

# **The Cost of Reducing Gasoline Consumption**

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## **I. Introduction**

High nominal gas prices, new awareness of threats to national security, and growing concern about global warming have reignited discussion of ways to reduce gasoline consumption in the United States. Debate centers on changing two policies already in place— the federal gasoline tax and Corporate Average Fuel Economy (CAFE) standards.<sup>1</sup> Two influential recent reports find that increasing the gas tax would attain a given reduction in gas consumption at lower cost than by attaining the same reduction by making CAFE standards more stringent (CBO 2003 and NRC 2002). The gas tax has this advantage because it encourages not just increases in fuel efficiency, but also reductions in miles driven. In contrast, CAFE standards actually encourage more driving, because increases in fuel efficiency reduce the cost of per mile driven.

We examine the cost of the gas tax relative to a CAFE standard, and take into account interactions with pre-existing tax distortions in the economy—an issue that has attracted substantial attention in other contexts, but that to our knowledge has not been studied in the context of the CAFE standard.<sup>2</sup> These tax interactions reduce the cost of the gas tax, but increase the cost of CAFE, thus substantially expanding the cost advantage enjoyed by the gas tax. This difference does not arise because the gas tax raises revenue, while the CAFE standard does not.<sup>3</sup> Rather, our result for the gas tax is similar to that in West and Williams (2004a), which showed that since gasoline and leisure are relative complements, raising the gas tax will increase labor supply, generating additional efficiency gains.

In this paper, we use data from the Consumer Expenditure Survey, the California Resources Board, and other sources to estimate a consumer demand system over miles driven, leisure, and other goods, and find that miles driven and leisure are relative complements. Thus, the gas tax encourages labor supply by raising the cost per mile driven, producing an additional efficiency gain. Conversely, because CAFE reduces the cost per mile, this effect goes in the opposite direction, discouraging labor supply and yielding an additional efficiency loss.

While the induced changes in labor supply are tiny relative to the labor market, they are still substantial relative to the gasoline market, and thus have a dramatic effect on the relative costs of the two policies. Our point estimates imply that they reduce the social marginal cost of the gas tax (starting from the status quo gas tax rate and ignoring the benefits of reduced gas consumption) by almost 30%, while increasing the marginal cost of CAFE by nearly 60%. Thus, even though in a first-best setting the initial marginal costs of the two policies would be essentially equal, in a second-best setting, CAFE's initial marginal cost is more than twice that of the gas tax. This result implies that the case for raising the gas tax rather than tightening the CAFE standard is far stronger than previous studies suggest. Indeed, it strongly suggests that any tightening at all of the CAFE standard would lower welfare unless the benefits of reduced gasoline consumption have been seriously underestimated.

## **II. A Framework for Comparing Policy Costs**

Here we very briefly outline the model used to compare the CAFE standard with those of the gas tax, and present expressions for the marginal cost per gallon of reducing gasoline consumption using each of the two policies.<sup>4</sup>

The model is similar to that used by West and Williams (2004a), except that the model used in that paper has more of a reduced-form structure, with gasoline consumption appearing directly as a term in household utility. In this paper, consumer utility depends on miles driven ( $M$ ), which are produced from gasoline ( $G$ ), with the ratio depending on the fuel efficiency of the household's vehicles, in miles per gallon ( $MPG$ ). Just like the model in West and Williams (2004a), the model used here includes many households, each of which includes one or more individuals, each of whom divides his or her time endowment between labor and leisure. Household utility depends on the leisure consumed by each individual, as well as on the number of miles driven and the amount of all other goods consumed. The government taxes both gasoline consumption and labor income, with the labor tax rate adjusted to keep total government revenue fixed. In this model, the elasticity of gasoline demand with respect to the gas price can be expressed as

$$(1) \quad \varepsilon_G = \frac{dG}{dp_G} \frac{p_G}{G} \approx -\varepsilon_{MPG \cdot p_G} + (1 - \varepsilon_{MPG \cdot p_G}) \sum_h \left( \frac{\partial M^h}{\partial p_M^h} \frac{p_M^h}{M^h} \right),$$

where  $p_G$  is the average gasoline price,  $G$  is the total amount of gasoline consumed,  $M^h$  and  $p_M^h$  are the number of miles driven and the cost of gasoline per mile for household  $h$ , and  $\varepsilon_{MPG \cdot p_G}$  is the elasticity of MPG with respect to the price of gasoline (which is implicitly assumed to be the same for all households).<sup>5</sup> The first term on the right-hand side of (1) is the effect of increased fuel efficiency resulting from the higher gas price, while the second term represents the reduction in miles driven. Note that the greater the fuel-efficiency response, the smaller will be the reduction in miles driven, because increases in fuel efficiency reduce the cost per mile, thus offsetting some of the direct effect of the higher gas price.

