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Abstract

This paper measures the incidence of a carbon tax on gasoline using current income and two measures of lifetime income to rank households. Our results suggest that carbon taxes on gasoline are more regressive when annual income is used as a measure of economic welfare than when lifetime income measures are used. In addition we find that the regional variation in the gasoline tax burden is likely to be modest varying by less than one-half of a percentage point with little fluctuation over the years of our analysis. These results carry through when we consider the incidence of the current state gasoline taxes, both across income deciles as well as across regions.

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I. Introduction

Gasoline is one of the major fuels consumed in the United States and the main product refined from crude oil. Consumption in 2007 was about 142 billion gallons, an average of about 390 million gallons per day and the equivalent of about 61% of all the energy used for transportation, 44% of all petroleum consumption, and 17% of total U.S. energy consumption.¹ About 47 barrels of gasoline are produced in U.S. refineries from every 100 barrels of oil refined to make numerous petroleum products. While gasoline is produced year-round, extra volumes are made and imported to meet higher demand in the summer. Gasoline is delivered from oil refineries mainly through pipelines to an extensive distribution chain serving about 167,500 retail gasoline stations in the United States.

Most gasoline is used in cars and light trucks. It also fuels boats, recreational vehicles, and farm, construction, and landscaping equipment. A major concern with the use of gasoline today is in the context of climate change. The use of gasoline in transportation results in carbon-dioxide (CO₂) emissions which have been increasing at a rapid pace since the 1990s. In 2007, total carbon dioxide emissions stood at 6,022 MMT, an increase of more than 17 percent since 1990. The vast majority of carbon dioxide emissions come from the combustion of fossil fuels such as petroleum, coal and natural gas, with petroleum accounting for nearly 43 percent of all emissions from these energy sources.²

The Energy Information Administration further provides a breakdown of energy use by end-use sectors. In 2007, the transportation sector was the largest source of emissions relative to the residential, commercial and industrial sectors, accounting for about 34 percent of all CO₂ emissions.³

In discussions over how best to address climate change issues, there are essentially two market-based approaches that are being considered, a carbon tax and a cap and trade system. In this paper, we focus on the effect of a carbon tax on gasoline to reduce carbon dioxide emissions, though our results essentially carry through for a cap and trade program as well.⁴ A carbon tax is essentially a market-based instrument that creates a cost to emissions by directly taxing the carbon content of fuels. In the case of gasoline, this is essentially a tax on petroleum.

¹ The rest is about 24 percent diesel, 8% jet fuel and 2% natural gas.

² "Emissions of Greenhouse Gases in the United States 2007" (EIA, 2008)

³ "Emissions of Greenhouse Gases in the United States 2007" (EIA, 2008)

⁴ For our paper on the distributional consequences of cap-and-trade, see Hassett, Mathur and Metcalf (2009), "The Consumer Burden of a Cap-and-Trade Program," AEI Working Paper#144

A consequence of a carbon tax (or a cap and trade program to cut emissions) is the subsequent rise in energy prices (as well as prices of energy intensive goods and services) which would be passed on from the firm to the consumers in the form of higher prices of gasoline and other commodities. Therefore a major concern with any such program is that the burden of the costs arising from such a policy will fall disproportionately on low income households. In other words, the policy will be regressive. For instance, a recent CBO paper (2007) estimates that the price increases resulting from a 15 percent cut in CO₂ emissions through a cap and trade program would cost the average household approximately \$1600 (in 2006 dollars) and about 3.3 percent of income for households in the bottom quintile of the population.⁵ In Hassett, Mathur and Metcalf (2009), we estimate that the cost of a carbon tax on the lowest decile of the population would be about 3.74 percent of income, over four times the cost on the highest income decile.

In this paper, we measure to what extent a carbon tax on gasoline is regressive in a lifetime income framework. Note that our analysis involves imposing a carbon tax on all fossil fuels (coal, petroleum and natural gas) and then assessing the price increases for all consumer goods that would occur as a result of the tax. While our detailed methodology for computing the price increases is discussed in our earlier paper, Hassett, Mathur and Metcalf (2009), we focus in this paper only on the price increase for gasoline, an essential transport fuel, and the burden of this price increase on households at different income levels.⁶ It is also worth noting that other externalities in addition to global warming may require differential taxation of energy sources. To the extent that current gasoline taxes are Pigovian with regard to other factors such as congestion, then it may be that gasoline taxes may continue to exist even after the imposition of a carbon tax.⁷ Accordingly, a separate analysis of the distributional impact of changes in the tax treatment of gasoline may be of some use to policymakers. Therefore, we present results for the incidence of current state gasoline taxes both across income deciles as well as regions.

Lifetime income measures are considered here since in several cases measures based on current or annual income may provide a misleading picture of actual household incomes and may overstate regressivity. We discuss this in detail in the section to follow. Further, to capture intertemporal patterns, we look at three different years, 1987, 1997, and 2003 to see how the incidence would change had a carbon tax been in effect in these three time periods.

⁵ CBO (2007)

⁶ Note that this experiment is different than simply raising the gasoline tax. Coal and natural gas are used (indirectly through electricity) in the production of gasoline. A carbon tax raises the price of these fuels while a gasoline tax would not (except to the extent that higher gasoline prices raise the price of coal and natural gas).

⁷ See Parry and Small (2005) for a discussion of why a portion of gasoline taxes may be considered Pigovian.

Our results suggest that in general, gasoline taxes (both carbon taxes as well as state taxes) appear more regressive when income is used as a measure of economic welfare than when consumption (current or lifetime) is used to measure incidence. Studying the intertemporal distribution, we find that between 1987 and 2003, gasoline taxes have become marginally more regressive when calculated as a fraction of income.⁸

Gasoline taxes are also likely to have uneven regional effects depending upon the use of transportation in different regions. We report the average gasoline tax paid per household across regions and find that the regional variation is relatively modest.

In the next section, we explore different methods used to measure incidence and motivate the lifetime measure of consumption employed in Bull et al.(1994). Section III details our data and methodology. Section IV presents results for the economic incidence of the tax. Section V concludes.

II. Measurement of Incidence

Tax incidence measures the ultimate impact of a tax on the welfare of members of society. The economic incidence of a tax may differ markedly from the statutory incidence due to price changes. For a carbon tax, the short run economic incidence is likely to differ markedly from the statutory incidence. While the statutory incidence of an upstream tax on gasoline may be on the refinery owner, the economic incidence is likely to be on final consumers as the tax is shifted forward to consumers in the form of higher prices. Measuring the incidence of a tax requires numerous assumptions and we begin the analysis by setting out our assumptions and methodology.

