioxide, and nitrogen oxides in the U.S., see Muller and Mendelsohn (2007).

[16] The authors assume that dividends are distributed equally per person, rather than equally per household as in the CBO (2000) and Dinan and Rogers (2002) studies.

[17] A doubling of the permit price would not quite double total revenue and net benefits, because it would entail reduced demand and fewer permits.

[18] For energy sectors, the elasticities are based on the literature review by Dahl (1993). For food, services, and in-

dustrial goods, we use Williamson's (2006) "stylized facts of demand."

[19] This falls near the middle of the $50-300 billion/year range (in 2007 dollars) that the U.S. Congressional Budget Office (2007, p. 2) reports as the likely value of carbon emission permits in 2020, based on a review of the existing literature and the range of emission-reduction goals currently being debated.

[20] One rationale sometimes offered for a cap-and-giveaway strategy is that it would compensate shareholders of fossil-fuel companies for declines in stock values arising from lower sales. At the same time, however, shareholders of renewable-energy companies would be expected to experience increases in stock values due to higher sales. Some shareholders win, others lose. We see no compelling reason for the public to insure the shareholders of polluting firms against the risk that society will adopt policies to curb pollution. In any event, as the U.S. Congressional Budget Office (2007, p. 5) notes, compensation to adversely affected shareholders would require only a "small fraction" of the total value of carbon permits. Goulder (2002) estimates that a cap-and-giveaway policy with permits rising from a modest initial price of $25/tC to a final price of $50/tC would lead to a sevenfold increase in stock values for coal companies and to a doubling of stock values for oil and gas firms.

[21] The deciles in Table 8 are grouped by per capita income rather than per capita expenditure. (The difference between the two probably explains the anomalous finding that the bottom decile owns somewhat more stock than the second lowest decile.) We have not found comparable data for expenditure deciles. These stock ownership data include both direct ownership of stocks and indirect ownership through mutual funds and other sources. For discussion, see Bucks et al. (2006).

[22] For simplicity, we assume that all windfall profits are recycled to U.S. households in proportion to their stock ownership. In practice, some profits would "leak" out of the country in returns to foreign owners of stock in fossil-fuel companies, diminishing net benefits of the cap-and-giveaway policy to U.S. households. Some profits might also be withheld from shareholders and instead used to increase executive compensation. For both reasons, the cap-and-giveaway results presented in Table 9 can be regarded as a "best-case" approximation that, if anything, understates net costs for the majority of households.

[23] This is the average per capita charge for the 5th and 6th deciles, multiplied by the average household size in these deciles, as reported in Table 7.

[24] A similar situation could arise for tradable goods producers who face competition from foreign firms not covered by the carbon permit mandate. All else equal, the introduction of carbon permits in the U.S. economy would make imports more competitive and exports less competitive. In industries where these trade effects are significant, there is a case for corrective policies: tariffs on imports (based on fossil carbon emissions in their production) and dividends on exports. Careful research is needed to assess needs for such compensating policies. We note, however, that many foreign competitors (notably in Europe) now pay higher prices for fossil fuels than U.S. producers, due to government environmental and taxation policies. In these cases, it would be difficult to argue that introducing carbon permits would place U.S. firms at an unfair disadvantage. More generally, trade competitiveness depends on many factors – including exchange rates, labor costs, taxation, and the pace of technological innovation – and these are likely to overshadow the effects of environmental policies, which empirical studies generally find to be quite small (for discussions, see Goodstein 1999 and Ackerman 2006).

[25] To be sure, lower-income households devote a higher proportion of their expenditure to necessities than to luxuries, and from this it is sometimes inferred that they tend to be less responsive, for example, to changes in the price of gasoline (Kayser 2000). But the same reasoning applies to non-fuel expenditures by lower-income households: not cutting gasoline consumption in response to higher prices would imply bigger cutbacks in other necessities such as food and health care. A more plausible reason to expect greater price responsiveness among upper-income households is that in some cases (such as buying more energy-efficient vehicles), cutbacks in fuel consumption require investments in expensive durable goods.

[26] Other studies of price elasticity differences across the income spectrum have produced mixed results. West (2004) and Archibald and Gillingham (1980) also find that lower-income US households are more responsive to gasoline prices than are upper-income households, while Kayser (2000) reports a contrary finding. In a study in the United Kingdom, Dargay and Vythoulkas (1999) also find greater price-responsiveness among lower-income households: the long-run elasticity of car ownership with respect to running costs is -0.92 for low-income groups, -0.51 for middle-income groups, and -0.38 for high-income groups (see also U.K. Department for Transport, 2006). In a study of Denmark, Brännlund and Nordstrom (2004) find little variation across income groups in the price elasticities of demand for gasoline and other goods.

[27] Unlike the CEX, the NIA consumption measure includes expenditures by non-profit institutions serving households, which account for roughly 11% of consumption, or 8% of GDP (based on 1993 data cited by Garner et al. 2006, p. 22). Subtracting this from the NIA measure, household consumption represented roughly 63% of national income.

[28] Another possible source of discrepancy between the two figures is under-reporting of consumption in the CEX. The CEX-based estimate of total consumption in the United States, derived from household surveys, is roughly 60% of the National Income Accounts-based estimate of aggregate consumption, derived primarily from economic censuses of firms (for discussion, see Garner et al. 2006). In part, this disparity arises from definitional differences (for example,

the latter includes consumption by many non-profit institutions whereas the CEX does not), and in part from measurement errors in one or both instruments. Insofar as under-reporting in the CEX accounts is to blame, this would affect the pattern of distributional impacts reported here only if the under-reporting were uneven across expenditure deciles. Since we lack adequate data on which to assess this possibility, we make do with the data at hand. If the degree of any under-reporting in the CEX is roughly constant across deciles, then its only effect on the distributional impacts of a cap-and-dividend policy reported in Table 7 would be on absolute magnitudes, not on the pattern of relative impacts across deciles.

[29] If investment per unit output and carbon emissions per dollar investment are roughly the same across sectors, inclusion of investment-related emissions would somewhat reduce the disparities in carbon content across consumption categories reported in Table 3. Since low-carbon categories account for a larger share of expenditure by upper-income households, this would reduce the regressivity of carbon charges and enhance the progressivity of the cap-and-dividend outcome.

[30] In some cases, however, trade policies may compensate for these effects; see note 24.

[31] To put this number in perspective, in 2005 public expenditure on research & development for wind energy, fuel cells and photovoltaics combined was about $250 million (Kammen and Nemet 2005, p. 86).

[32] See “Solving the Climate Crisis,” speech by Al Gore at New York University, 18 September 2006. Available at http://www.nyu.edu/community/gore.html.

NOTE TO APPENDIX

[33] A related but distinct issue is the impact of higher prices on the “welfare triangles” of consumers’ surplus and producers’ surplus. Basic microeconomic theory tells us that the ratio of these welfare losses depends on price elasticities of demand and supply: the more inelastic the demand curve, the higher the share of consumers; the more inelastic the supply curve, the higher the share of producers. These calculations assume that the full cost of carbon permits (or carbon taxes) is passed through to consumers. If the supply curve is not perfectly elastic, the reduction in output leads to a decline in marginal cost and this dampens the rise in the market price, but consumers still are assumed to pay the full carbon charge (the difference between the marginal cost of production without permits and the market price with permits). Here we do not attempt to incorporate the welfare losses from reduced consumers’ surplus and producers’ surplus, nor the welfare gains from reduced carbon emissions, for reasons explained in section 3.

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