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****DRAFT FOR COMMENTS** 4th October 2009**

Introduction

Like cap and trade, a cap and dividend policy imposes a declining cap on greenhouse gas emissions and allows pollution permits to be traded among polluters. The key difference is in how the permits are distributed; cap and dividend is the name given to the subset of cap and trade policies in which all permits are auctioned and a significant fraction of the auction revenue is distributed back to consumers to offset increased energy prices. Cap and trade programs generally allow for some portion of the pollution permits to be given away (grandfathered) to certain polluters, and revenues from the auctioned permits are not necessarily returned to consumers. If the cost of complying with the cap is passed on to consumers, such policies will be regressive because lower income households spend a higher fraction of their income on energy than higher income households.

We assess the impact of a cap and dividend policy in California across different regions of the state for different levels of income. We model the cap and dividend policy by assuming that 100% of permits are auctioned and a given fraction of the auction revenue is returned to the public in the form of equal per capita dividends. We also model the impact on consumers of increased costs of electricity, natural gas, and transportation fuels, neglecting the increased cost of general consumer goods. We expect these costs to vary geographically because of the large variation in carbon intensity of electricity by region, as well as the variation in natural gas use and gasoline use (both electricity carbon intensity and gasoline consumption vary by nearly a factor of four across the state and natural gas consumption varies by a factor of three, as shown in Figures 1 through 3).

Methodology

The American Community Survey provides data on household incomes and electricity expenditures for nearly 400,000 households in CA, which we aggregate into 41 regions (individual counties or groups of counties) and sort into deciles of per capita income. Matching each region with the electric utility(s) serving the region, we can calculate the increase in expenditure due to higher electricity prices in 2020[1]. The electricity sector is assumed to de-carbonize by 10% relative to 2007, in line with CA's goal of reducing emissions to 1990 levels by 2020. Electricity prices in 2020 are a function of the 2007 electricity price (from EIA Form 861 data), an assumed annual real rate of price escalation independent of the carbon price, and the carbon price.

[1] A few of the regions are missing data for important local utilities. Specifically, the region comprising Del Norte, Lassen, Modoc, and Siskiyou Counties is missing Lassen MUD, Pluma/Sierra Co-op, and Surprise Valley Electric Corporation. The region of Colusa, Glenn, Tehama, and Trinity Counties is missing Trinity County Public Utility District. And the region of Nevada, Plumas, and Sierra Counties is missing Lassen MUD and Plumas/Sierra Co-op.

Our 41 regions are then matched with the natural gas utility(s) serving each region in order to calculate the increase in expenditure due to higher natural gas prices in 2020.[2] Natural gas prices in 2020 are a function of the 2007 natural gas price (from EIA Form 176 data), an assumed annual real rate of price escalation independent of the carbon price, and the carbon price. Natural gas consumption in 2020 is calculated by assuming a price elasticity of demand of -0.2.[3]

Household transportation expenditures are estimated using Bureau of Labor Statistics Consumer Expenditure Survey data to calculate per capita gasoline consumption by decile in California, and the results are given in Table 1. These expenditures are then weighted by region based on California Energy Commission data on total gasoline consumption by region in 2006 to arrive at an estimate of per capita gasoline consumption by decile in each region of the state. Future gasoline consumption in 2020 is calculated by assuming a price elasticity of demand of -0.3; this is a plausible estimate of the short-term elasticity for gasoline.[4]

We model the cap and trade system by assuming a fixed price for carbon. Because it is not known a priori what carbon price will be needed to achieve the emissions reductions that we assume, we consider scenarios with carbon prices ranging from $10/tCO2 to $100/tCO2.

In our base case scenarios, we set the rates of electricity, natural gas, and gasoline price increases to all be 0%. The rationale for considering this scenario is that the cap and dividend policy is only meant to protect consumers against price increases due to the policy, not from the general upward trends in real fuel prices.

We also consider the sensitivity of our results to different assumptions regarding demand elasticities for gasoline and the price escalation factors for the different fuels. It has been noted that demand for gasoline is more elastic for lower deciles, despite the fact that households in these deciles use less gasoline to begin with. Thus, we consider a scenario in which gasoline consumption is determined by using demand elasticities that vary by quintile from West and Williams, 2002[5]; elasticities are given in Table 2. (Note: West and Williams divides households into quintiles by household income, not per capita income, but we ignore this difference for the moment). The average elasticity in Table 2

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[2] Natural gas prices for 2007 were obtained from EIA Form 176 for the following utilities: City of Long Beach, Pacific Gas and Electric, San Diego Gas and Electric, Southern California Gas, and Southwest Gas. For the remaining utilities, an average price of $11.57/Mcf was used.