First, we must determine the appropriate unit of observation, which could be an individual or a household. For this study, we use the household as a unit. Second, we must choose the appropriate time frame of analysis. As we discussed in the introduction, the choice of the time frame for the analysis is extremely important. Early tax incidence analysis used current income as the base i.e. it compared the tax liability over a short period to income earned over that period. Following Friedman (1957) and the permanent income hypothesis, there was a realization that consumption decisions are made over a longer time horizon. Hence income should be measured as the present discounted value of lifetime earnings and inheritances. Failing to do so creates substantial measurement problems, particularly at the low end of the income distribution. For example, elderly people drawing down their savings in retirement will look poor when in fact, they may be

⁸ This refers only to the carbon tax induced burden of the gasoline tax since our analysis for state taxes refers only to 2003.

comfortably well off in a lifetime context. In other words, many low-income people are not necessarily poor.⁹ Caspersen and Metcalf (1993) report cross tabulations on income and consumption that show that a large fraction of households are in consumption deciles substantially above their income deciles.

Poterba (1989) follows the approach of using current consumption as a proxy for permanent income, since if consumer behavior is consistent with the permanent income hypothesis, then consumers would set current consumption proportional to permanent income. However, as we mentioned earlier, using data from the 1987 Consumer Expenditure Survey, Bull et al. (1994) show that consumption, instead of being smooth, closely tracks current income over the lifecycle. Moreover, energy consumption also shows a marked lifetime pattern.

This could be problematic for the incidence measurement. Suppose that as people grow old their energy consumption becomes a larger share of their total consumption, and suppose, as well, that over a lifetime the energy tax has a proportional incidence, then using current consumption to measure lifetime income, the energy tax would appear regressive.

As an alternative to current consumption, we use an adjusted lifetime measure for consumption that is intended to correct for long-run predictable swings in behavior. This measure was first employed in Bull et al. (1994). Ideally, a lifetime measure of incidence would be constructed by taking the ratio of lifetime energy taxes to lifetime earnings. Unfortunately, the lack of any sufficiently long longitudinal panel data set precludes such an approach.¹⁰

To proxy for lifetime consumption, we therefore use the age profile of people sampled in a particular year by the Consumer Expenditure Survey (a more detailed description of the calculation is presented in Bull et al. (1994)). In particular, we first classify people into different subsamples based on their educational level, since the pattern of income and consumption will be quite different for people with vastly different human capital stocks. For each sub sample, we then calculate a “typical” path of consumption through the averages for the age groups. For a given person in the sub sample we know the ratio of their current consumption to the average for their age group. We then compute their lifetime consumption by multiplying this ratio by the present value of the typical lifetime path.

⁹ Pechman (1985) realized that income data for the low income groups suffered from substantial income mismeasurement. Since then, the approach adopted by him and several others, including in this paper, is to discard the bottom half of the lowest decile i.e. to only look at the bottom 5-10 percent in the bottom decile, rather than the entire 10 percent.

¹⁰ The Panel Study of Income Dynamics (PSID) has good data on income but lacks detailed data on consumption which we would require. Other authors have used it to study the lifetime incidence of alcohol and cigarette taxes (Lyon and Schwab, 1995) and gasoline taxes (Chernick and Reschovsky, 1992).

For example, suppose an individual is a 35-year-old PhD whose energy consumption is 80 percent of the average for her age and education group. Let's say the present discounted value of total lifetime energy consumption for a person with a PhD is \$80,000. Then for this individual, the imputed lifetime energy consumption is \$64,000.

This procedure allows the age profile of each variable to be different. This flexibility helps to control for any confounding effects on the incidence calculation that predictable lifetime patterns of consumption behavior introduce in the cross-section. For example, suppose an alternative lifetime correction method was used where the share of consumption received at age 35 was used as the correction method. If 5 percent of consumption occurs on average at age 35 for a person in a given educational class, then that person's imputed lifetime consumption is 20 times their current consumption. Suppose that the lifetime incidence correction did not renormalize for each variable studied, but rather used the same correction factor for energy consumption. Then one would multiply current energy consumption by 20 to impute lifetime energy consumption. But if in reality, ten percent of energy consumption is spent on average at age 35 for a person in a given educational class, then that person's imputed lifetime energy consumption should be ten times their current energy consumption. Failing to renormalize the incidence correction for each of the variables studied in this example would incorrectly double lifetime energy consumption, biasing incidence results.

Using consumption as the base for measuring income also addresses the problem of transitory income shocks. For instance, a transitory negative shock to income may push the recipient into a lower income decile, while leaving their energy consumption unchanged. In this case, the ratio of energy taxes to income would be higher than it would be under a correct lifetime measure. Similarly, an upward shock to income may push the recipient into a higher income decile, while leaving their energy consumption unchanged. Here, the ratio of energy taxes to income is lower than it would be under a correct lifetime measure. The combination of these effects would lead an income-based lifetime incidence correction to be biased toward regressivity. When lifetime incidence is measured against consumption, however, such transitory effects are less likely to lead to bias, since energy consumption and total consumption are likely to react together to income shocks, if they react at all.

The final issue in an incidence analysis is the allocation of the tax burden between consumers and producers. Taxes on energy can be passed forward into higher consumer prices or backward in the form of lower returns to factors of supply (capital, labor, and resource owners). Our approach implicitly assumes that consumers bear the burden of the tax.

Considerable theoretical work has been carried out on the incidence of energy taxes in general, and of carbon taxes, in particular. A number of large-scale general equilibrium models (CGE models) suggest that in the short to medium run,

the burden of a carbon tax will be mostly passed forward into higher consumer prices (See, for example, Bovenberg and Goulder (2001) and Metcalf et al. (2008)).

This result falls out of the models because the demand for carbon intensive fossil fuels is relatively inelastic in the short run, while the supply, which is determined globally, is relatively elastic. In the longer run, as consumers find substitutes for fossil fuels, demand would likely be more elastic, and more of the burden would be shifted back to the producers. To the extent that owners of natural resources and capital have higher incomes, our results will then, tend to overstate the regressivity of a carbon tax.

While the identification of the full long run effects of a carbon tax requires a dynamic CGE model, our approach has certain advantages. Most CGE models rely on a number of assumptions relating to the functional form of the production and demand functions and the parameters defining the elasticity of substitution between factors of production as well as the relevant demand elasticities. Our approach, in contrast, is fairly transparent, and likely yields an accurate estimate of the short run impact of a tax, which, in itself, may be an upper bound on the regressivity of the tax.