The marginal cost per gallon of reducing gasoline consumption by increasing the gas tax follows

$$(2) \quad MC_G = \eta \tau_G + (1 - \varepsilon_{MPG \cdot p_G}) \theta \frac{p_G}{\varepsilon_G},$$

where  $\tau_G$  is the gas tax rate, and  $\eta$  is the marginal cost of public funds (MCPF), which is the cost to households of raising a marginal dollar of government revenue via the labor tax. The MCPF is typically estimated to be slightly greater than one, because the cost to households equals the dollar raised plus the marginal deadweight loss generated (for more detail, see West and Williams 2004a). Finally, the term  $\theta$  reflects the relative complementarity between miles driven and leisure, and is given by

$$(3) \quad \theta = (\eta - 1) - \eta \left( \sum_h \sum_i \frac{\tau_L^{hi}}{MPG^h} \frac{\partial l^{hi}}{\partial p_M^h} \right) / \sum_h G^h.$$

If miles driven are an average substitute for leisure, then  $\theta$  will equal zero. It will be positive if miles driven are more complementary to leisure than is the average good, and negative if miles are more substitutable for leisure.

In a first-best world (that is, one without a distortional labor tax),  $\eta$  would equal one, and thus the marginal cost would simply equal the tax rate. The presence of a distortional labor tax, however, affects the marginal cost in two ways. First, if miles driven are an average substitute for leisure, the net effect of

interactions with that tax distortion causes the marginal cost curve to pivot upward: the marginal cost is equal to the MCPF times the tax rate. This effect has been the focus of much of the prior literature on second-best environmental taxes. It occurs because a tax on the average consumption good is a less efficient source of revenue than the labor tax, because it has a narrower tax base. That inefficiency raises the cost of the gas tax somewhat.

Second, if miles are more complementary to or more substitutable for leisure than the average good, this will cause the marginal cost curve to shift down or up, respectively. Increasing the gasoline tax increases the price per mile driven, so if miles are relatively complementary to leisure, raising the gas tax will encourage labor supply, thus leading to a second-best welfare gain which will reduce the marginal social cost. If miles are relatively substitutable, then a higher gas price will discourage labor supply, thus increasing the marginal cost. Note that we have implicitly assumed here that tax-induced changes in fuel efficiency have the same effect on labor supply as tax-induced changes in consumption of the average good. Otherwise, equation (2) would include a third term, reflecting the relative complementarity between fuel efficiency and leisure.

The elasticity of gasoline consumption for the CAFE standard is given (in an expression analogous to (1)) by

$$(4) \quad \varepsilon_{GC} = \frac{dG}{dp_{GC}} \frac{p_{GC}}{G} \approx -\varepsilon_{MPG \cdot p_G} - \varepsilon_{MPG \cdot p_G} \sum_h \left( \frac{\partial M^H}{\partial p_M^h} \frac{p_M^h}{M^H} \right).$$

where  $\tau_{GC}$  represents the tax-equivalent of the CAFE standard (that is, the gasoline tax rate that would yield the same incentive to increase fuel economy), and  $p_{GC}$  is the corresponding implicit price of gasoline. The interpretation of equation (4) parallels that of equation (1), with the first term representing the increase in fuel efficiency and the second term representing the effect of changes in miles driven. Note, however, that in this case the cost per mile actually falls, because the CAFE standard improves fuel efficiency but, unlike the gas tax, does not affect the price of gasoline. Thus, the CAFE standard increases miles driven, thus offsetting some of the reduction in gasoline consumption from improved fuel efficiency (the well-known “rebound effect”).

The expression for the marginal cost under the CAFE standard (analogous to (2)) is

$$(5) \quad MC_C = \eta\tau_{GC} - \varepsilon_{MPG \cdot PG} \theta \frac{P_{GC}}{\varepsilon_{GC}},$$

Note that this expression is very similar to expression (2), except that in this case, the marginal cost is higher if miles are relatively complementary to leisure, and lower if they are relatively substitutable for leisure. The intuition is exactly the same as in the case of the gas tax, except that tightening the CAFE standard leads to a reduction in the cost per mile driven, rather than an increase, as under the gas tax, and thus the effect of  $\theta$  on marginal cost also goes in the opposite direction.