[3] J.K. Boyce and M. Riddle, "Cap and Dividend: How to Curb Global Warming While Protecting the Incomes of American Families," Political Economy Research Institute, November 2007.

[4] Ibid.

[5] S.E. West and R.C. Williams, "Estimates from a Consumer Demand System: Implications for the Incidence of Environmental Taxes" *Journal of Environmental Economics and Management* 47.3 (2004): 535-558.

is approximately -0.65, which is a plausible estimate for the long-term elasticity of gasoline.[6,7]

We also consider a different price escalation scenario, in which the rates of increase of electricity, natural gas, and gasoline prices follow historical trends. Nominal electricity prices have increased 2.3%/year in CA and nominal gasoline prices have increased 5.6%/year over the past couple of decades, according to the California Energy Commission; natural gas prices have increased 6.4% according to the EIA. Subtracting out inflation of 2-3%/year, we assume real rates of increase of 0%/year for electricity, 3%/year for gasoline, and 4%/year for natural gas. Under this scenario, the gasoline price increases from $3.6/gallon to $5.3/gallon in 2020.

Results

Figure 4 shows how the fraction of households that receive positive net benefits (i.e. their household dividend is larger than the increase in household fuel expenditures) varies across the state. Figure 4 corresponds to a carbon price of $30/tCO2, but we do not find a strong sensitivity to carbon price because household dividends increase linearly with the carbon price and fuel expenditures also increase nearly linearly with the carbon price (in this scenario with 0% fuel price escalation). For clarity, and to emphasize the geographic variation, Figure 4 includes only the 5 regions with the fewest households receiving positive net benefits and the 5 regions with the most households receiving positive net benefits. The region of Del Norte/Lassen/Modoc/Siskiyou fares the worst. This region has high household electricity consumption, driven by the cheap price of electricity from PacifiCorp, the dominant utility; PacifiCorp also has the highest carbon intensity of any of the utilities considered. (However, results for Del Norte/Lassen/Modoc/Siskiyou may be misleading because we are missing carbon intensity data for 2 utilities serving the region: Lassen MUD and Plumas/Sierra Co-op.) San Francisco County fares best, due to a combination of low natural gas consumption, low gasoline consumption, and the relatively low carbon intensity of PG&E's electricity. Figures 5 and 6 show the variation in households receiving positive net benefits across all regions. As shown by Figure 7, the cap and dividend policy is progressive, with a greater fraction of households in the poorest deciles receiving positive net benefits.

We note that with 100% of revenue distributed in the form of per capita dividends, more than 70% of households receive positive net benefits in all regions. With 50% of revenue distributed as per capita dividends, only 8 of our regions (representing only 4% of the state's population) have fewer than half of households receiving dividends. Moreover, the households that receive positive net benefits from the policy are more likely to be in the poorer income deciles.

Variable demand elasticities

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[6] K. Storchmann, "Long-run gasoline demand for passenger cars: the role of income distribution", Energy Economics, Vol 27, 2005.

[7] A.M. Bento, L.H. Goulder, M.R. Jacobsen, and R.H. von Haefen, "Distributional and efficiency impacts of increased U.S. gasoline taxes," American Economic Review, Vol. 99 (3), 2009.

We also consider a scenario in which the demand elasticity for gasoline varies by decile; the elasticities are given in Table 2. We continue to assume 0% price escalation and a carbon price of $30/tCO2. Figure 8 shows the variation of positive net benefits by decile; as expected, the variation across deciles is more pronounced than in Figure 7.

Under this scenario, if 100% of revenue is distributed in the form of per capita dividends, then more than 85% of households receive positive net benefits in all regions. With 50% of revenue distributed as per capita dividends, all regions have more than half of households receiving dividends.

Historical price escalation

We next consider a scenario in which electricity prices increase 0%/year, natural gas prices increase 4%/year, and gasoline prices increase 3%/year, in addition to the price increases imposed by the carbon price (assumed to be $30/tCO2). With constant demand elasticities, the fraction of households receiving a positive net benefit from the policy is shown in Figure 9. This figure is qualitatively similar to Figure 7, but with fewer households receiving positive net benefits overall. For the poorest decile, all but 7 regions (representing less than 4% of the state's population) have more than half of households receiving positive net benefits with all of the auction revenue going to dividends. For the wealthiest decile, no households receive positive net benefits across all regions.

Because the transportation price increases so much by 2020 in this scenario (nearly 50%), the results are highly sensitive to the assumed demand elasticities for gasoline; at lower elasticities (e.g. -0.3), the increased transportation and natural gas expenditures can entirely wipe out the positive net benefits across all regions.