Another advantage of our approach is that we are able to work with far more disaggregated data than the typical CGE model. In general, these models allow for a limited number of industrial sectors and consumption goods for ease of exposition and computability. However, we are able to work with more than 50 industry and commodity groups and more than 40 consumer goods. We can explore regional variation in the incidence of the tax as well.¹¹

Our analytic approach assumes no consumer behavioral response. Consumer substitution away from more carbon-intensive products will contribute to an erosion of the carbon tax base. The burden for consumers, however, will not be reduced as much as tax collections will fall. Firms incur costs to shift away from carbon-intensive inputs, costs that will be passed forward to consumers. Consumers also will engage in welfare-reducing activities as they shift their consumption activities to avoid paying the full carbon tax. Although the burden impacts reported here do not take account of the range of economic responses to the tax, the impacts provide a reasonable first approximation of the welfare impacts of a carbon tax.

¹¹ For those wishing to use our research as a jumping off point for more disaggregated CGE modeling, all data and programs are available at www.aei.org/carbontax.

III. Methodology and Data

For purposes of our analysis, we consider the effect of a carbon tax set at a rate of \$15 per metric ton of carbon dioxide assuming it were in effect in three different years: 1987, 1997, and 2003.¹² This allows us to see how changing consumption patterns over time influence the distribution of the tax. Because we are considering a carbon tax in different years, we deflate the tax rate to keep it constant in year 2005 dollars. Using the CPI deflator, the tax rates we consider are \$8.73 in 1987, \$12.33 in 1997, and \$14.13 in 2003. The incidence calculations require two types of data. First, to assess the impact of the carbon tax on industry prices and subsequently on prices of consumer goods, we use the Input-Output matrices provided by the U.S. Bureau of Economic Analysis. Second, once we have the predicted price increases for the consumer goods, we need to assess incidence at the household level. For this, we used data from the U.S. Bureau of Labor Statistics Consumer Expenditure Survey for various years. Note that the carbon tax is essentially applied to coal, petroleum and natural gas, and we obtain price increases for all consumer goods. These price increases were the focus of our previous paper, Hassett, Mathur and Metcalf (2009) and are reported here in Appendix Table 1. In this paper, we focus on the gasoline price increase as a result of the tax and estimate the tax burden on households. As the table shows, the estimated gasoline price increase is approximately 9.67% in 1987, 7.64% in 1997 and 7.73% in 2003. In this section, we discuss how we combined the two different datasets to calculate the incidence at the household level.

Energy related emissions of CO₂ were 4,821 million tons in 1987, 5,422 million tons in 1997, and 5,800 million tons in 2003. Given the tax rates and ignoring initial reductions in emissions, the tax would raise \$42.1 billion in 1987, \$66.9 billion in 1997, and \$82.0 billion in 2003.¹³

We assume the tax is levied on coal at the mine mouth, natural gas at the well head, and on petroleum products at the refinery. Imported fossil fuels are also subject to the tax. As noted above we assume in all cases that the tax is passed forward to consumers in the form of higher energy prices. Metcalf (2007) estimates that a tax of \$15 per metric ton of CO₂ applied to average fuel prices in 2005 would nearly double the price of coal, assuming the tax is fully passed forward. Petroleum products would increase in price by nearly 13 percent and natural gas by just under 7 percent. The tax is also passed on indirectly to other industries that use these energy sources as inputs.

The procedure for evaluating the effect of a carbon tax as it is passed through the economy is discussed in detail in Fullerton (1995) and Metcalf (1999). We provide a summary of the methodology in the Appendix. The starting point for the

¹² The effect of a different tax rate on consumer goods prices can be approximated by appropriately grossing up (or down) Appendix Table 1.

¹³ An analysis by the Energy Information Administration suggests that a \$15 tax on CO₂ would reduce emissions by about five percent in the short-run (see Energy Information Administration (2006)).

analysis is the use of Input-Output matrices available from the Bureau of Economic Analysis. In particular, we use the Summary Make and Use matrices from the I-O tables for 1987, 1997, and 2003. The Make matrix shows how much each industry makes of each commodity and the Use matrix shows how much of each commodity is used by each industry. Using these two matrices for each year, we derive an industry-by-industry transactions matrix which enables us to trace the use of inputs by one industry by all other industries. Various adding-up identities along with assumptions about production and trade allow the accounts to be manipulated to trace through the impact of price changes (and taxes) in one industry on the products of all other industries in the economy.

For each year, we cluster the industry groups provided in the I-O tables into 60 categories. For 2003, we separate out aggregate mining into two separate groups, mining and coal mining using the split provided in the 2002 benchmark I-O files. We do a similar split to break out electricity and natural gas from other utilities. This was not a problem for the 1987 and 1997 benchmark I-O files, where these splits already existed.

Once we obtained the effect of the tax on prices of consumer goods, we used data from the Consumer Expenditure Survey (CEX) to compute energy taxes paid by each household in the survey. The CEX contains data on household income and expenditures for numerous consumption goods. We combine commodities to work with 42 categories of personal consumption items. Having computed the average price increase for each industry using the Input-Output tables from the Bureau of Economic Analysis, we translate those price increases into corresponding price increases for these consumer items. This is also discussed in detail in the Appendix, and we provide tables showing the recorded price increases in each year for each consumer item as a result of the tax.

IV. Results

IV.A. Carbon Tax Burden of Gasoline

Table 1 presents our results for incidence using annual income as our measure of economic welfare. We have grouped households by annual income and sorted the households into ten income deciles from the poorest ten percent of the population to the richest ten percent. Confirming conventional wisdom, the gasoline tax is quite regressive when measured relative to current income for all three years. The burden in the lowest decile in 1997 and 2003, for example, is over four times the burden in the top decile when measured as a fraction of annual income.

Table 1A shows that the overall burden distribution changes marginally across the sixteen year period when annual income is used to rank households. The burden has increased marginally in the bottom decile but declined for all other

deciles between 1987 and 2003. For the top income household, the burden of the tax falls from about 0.23 percent of income to about 0.15 percent of income. On average, taxes paid as a fraction of income have declined over the sixteen year period. This in part reflects the greater energy efficiency of the economy. Aggregate energy intensity in the United States (measured as energy consumption relative to real GDP) fell by 23 percent between 1987 and 2003.¹⁴

The overall picture that emerges from Table 1A is that had a carbon tax been in effect in 1987, 1997, and 2003, the gasoline burden of the tax would have looked quite regressive using annual income as a measure of household well being. Using an annual income approach, the regressivity is increasing slightly over this time period.

As an interesting aside, we show the total incidence of the carbon tax across income deciles in 2003 in Table 1B. To study whether there are any qualitative or quantitative differences in the gasoline portion of the tax relative to the overall carbon tax, we present Figure 1. Figure 1 essentially scales the burden for each income group by the average across all income groups. For instance, the average carbon tax across all income groups is about 1.88 percent. Therefore, for the bottom decile (and all other deciles) we plot the ratio of their burden scaled by 1.88. This should show whether the gasoline burden is relatively higher or lower than the carbon tax burden for each income group. One interesting pattern that emerges is that the relative carbon tax burden seems to be higher than the average and the gasoline burden lower than the average for the bottom income deciles. The picture is reversed at the top where the gasoline burden is higher and the carbon tax burden is lower than the average for all incomes. Therefore, richer households pay a larger fraction of the gasoline tax than they pay of the total carbon tax.

Turning to the measures of incidence using consumption as a proxy for lifetime income, the results change dramatically. Table 2 shows the distribution of the gasoline tax in the three years when households are sorted by current consumption. Now we find that the total tax is less regressive, with the ratio of average taxes paid by the bottom and the top varying from about 1.5 to 2.0 across the three years. The primary force driving this result is the tendency for consumption to be more evenly distributed than income, especially when one looks at the lower brackets.¹⁵

This result was similarly reported in Bull, Hassett, and Metcalf (1994) who found that the lifetime calculation changed the results because the proportion of energy in total consumption (or ratio of energy consumption to income) varied significantly over the life cycle, with the elderly low income individuals, in particular, having relatively large current energy consumption.

¹⁴ See Metcalf (2008) for an analysis of the determinants of changes in energy intensity.

¹⁵ This relationship is well known in the literature. Krueger and Perri (2002) for example, document this fact.

Turning to the measures of average tax burdens using lifetime consumption (Table 3), we see that this correction flattens the distribution even more. The incidence of the total tax is nearly proportional, with the ratio of burden in the lowest to top decile varying from 1.2 to 1.3 across the three years.

In summary, incidence calculations based upon annual income imply much steeper regressivity than do calculations based upon lifetime income measures. Moreover, the inter-temporal variation in incidence is reduced substantially using measures based on lifetime consumption rather than those using income. We suspect this occurs in large part because transitory income shocks exacerbate the apparent regressivity of the tax when measured against income.

We next turn to a regional analysis of the incidence of the tax. Policy makers are often concerned that a tax might disproportionately burden one region or part of the country at the expense of another. To measure the geographic burden of the tax, we group households by region and measure their average tax rate using weighted averages of the tax burdens.¹⁶ Results are shown in Table 4.¹⁷ Variation in the average tax rates is modest. The maximum difference in the average rate across regions is close to 0.30 percentage points in 1987 and 0.20 percentage points in 1997. A closer look at the data reveals that the high regional burden for the Mountain and Pacific regions for instance may be due to the relatively higher need for transportation to travel long distances, relative to other regions.

IV.B. State Tax Burden of Gasoline

To calculate the incidence of current state taxes on gasoline, we collected information on gasoline prices (inclusive of tax) and taxes for the most recent year of our analysis, 2003. Information on these variables for earlier years was missing for several states for 1997 and was unavailable for 1987. However, the results for 2003 should give a clear picture of how environmental taxes on gasoline would affect households across income levels and regions. We obtained data on gasoline prices and taxes from the U.S. Department of Energy as well as the International Fuel Tax Association.

The average gas tax across all regions (unweighted) was approximately 20 cents per gallon in 2003, and the average gasoline price was approximately \$1.51 per gallon. From this we calculated the proportionate increase in price

¹⁶ As with the distributional tables across income, we drop the bottom five percent of the income distribution from the analysis before carrying out the regional analysis.

¹⁷ The states in each region are as follows: New England: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island; Midatlantic: New Jersey, New York, Pennsylvania; South Atlantic: West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, District of Columbia, Maryland, Delaware; East South Central: Kentucky, Tennessee, Missouri, Alabama, Mississippi; East North Central: Wisconsin, Illinois, Michigan, Indiana, Ohio; West North Central: North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa; West South Central: Texas, Oklahoma, Arkansas, Louisiana; Mountain: Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico; Pacific: California, Oregon, Washington, Alaska, Hawaii.

induced by the gas tax by taking the ratio of the gasoline tax in each region to the gasoline price in that region. These calculations are shown in Appendix Table 2. The average proportionate increase in price due to the gasoline tax was approximately 13 percent across regions. We then applied these price increases to the expenditure data in the CEX to calculate the incidence.

Tables 5 and 6 show the results of our calculations. The current state taxes on gasoline are marginally less regressive when measured as a fraction of income, than carbon taxes on gasoline would be. The burden on the lower income groups is nearly 4 times that on the top. The picture improves as we use current consumption and lifetime consumption (income) to measure the incidence. With lifetime incomes, the burden on the lowest decile is about 0.33 percent of income and that on the top is about 0.29 percent of income. Turning to the regional incidence, the burden is fairly modest and evenly distributed averaging about 0.56 percent of income.

V. Conclusion

This paper measures the incidence of carbon taxes on gasoline using a lifetime incidence framework. We analyze the household burden of a \$15 per metric ton tax on CO₂ in constant 2005 dollars at three different points in time. In particular, the focus is on the impact of such a tax on gasoline prices and the subsequent burden on consumers. The burden is measured ranking households by current income, current consumption and lifetime consumption as the basis for the incidence measures. The methodology involves first working with the economy-wide Input-Output tables from the Bureau of Economic Analysis to assess how the \$15 tax would affect the industrial sector, in particular the prices of energy goods and other industrial goods in which these energy goods serve as inputs. We then use this information to calculate the increase in prices of consumer goods as a result of the tax. Once we obtain the price increase in 42 categories of consumer goods, we calculate the burden of the tax on households using consumption data from the Consumer Expenditure Survey.

As the paper discusses, energy taxes have different incidence effects across the lifecycle. Therefore, it is important to measure the burden of taxes in terms of lifetime incidence, not just their burden in a given year. To take account of the lifetime incidence, we use two proxies. First we use current consumption following work of Poterba (1989). Second we use lifetime-corrected consumption introduced in Bull et al. (1994) and explained in detail in the Appendix to that paper.

Our results suggest that when the total lifetime effect of a carbon tax is taken into account, the regressivity of the tax decreases. This is particularly true when we use lifetime-corrected consumption to rank households, rather than current consumption. In addition to looking at the economic incidence of the tax, we studied the incidence of the tax across regions.