Conclusions

We find that cap and dividend is a progressive policy that can result in the majority of California households receiving positive net benefits, depending on the fraction of carbon allowance revenue allocated towards equal per capita dividends. Despite the variation in fuel consumption and electricity carbon intensity across the state, it is still possible to return positive net benefits to the majority of households in regions representing 96% of the state's population, even with the government retaining 50% of the allowance revenue.

Based on our analysis of historical fuel price increases, we note that although the cap and dividend policy will be able to more than offset the increase in fuel prices due to the carbon price for most households, it will not necessarily offset fuel price increases in general.

The largest uncertainty in this analysis is the demand elasticity of gasoline. In this paper, we have conservatively chosen to use a short-run elasticity for gasoline that does not vary across deciles. Larger (i.e. long-run) elasticities would result in more households receiving positive net benefits; using elasticities that vary across deciles would have resulted in more progressive results because poorer households are more sensitive to changes in gasoline prices. We did not consider scenarios in which the demand elasticity

for natural gas varies across deciles, but presumably this would have a similarly large effect on the analysis.

It is important to note that this paper is considering a narrow definition of "benefits" to households; by considering only the direct per capita dividends, we are ignoring the benefits that all households receive from reduced climate change damages. Estimates of the climate change mitigation benefits of the Waxman-Markey legislation in 2020 range from $7.6 billion to $130 billion, or per capita benefits of $22 to $380.[8] Under a cap and dividend scenario for California with 100% revenue returned as dividends, the per capita dividend is $310. Thus, the additional benefits from climate change mitigation are likely to be of the same order of magnitude as the direct dividends, implying that benefits to households from the cap and dividend policy are significantly greater than those included in our analysis.

Tables

Decile	1	2	3	4	5	6	7	8	9	10
Per capita gasoline consumption (relative to poorest decile)	1.0	1.3	1.8	1.9	2.0	2.3	2.6	2.9	2.8	3.7

Table 1. Per capita gasoline consumption by per capita income decile in CA. Source: Bureau of Labor Statistics Consumer Expenditure Survey

1st	2nd	3rd	4th	5th
-0.67	-0.79	-0.69	-0.78	-0.34

Table 2. Price elasticity of demand for gasoline by quintile. Source: West and Williams, 2002.

Figures

[8] J.S. Holladay and J.A. Schwartz, "The Other Side of the Coin: The economic benefits of climate legislation," Institute for Policy Integrity, New York University School of Law, September 2009.

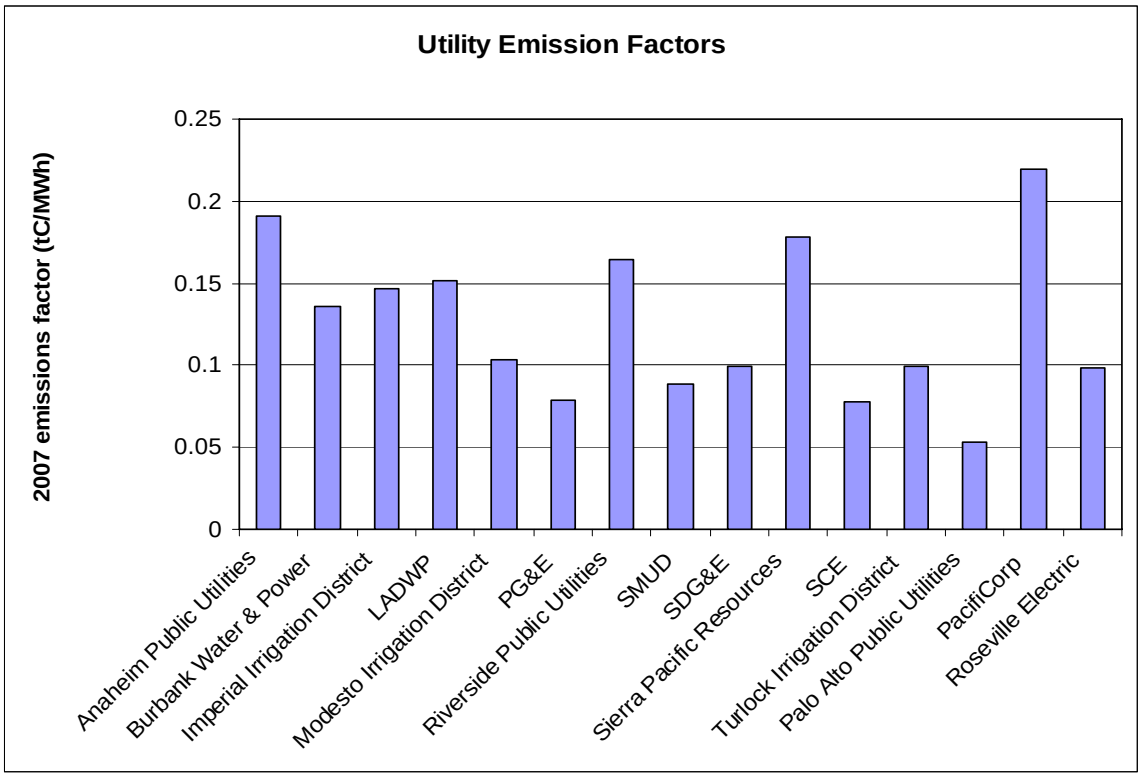

Figure 1. 2007 emissions factors for major CA utilities. Source: California Climate Action Registry.