These data show that the variation across regions is fairly modest with marginally higher values driven by the relatively higher use of gasoline in the Mountain and Pacific regions.

These results carry through to our analysis of current state taxes on gasoline consumption. The tax is fairly regressive when using current income to measure incidence, but is less regressive using lifetime income measures. Further, the regional burden of the tax is fairly evenly distributed.

References

- Armington, Paul S. (1969). "A Theory of Demand for Products Distinguished by Place of Production." International Monetary Fund, Staff Paper # 16:159-176.
- Bovenberg, A. Lans and Lawrence Goulder (2001). "Neutralizing the Adverse Industry Impacts of CO₂ Abatement Policies: What Does It Cost?." In C. Carraro and G. E. Metcalf, eds., *Distributional and Behavioral Effects of Environmental Policy*. Chicago: University of Chicago Press, pp. 45-85.
- Boyd, R. and N.D. Uri (1991), "The Impact of a Broad based Energy Tax on the U.S. Economy." *Energy Economics*, 13(4): 258-273
- Bull, Nicholas, Kevin A. Hassett, and Gilbert E. Metcalf (1994). "Who Pays Broad-Based Energy Taxes? Computing Lifetime and Regional Incidence." *The Energy Journal*, 15(3): 145-164.
- Burtraw, Dallas, Alan Krupnick, Karen Palmer, Anthony Paul, Michael Toman, and Cary Bloyd (YEAR). "Ancillary Benefits of Reduced Air Pollution in the U.S. from Moderate Greenhouse Gas Mitigation policies in the Electricity Sector." *Journal of Environmental Economics and Management* 45(3)650-673.
- CBO (2007), "Trade-Offs in Allocating Allowances for CO₂ Emissions"
http://www.heartland.org/custom/semod_policybot/pdf/21340.pdf
- Caspersen, E. and Gilbert Metcalf (1993), "Is a Value Added Tax Progressive? Annual Versus Lifetime Measures." *National Tax Journal*. 47(ISSUE): 731-746.
- Chernick, H. and A. Reschovsky (1992). "Is the Gasoline Tax Regressive?," Institute for Research on Poverty, Discussion Paper, 980-92
- Energy Information Administration (2006). "Emissions of Greenhouse Gases in the United States 2005." Washington DC, EIA
- Energy Information Administration (2006). "Energy Market Impacts of Alternative Greenhouse Gas Intensity Reduction Goals." Washington DC, EIA
- Friedman, M.A. (1957), *A Theory of the Consumption Function*. Princeton: Princeton University Press.
- Fullerton, Don and Gilbert E. Metcalf (1998), "Environmental Taxes and the Double Dividend Hypothesis: Did You Really Expect Something for Nothing?," *Chicago-Kent Law Review*. 73(1): 221-256.
- Fullerton, Don (1995). "Why Have Separate Environmental Taxes?." NBER, Working paper # 5380.
- Goulder, L.H. (1992). "Carbon Tax Design and U.S. Industry Performance." *Tax Policy and the Economy* 6(ISSUE):59-104.
- Hannon, B. (1982). "Analysis of the Energy Cost of Economic Activities: 1963 to 2000." *Energy Systems Policy* 6(3):249-278.
- Hannon, B., Richard G. Stein, B. Z. Segal, and Diane Serber (1978). "Energy and Labor in the Construction Sector." *Science* 202 (204):37-47
- Hassett, Kevin A., Aparna Mathur and Gilbert E. Metcalf (2009), "The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis," *The Energy Journal*, Vol.30, No.2.
- Herendeen, R.A., C. Ford and B. Hannon (1981). "Energy Cost of Living, 1972-1973." *Energy* 6(12):1433-1450.
- Hudson, E.A. and D.W. Jorgenson (1974). "U.S. Energy Policy and Economic Growth, 1975-2000." *Bell Journal of Economics* 5(0): 461-514.
- Intergovernmental Panel on Climate Change (2007). "Contribution of Working Group I to the Fourth Assessment Report." Geneva Switzerland: IPCC.
- Jorgenson, D.W. and P.J. Wilcoxon (1992). "Reducing U.S. Carbon Dioxide Emissions: An Assessment of Different Instruments." Harvard Institute of Economic Research, Discussion paper # 1590.
- Krueger, Dirk and Perri, Fabrizio (2002). "Does Income Inequality Lead to Consumption Inequality? Evidence and Theory." NBER, Working paper # 9202.
- Leontief, W. (1986). *Input-Output Economics*, 2nd Edition. New York: Oxford University Press. pp.XX-XX.
- Lyon, A. and R. Schwab (1995). "Consumption Taxes in a Life-Cycle Framework: Are Sin Taxes Regressive?," *Review of Economics and Statistics*, 77(3):389-406.
- Metcalf, Gilbert E. (1999). "A Distributional Analysis of Green Tax Reforms," *National Tax Journal* 52(4): 655-682.
- Metcalf, Gilbert E. (2005). "Tax Reform and Environmental Taxation," NBER, Working paper # 11665.
- Metcalf, Gilbert E. (2007). "A Proposal for a U.S. Carbon Tax Swap: An Equitable Tax Reform to Address Global Climate Change," *The Hamilton Project, Brookings Institution*. October.
- Metcalf, Gilbert E (2008). "An Empirical Analysis of Energy Intensity and Its Determinants at the State Level," *The Energy Journal* 29(3)
- Metcalf, Gilbert E.; Sergey Paltsev; John M. Reilly; Henry D. Jacoby and Jennifer Holak (2008). "Analysis of U.S. Greenhouse Gas Tax Proposals," MIT Joint Program on the Science and Policy of Global Change, Report # 160.

- Musgrave, R., K. Case and H. Leonard (1974). "The Distribution of Fiscal Burdens and Benefits." *Public Finance Quarterly* 2: 259-311.
- Paltsev, Sergey; John M. Reilly; Henry D. Jacoby; Angelo C. Gurgel; Gilbert E. Metcalf; Andrei P. Sokolov and Jennifer F. Holak (2007). "Assessment of U.S. Cap-and-Trade Proposals," MIT Joint Program on the Science and Policy of Global Change, Report # 146.
- Parry I W H and Small K A 2005. Does Britain or the United States have the right gasoline tax? *American Economic Review*, Vol. 95, No. 4, pp. 1276-1289.
- Pearce, David (1991). "The Role of Carbon Taxes in Adjusting to Global Warming." *The Economic Journal* 101(ISSUE): 938-948.
- Pechman, J. A. (1989). "Who Paid the Taxes, 1966-1985?," Washington, DC: The Brookings Institution.
- Poterba, James (1989), "Lifetime Incidence and the Distributional Burden of Excise Taxes," *The American Economic Review* 79(2): 325-330.
- Stolberg, Sheryl Gay (2007). "Bush Proposes Goal to Reduce Greenhouse Gas Emissions." *New York Times*, June 1, 2007.
- Tullock, Gordon (1967). "Excess Benefit." *Water Resources Research* 3(2):643-644.

Appendix

1. Using the Input-Output Accounts¹⁸

The Input-Output accounts trace through the production of commodities by industries and the use of those commodities by industries. The Bureau of Economic Analysis provides two kinds of matrices that help us to track such transactions through the economy. The Make-matrix, M_{IXC} , shows how much each industry makes of each commodity, and the Use-matrix, U_{CXI} , shows how much of each commodity is used by each industry. Combining these two, we can derive the industry-by-industry transactions matrix by dividing each entry of M_{IXC} by its column sum and multiplying the resulting matrix by the use matrix, U_{CXI} . Using the resulting matrix, it is possible to trace the use of inputs by one industry by all other industries. Further, it is also possible to trace through the impact of price changes in one industry on the products of all other industries in the economy. Below we detail some of the steps involved.

Tracing price changes through the economy on the basis of Input-Output accounts dates back to work by Leontief (1986). The model makes a number of important assumptions, the most important of which are (1) goods are produced and sold in a perfectly competitive environment such that all factor price increases are passed forward to consumers, (2) domestic and foreign goods are sufficiently different so that the price of domestic goods can adjust following changes in factor prices (Armington, 1969) and (3) input coefficients (the amount of industry i used in the production of industry j) are constant. Thus, input substitution is not allowed as factor prices change. This last assumption means that price responses are only approximate as they don't allow for product mix changes as relative prices change. In effect, the Input-Output accounts can be used to trace first-order price effects through the economy.

Two sets of equations define the basic Input-Output accounts. The first set relates the demand for goods from an industry to the value of output from that industry:

¹⁸ This section is based on based on Fullerton (1995), and Metcalf (1999).

$$\begin{aligned}
x_{11}p_1 + x_{12}p_1 + \dots + x_{1N}p_1 + d_1p_1 &= x_1p_1 \\
x_{21}p_2 + x_{22}p_2 + \dots + x_{2N}p_2 + d_2p_2 &= x_2p_2 \\
\cdot & \\
\cdot & \\
\cdot & \\
x_{N1}p_N + x_{N2}p_N + \dots + x_{NN}p_N + d_Np_N &= x_Np_N
\end{aligned}
\tag{1}$$

Where x_{ij} is the quantity of the output from industry i used by industry j , p_i is the unit price of product i , d_i is the final demand for output i and x_i is the total output of industry i . These N equations simply say that the value of output from each industry must equal the sum of the value of output used by other industries (intermediate inputs) plus final demand. Without loss of generality, we can choose units for each of the goods so that all prices equal 1. This will be convenient as the expenditure data in the Input-Output accounts can then be used to measure quantities prior to any taxes that we impose.

The second set of equations relates the value of all inputs and value added to the value of output:

$$\begin{aligned}
x_{11}p_1 + x_{21}p_2 + \dots + x_{N1}p_N + v_1 &= x_1p_1 \\
x_{12}p_1 + x_{22}p_2 + \dots + x_{N2}p_N + v_2 &= x_2p_2 \\
\cdot & \\
\cdot & \\
\cdot & \\
x_{1N}p_1 + x_{2N}p_2 + \dots + x_{NN}p_N + v_N &= x_Np_N
\end{aligned}
\tag{2}$$

Where v_i is value added in industry i . Define $a_{ij}=x_{ij}/x_j$, the input of product i as a fraction of the total output of industry j . The system [2] can be written as

$$\begin{aligned}
(1 - a_{11})p_1 - a_{21}p_2 - \dots - a_{N1}p_N &= v_1 / x_1 \\
-a_{12}p_1 + (1 - a_{22})p_2 - \dots - a_{N2}p_N &= v_2 / x_2 \\
\cdot & \\
\cdot & \\
\cdot & \\
-a_{1N}p_1 - a_{2N}p_2 - \dots - a_{NN}p_N &= v_N / x_N
\end{aligned}
\tag{3}$$

These equations can be expressed in matrix notation as

$$(I - A')P_1 = V \tag{3A}$$

Where I is an $N \times N$ identity matrix, A is an $N \times N$ matrix with elements a_{ij} , P_I is an $N \times 1$ vector of industry prices, p_i , and V is the $N \times 1$ vector whose i th element is v_i/x_i . Assuming that $(I - A')$ is nonsingular, this system can be solved for the price vector:

$$P_I = (I - A')^{-1}V \quad [4]$$

With the unit convention chosen above, P_I will be a vector of ones. However, we can add taxes to the system in which case the price vector will now differ from a vector of ones as intermediate goods taxes get transmitted through the system. Specifically, let t_{ij} be a unit tax on the use of product i by industry j . In this case, the value of goods used in production (grossed up by their tax) plus value added now equals the value of output:

$$\begin{aligned} x_{11}p_1(1+t_{11}) + x_{21}p_2(1+t_{21}) + \dots + x_{N1}p_N(1+t_{N1}) + v_1 &= x_1p_1 \\ x_{12}p_1(1+t_{12}) + x_{22}p_2(1+t_{22}) + \dots + x_{N2}p_N(1+t_{N2}) + v_2 &= x_2p_2 \\ \cdot & \\ \cdot & \\ \cdot & \\ x_{1N}p_1(1+t_{1N}) + x_{2N}p_2(1+t_{2N}) + \dots + x_{NN}p_N(1+t_{NN}) + v_N &= x_Np_N \end{aligned} \quad [5]$$

This set of equations can be manipulated in a similar fashion to the equations above to solve for the price vector:

$$P_I = (I - B')^{-1}V \quad [6]$$

where B is an $N \times N$ matrix with elements $(I+t_{ij})a_{ij}$.

We regrouped industries in the Input-Output Accounts into 60 industry groupings. For the years 2003 and 1997, a separate industry for coal mining was created out of the industry group including all mining. This was done using the split between mining and coal provided in the 1994 benchmark Input-Output accounts. For the year 1987, we used the benchmark Input-Output table which already has coal mining as a separate industry.