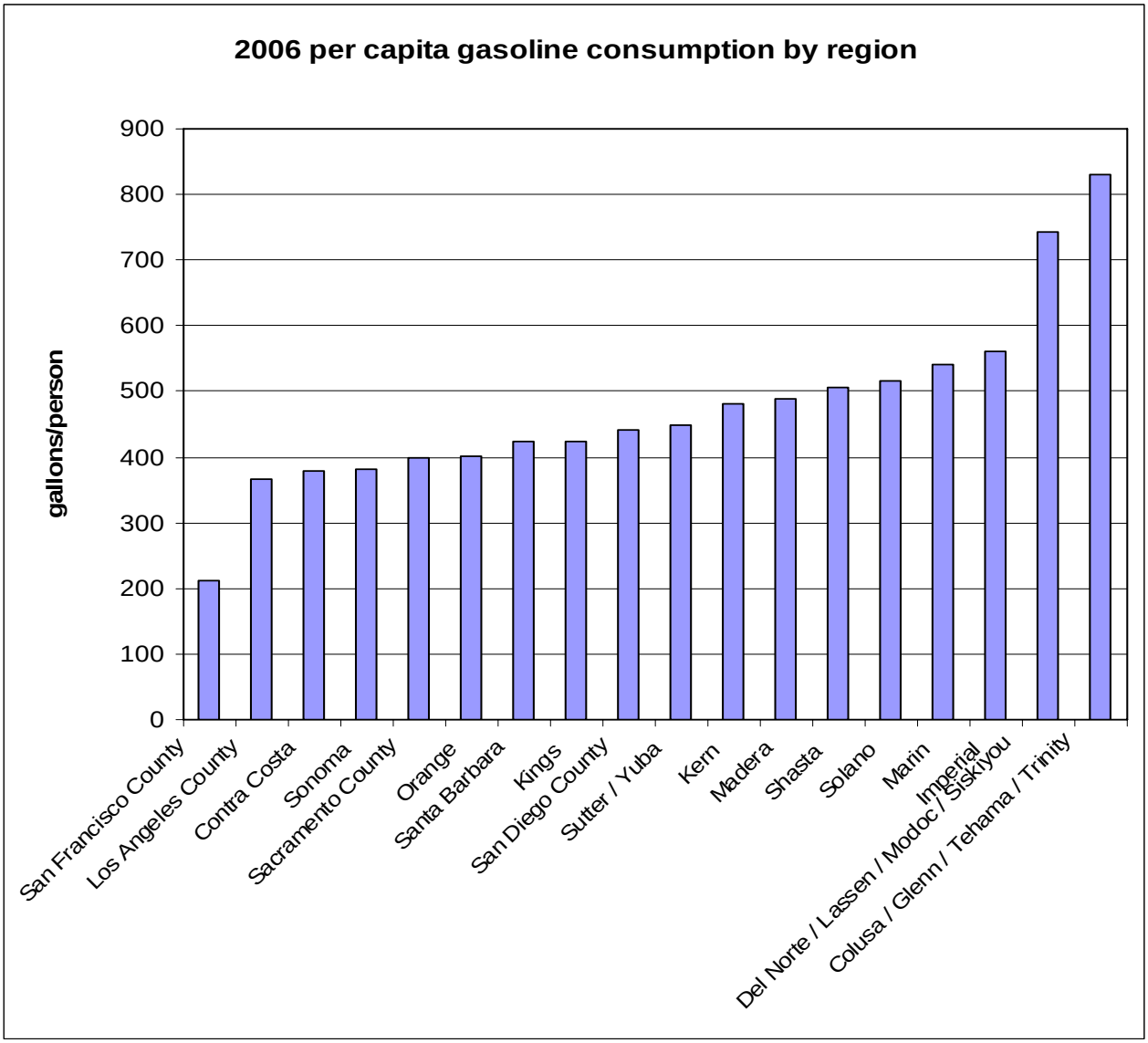

Figure 2. Per capita gasoline consumption for selected regions. Source: California Energy Commission, and U.S. Census Bureau