Tax rates are computed as the ratio of the required tax revenue from the industry divided by the value of output from that industry. For the carbon tax, the tax rate on coal equals

$$t_{4.} = \frac{\alpha_C R}{\sum_{j=1}^N x_{4j}}$$

where R is the total revenue from the carbon tax and α_c the share of the tax collected from the coal industry (industry 4). Based on carbon emissions in 2003, the share of the tax falling on the coal industry is 0.361. The taxes for oil and natural gas are computed in a similar manner.

Equation [6] indicates how price changes in response to the industry level taxes. We next have to allocate the price responses to consumer goods. The Input-Output accounts provide this information by means of the Personal Consumption Expenditures (PCE) Bridge tables for each year that show how much of each consumer item is produced in each industry. Let Z be an $N \times M$ matrix, where z_{ij} represents the proportion of consumer good j ($j=1, \dots, M$) derived from industry i ($i=1, \dots, N$). The columns of Z sum to 1. An example of the Z -matrix is provided in Appendix Table 2 for a subset of consumer goods. If P_c is a vector of consumer goods prices (an $M \times 1$ vector), then

$$P_c = Z'P_1.$$

The consumer prices derived using this methodology are then applied to consumption data in the CEX. The consumer prices derived using this methodology are provided in Appendix Table 1 for all three years.

2. A Lifetime-Corrected Incidence Measure

This section presents our derivation of the lifetime-corrected incidence measure. The starting point is the assumption that the expected consumption and income streams for people with vastly different human capital stocks are likely to be very different. Hence we first classify people into different sub samples based on their education levels. Within each education class, we then calculate average consumption for people in different age groups. The “typical” path of lifetime consumption can therefore be proxied by the average consumption for each age group within an education class, starting from the youngest to the oldest. Using this path of lifetime consumption, we then derive the present value of lifetime consumption for each education class.

Once we have the present value of lifetime consumption for each education class, we can use this to derive the lifetime consumption for any individual in the sample. For instance, suppose that an individual is a 35 year old Ph.D whose current consumption is 80 percent of the average for her age and education group. If the present value of lifetime consumption for a Ph.D is \$1 million, then her lifetime consumption is calculated as 80 percent of \$1 million or \$800,000. We can use a similar technique to derive lifetime measures of income, direct and indirect taxes for every individual in the sample. Below, we present the mathematical derivation of our lifetime measures.

For each observation in the CEX sample, we know the age and education level. We first assign each observation to a particular education group, e , where e goes from 1 to 11 (1=no schooling, 11=doctorate). Then within the education group, we calculate the average of consumption for different age groups, a . We include all individuals above 20 years of age. Let $\bar{C}^a(e)$ be the average consumption for all individuals in education group e and age a . (We can similarly define $\bar{Y}^a(e)$, $\bar{D}^a(e)$ and $\bar{I}^a(e)$, respectively for income, direct taxes and indirect taxes).

Let $\hat{C}(e)$ denote the present value of lifetime consumption for all individuals in the same education group. This is derived as the present discounted value of average consumption across all age groups within the same education group, as shown below.

$$\hat{C}(e) = \sum_{a=a_0}^A \left(\frac{1}{1+r} \right)^{(a-a_0)} \bar{C}^a(e) \text{ where } a_0=20, A \text{ is the highest age group and } r=5\%.$$

To compute the lifetime consumption for each individual, we take the ratio of their actual consumption, $C_i^a(e)$, to the average for their age and education group, and then multiply this ratio by the computed present value of lifetime consumption for their education class. Therefore,

$$\hat{C}_i^a(e) = \frac{C_i^a(e)}{\bar{C}^a(e)} \hat{C}(e)$$

We can compute similar measures for income ($\hat{Y}_i^a(e)$), direct ($\hat{D}_i^a(e)$) and indirect taxes ($\hat{I}_i^a(e)$).

Finally, we can compute the lifetime-corrected incidence of direct carbon taxes as a proportion of consumption as follows;

$$\lambda_{D_i}^a(e) = \frac{\hat{D}_i^a(e)}{\hat{C}_i^a(e)}$$

Similar measures can be computed for the lifetime-corrected incidence of indirect and total carbon taxes.

To compute the incidence across income or consumption groups, we can repartition the sample into deciles of lifetime income or consumption and then take the average across each decile of the incidence for members of that decile.

Appendix Table 1: Consumer Goods Price Increases as a Result of the Carbon Tax

	CEX categories	1987	1997	2003
1	food at home	0.57%	0.65%	0.70%
2	food at restaurants	0.47%	0.56%	0.58%
3	food at work	0.61%	0.75%	0.86%
4	tobacco	0.54%	0.60%	0.67%
5	alcohol at home*	0.47%	0.56%	0.58%
6	alcohol on premises*	0.47%	0.56%	0.58%
7	clothes	0.53%	0.52%	0.40%
8	clothing services	0.75%	0.38%	0.41%
9	jewelry	0.54%	0.45%	0.43%
10	toiletries	0.87%	0.85%	0.72%
11	health and beauty	0.70%	0.38%	0.42%
12	tenant occupied non-farm dwellings	0.14%	0.21%	0.31%
13	other dwelling rentals	0.65%	0.41%	0.42%
14	furnishings	0.64%	0.62%	0.55%
15	household supplies	0.78%	0.77%	0.71%
16	electricity	10.18%	13.15%	12.55%
17	natural gas	16.87%	16.61%	12.28%
18	water	1.20%	0.73%	0.63%
19	home heating oil	7.67%	10.33%	9.56%
20	telephone	0.20%	0.21%	0.26%
21	domestic services	0.70%	0.41%	0.49%
22	health	0.44%	0.37%	0.39%
23	business services	0.14%	0.21%	0.50%
24	life insurance	0.28%	0.21%	0.31%
25	automobile purchases	0.67%	0.59%	0.90%
26	automobile parts	0.70%	0.64%	0.65%
27	automobile services	0.75%	0.34%	0.40%
28	gasoline	9.67%	7.64%	7.73%
29	tolls	0.65%	0.30%	0.64%
30	automobile insurance	0.14%	0.21%	0.31%
31	mass transit	0.95%	0.70%	0.90%
32	other transit	0.96%	0.50%	0.62%
33	air transportation	1.93%	1.82%	1.86%
34	books	0.43%	0.32%	0.34%
35	magazines	0.45%	0.31%	0.49%
36	recreation and sports equipment	0.52%	0.56%	0.42%
37	other recreation services	0.60%	0.36%	0.51%
38	gambling	0.39%	0.28%	0.31%
39	higher education	0.56%	0.27%	0.30%
40	nursery, primary, and secondary education	0.60%	0.33%	0.34%
41	other education services	0.62%	0.26%	0.30%
42	charity	0.74%	0.43%	0.41%

Notes:

1. Values for alcohol have been set equal to the value for food at restaurants in each year
2. These price increases are calculated using a \$15 per metric ton carbon dioxide tax

Appendix Table 2: Regional Gasoline Taxes as a Fraction of Regional Gasoline Prices (2003)

	Regions	Tax Inclusive Price (cents)	Tax(cents)	Tax as a Share of Final Price
1	New England	155	22	0.143
2	Mid Atlantic	150	22	0.144
3	South Atlantic	141	16	0.117
4	East South Central	143	17	0.122
5	East North Central	151	24	0.161
6	West North Central	148	20	0.134
7	West South Central	142	20	0.138
8	Mountain	158	21	0.133
9	Pacific	168	20	0.116

Table 1A: Distribution of Carbon Tax Burden on Gasoline: Annual Income

Decile	1987	1997	2003
Bottom	0.69	0.66	0.70
Second	0.57	0.51	0.49
Third	0.58	0.56	0.47
Fourth	0.62	0.47	0.45
Fifth	0.48	0.41	0.40
Sixth	0.44	0.35	0.35
Seventh	0.44	0.32	0.29
Eighth	0.36	0.30	0.26
Ninth	0.31	0.23	0.22
Top	0.23	0.16	0.14

Source: Authors' calculations. The table reports the within decile average ratio of gasoline tax burdens to income.

Table 1B: Distribution of Total Carbon Tax Burden 2003: Annual Income

Decile	2003
Bottom	3.74
Second	3.06
Third	2.36
Fourth	2.06
Fifth	1.76
Sixth	1.53
Seventh	1.3
Eighth	1.23
Ninth	1.01
Top	0.81

Source: Authors' calculations. The table reports the within decile average ratio of gasoline tax burdens to income.

Figure 1: Relative Burdens of the Carbon Tax and the Gasoline Portion of the Carbon Tax Across income Deciles.

2003

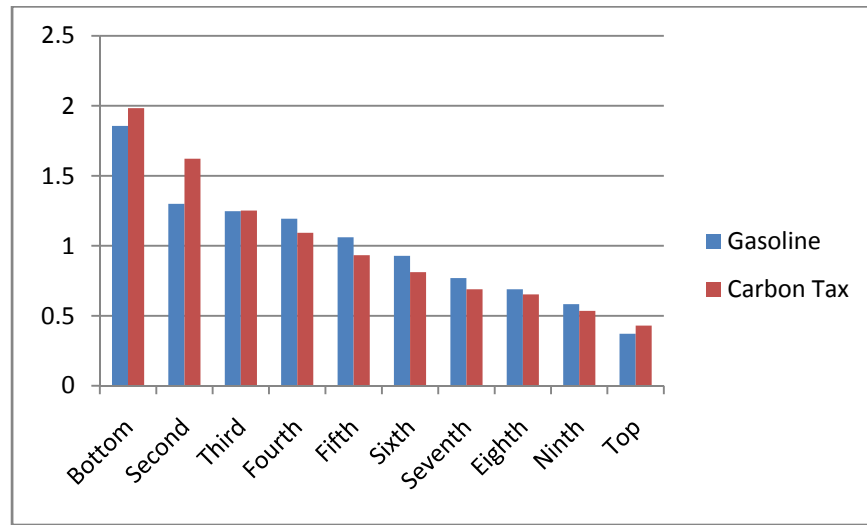


Table 2: Distribution of Carbon Tax Burden on Gasoline: Current Consumption

Decile	1987	1997	2003
Bottom	0.38	0.29	0.30
Second	0.41	0.29	0.31
Third	0.40	0.32	0.29
Fourth	0.42	0.32	0.32
Fifth	0.41	0.29	0.28
Sixth	0.40	0.29	0.25
Seventh	0.35	0.27	0.26
Eighth	0.34	0.24	0.23
Ninth	0.32	0.21	0.20
Top	0.25	0.17	0.15

Source: Authors' calculations. The table reports the within decile average ratio of carbon tax burdens to current consumption.

Table 3: Distribution of Carbon Tax Burden on Gasoline: Lifetime Consumption

Decile	1987	1997	2003
Bottom	0.40	0.27	0.21
Second	0.38	0.28	0.24
Third	0.36	0.28	0.29
Fourth	0.39	0.29	0.23
Fifth	0.42	0.29	0.30
Sixth	0.40	0.30	0.26
Seventh	0.40	0.30	0.25
Eighth	0.42	0.32	0.23
Ninth	0.34	0.27	0.20
Top	0.30	0.22	0.17

Source: Authors' calculations. The table reports the within decile average ratio of carbon tax burdens to lifetime consumption.

Table 4: Distribution of Carbon Tax Burden on Gasoline: Annual Income

Region	1987	1997	2003
New England	0.30	0.29	0.27
Mid Atlantic	0.35	0.29	0.25
South Atlantic	0.46	0.37	0.31
East South Central	0.45	0.44	0.38
East North Central	0.42	0.31	0.30
West North Central	0.49	0.32	0.30
West South Central	0.51	0.46	0.36
Mountain	0.46	0.40	0.40
Pacific	0.43	0.33	0.39

Source: Authors' calculations. The table reports the within region average ratio of carbon tax burdens to income. Regions are defined in footnote 18.

Table 5: Distribution of Burden of State Gasoline Taxes: 2003

Decile	Annual Income	Current Consumption	Lifetime Consumption
Bottom	0.92	0.37	0.33
Second	0.77	0.50	0.36
Third	0.74	0.48	0.42
Fourth	0.74	0.53	0.38
Fifth	0.65	0.47	0.50
Sixth	0.57	0.43	0.45
Seventh	0.50	0.42	0.46
Eighth	0.43	0.39	0.40
Ninth	0.37	0.35	0.34
Top	0.25	0.28	0.29

Source: Authors' calculations. The table reports the within decile average ratio of gasoline tax burdens to income.

Table 6: Regional Distribution of Burden of State Gasoline Taxes: 2003

Region	Annual Income
New England	0.51
Mid Atlantic	0.48
South Atlantic	0.47
East South Central	0.61
East North Central	0.63
West North Central	0.52
West South Central	0.65
Mountain	0.70
Pacific	0.60

Source: Authors' calculations. The table reports the within region average ratio of carbon tax burdens to income. Regions are defined in footnote 18.