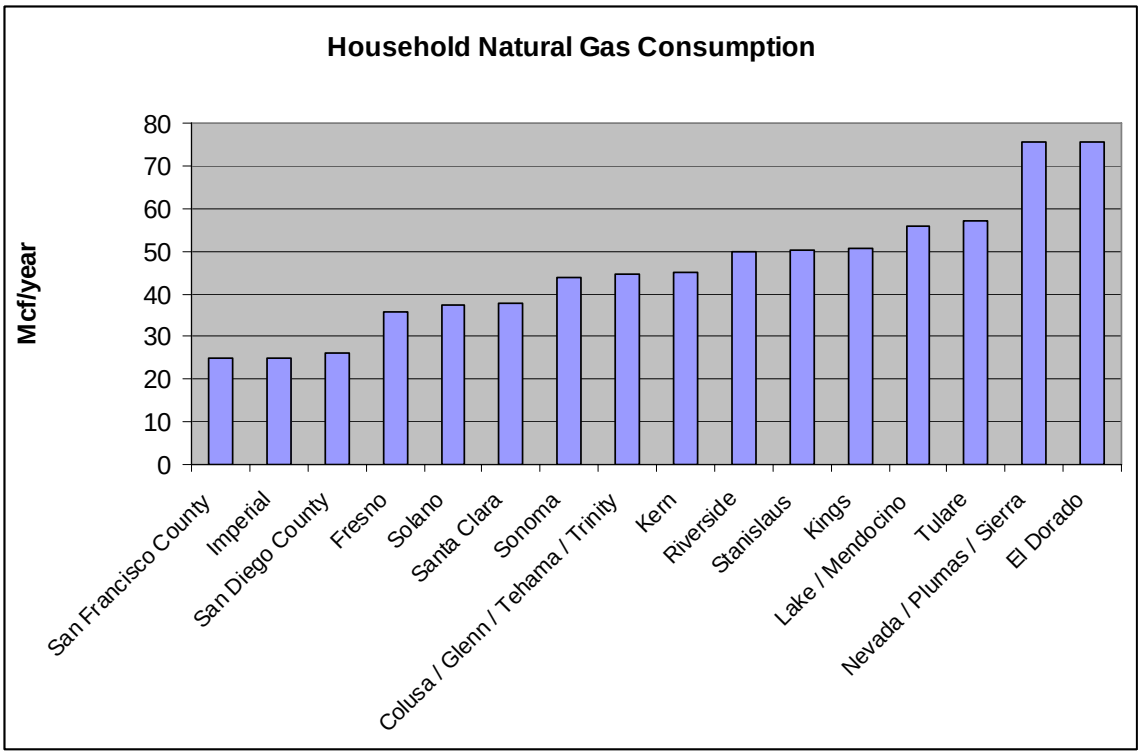

Figure 3. Natural gas consumption for selected regions. Source: American Community Survey, 2005-2007

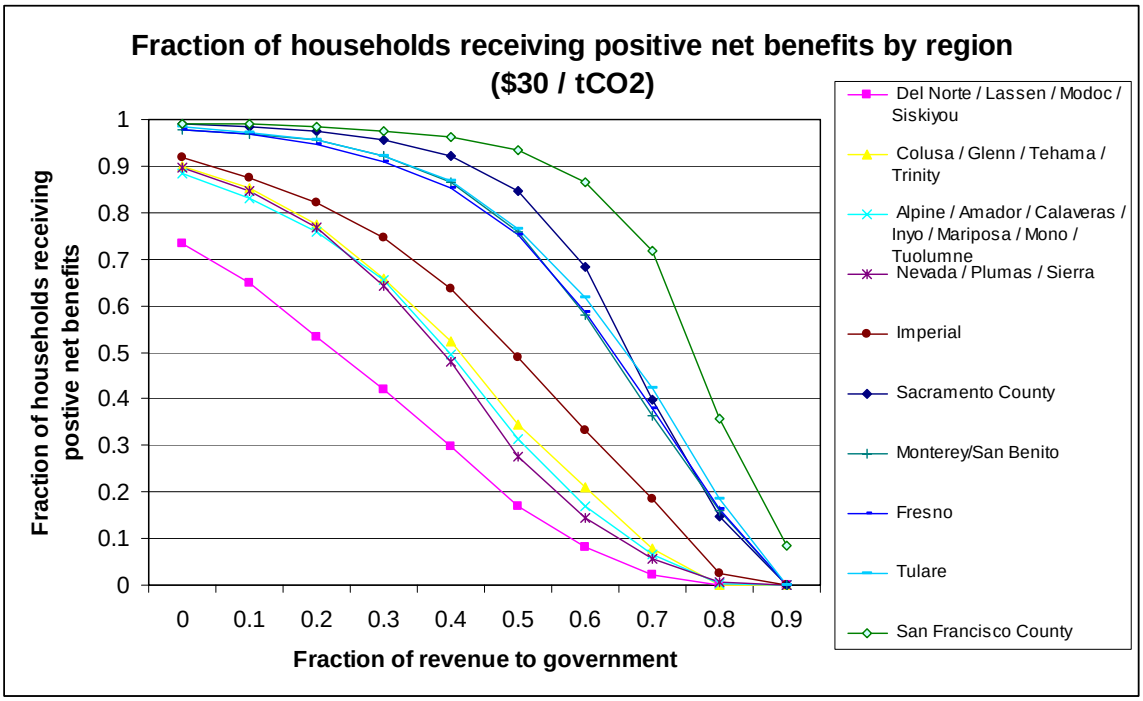

Figure 4. Fraction of households receiving positive net benefits for selected regions as a function of revenue returned to government. Carbon price: $30/tCO2, 0% price escalation.

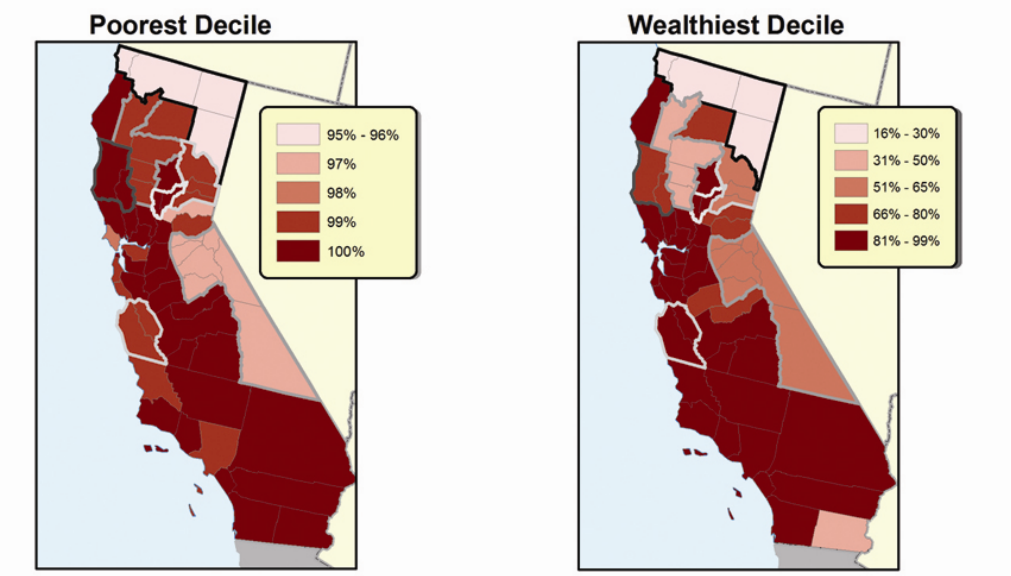

Figure 5. Fraction of households receiving positive net benefits by region with 0% of revenue retained by government. Gray lines indicate region boundaries for regions that comprise multiple counties. Carbon price: $30/tC. 0% price escalation

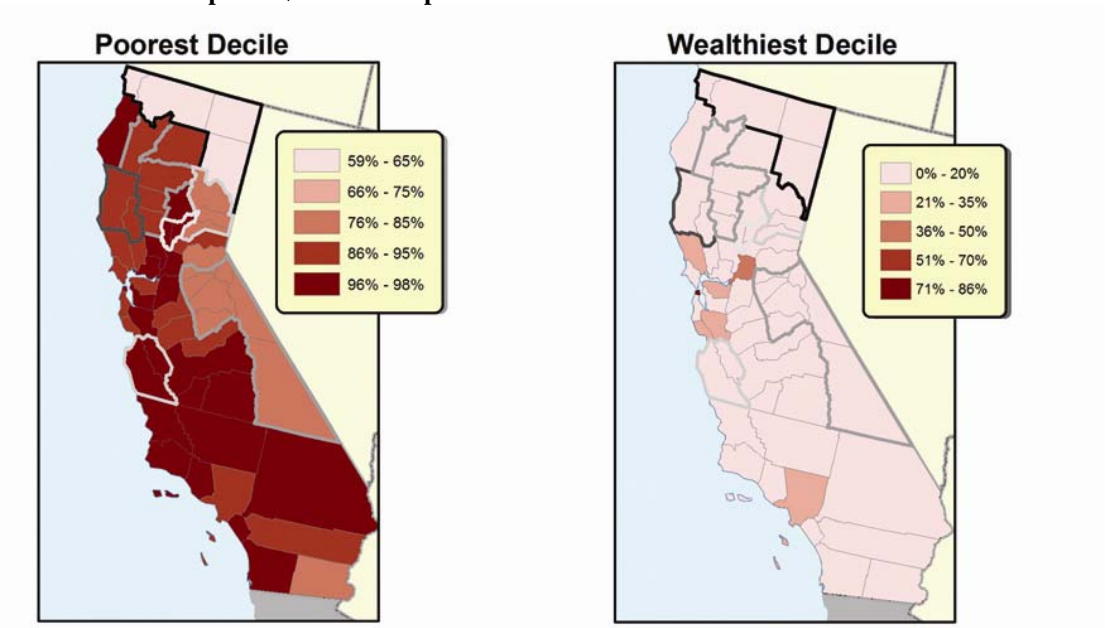

Figure 6. Fraction of households receiving positive net benefits by region with 50% of revenue retained by government. Gray lines indicate region boundaries for regions that comprise multiple counties. Carbon price: $30/tC. 0% price escalation.

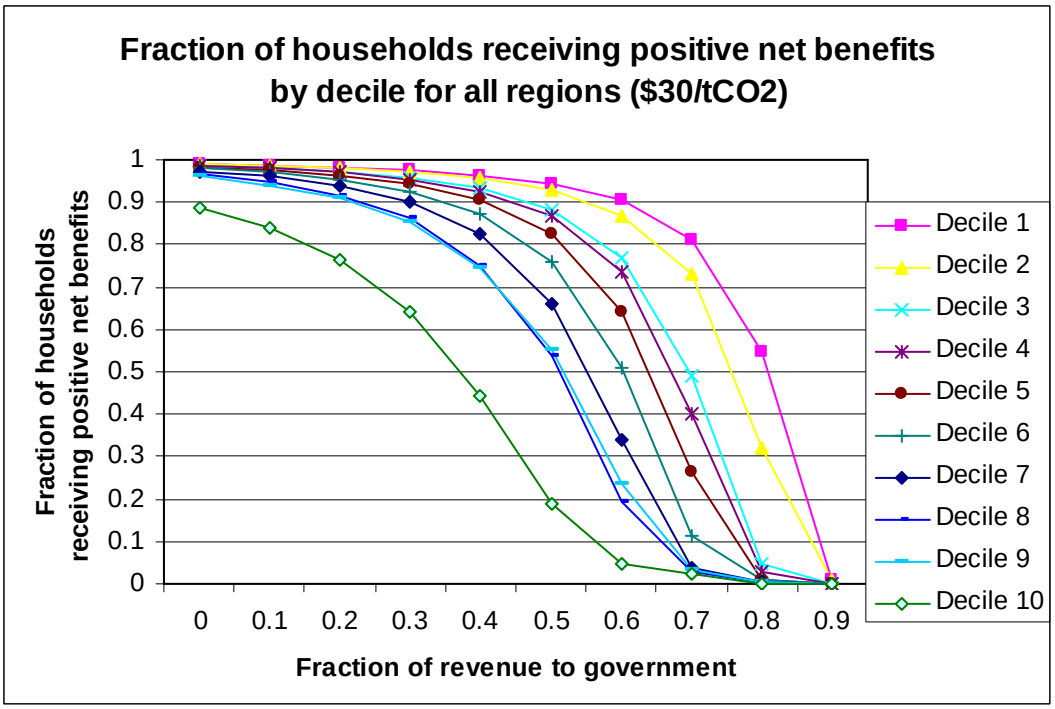

Figure 7. Fraction of households receiving positive net benefits by per capita income decile. Carbon price: $30/tCO2, 0% price escalation.

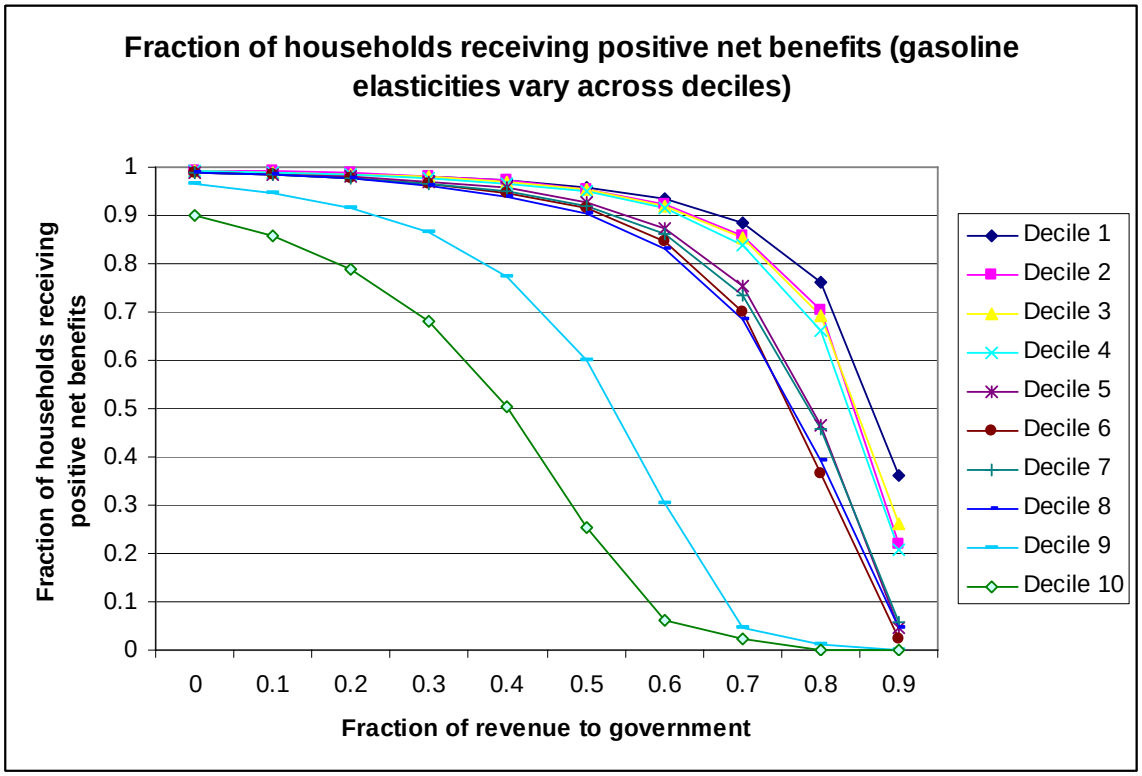

Figure 8. Fraction of households receiving positive net benefits by per capita income decile. Gasoline elasticities vary across deciles, as given in Table 1. Carbon price: $30/tCO2, 0% price escalation.

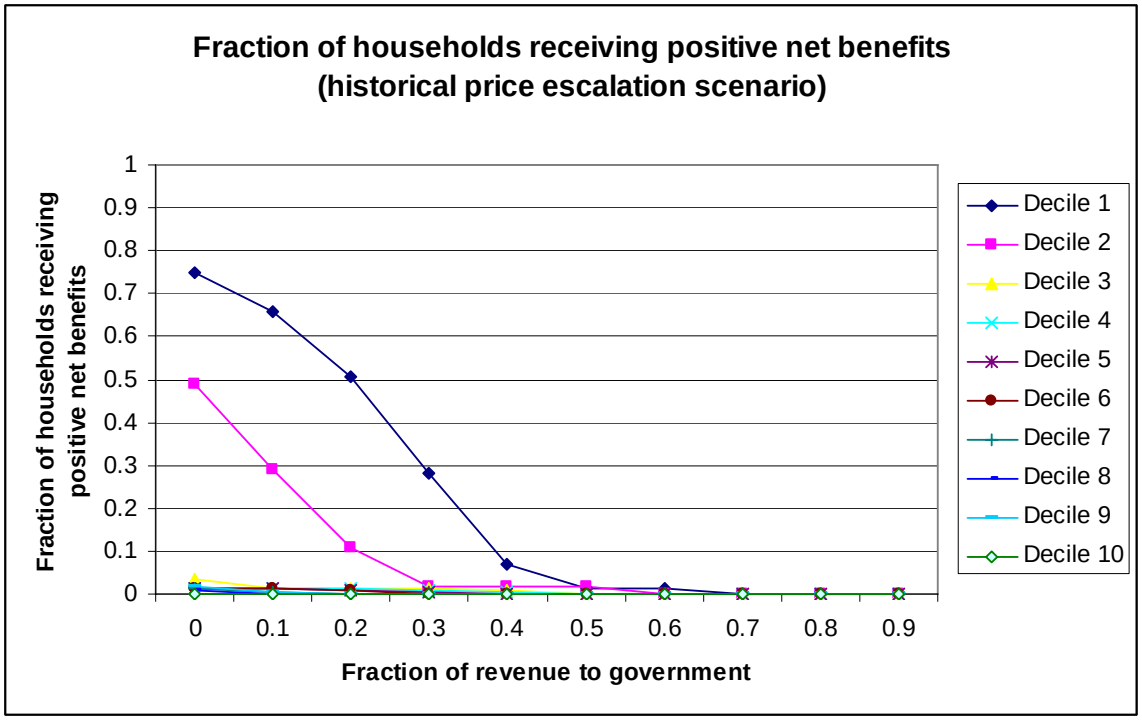

Figure 7. Fraction of households receiving positive net benefits by per capita income decile. Carbon price: $30/tCO2, 0% price escalation for electricity, 3% price escalation for gasoline, and 4% price escalation for natural gas.

Data Sources:

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Acknowledgements

Thanks to Mike Sandler for generating Figures 5 and 6.