### III. Elasticities

We modify the Almost Ideal Demand System (AIDS) from West and Williams (2004a and b) to estimate the demand for miles, leisure, and a composite of all other goods. We estimate two demand systems: one for one-adult households and the other for two-adult households with one adult male and one adult female (where an adult is at least 18 years of age).<sup>6</sup> Each adult's leisure is treated as a separate good. Thus, the two-adult demand system includes four goods: miles, male leisure, female leisure, and a composite of all other goods.

We use a sample of 9706 households from the 1996 through 1998 Consumer Expenditure Surveys (CEX), to obtain weekly work hours, gasoline expenditures, and spending on other goods (total consumption expenditure less that on gasoline) and household characteristics. Leisure is calculated by subtracting work hours from a (non-sleep) time endowment of 90 hours per week (the highest hours worked for any household in the sample). The price of leisure or net wage is obtained using the gross wage from the CEX, adjusted for federal and state income taxes and earned income and child tax credits for different wage rates from NBER's TAXSIM model (e.g., Feenberg and Coutts 1993). Since we do not observe wages for individuals who do not work, we correct for selectivity bias (Heckman 1979). Full income is total expenditures plus the product of leisure and the selectivity-corrected net wage. Prices are obtained from the American Chambers of Commerce Researchers' Association (ACCRA) cost-of-living index.<sup>7</sup>

Since the CEX does not record vehicles' fuel efficiencies, we use data from the California

Air Resources Board (CARB) to estimate a regression of miles per gallon (*MPG*) on engine size and vehicle vintage.<sup>8</sup> Smaller or newer vehicles are more fuel efficient. Since some households own no vehicles, we apply a Heckman correction for *MPG* analogous to that for the wage: we assign selectivity corrected *MPG* to households that do drive and a predicted *MPG* to households without cars. Because our data is primarily cross-sectional, it is poorly suited for estimating the elasticity of *MPG* with respect to the gas price. Therefore, we take a value of 0.3 for that elasticity from Wheaton (1982), and constrain the first-step estimate from the Heckman correction to match that value. The fuel cost per mile equals the price of gas divided by *MPG*, and we divide the household's gas expenditure by that cost per mile to obtain miles driven.

We estimate the system using three-stage least squares, using occupation-average wages as an instrument to address potential endogeneity of the after-tax wage. Estimated parameters are used to compute miles and labor elasticities (see West and Williams 2004a). Elasticities are calculated separately for each household and then aggregated, rather than being calculated for a representative household.

The miles own-price elasticity estimates are roughly  $-0.74$  for one-adult households and  $-0.51$  for two-adult households. For one-adult households, the compensated and uncompensated labor supply elasticities are 0.45 and 0.29, respectively. For two-adult households, compensated own-wage labor supply elasticities are 0.23 for men and 0.35 for women, while uncompensated elasticities are 0.13 and 0.28.

The uncompensated cross-price elasticity of labor with respect to the price of miles is  $-0.0062$  in the one-adult sample, and 0.0056 for men and  $-0.0027$  for women in the two-adult sample. In each case, the estimates suggest that miles are more complementary to leisure than the average good, though the difference is significant only for men in the two-adult sample.

#### **IV. Results**

The status quo gas tax rate in our sample is 36.7¢ per gallon, and we assume that status quo CAFE standard is non-binding.<sup>9</sup> In a first-best setting, this would also be the initial marginal cost

per gallon reduction in gas consumption under either policy, starting from the status quo gas tax rate. Our results imply that the cost in a second-best setting is dramatically different, however. Our point estimate for the initial marginal cost of the gas tax is 26¢ per gallon, nearly 30% less than the first-best cost. The initial marginal cost under the CAFE standard, however, rises to 57.6¢ per gallon in a second-best setting, nearly 60% higher than in a first-best setting, and more than double the initial marginal cost under the gas tax.

Figure 1 plots the estimated marginal cost and associated 95% confidence interval for the gas tax, over the range from a 0% to 20% reduction in gasoline consumption from the status quo level. Figure 2 is an analogous plot for the CAFE standard, but covers only a 0% to 10% reduction. Comparing the bias-corrected bootstrap confidence intervals for these estimates suggests that the difference is even larger: the 95% confidence interval for the initial marginal cost under the gas tax runs from -11.9¢ to 32.8¢ per gallon, while the same interval for the initial marginal cost under CAFE runs from 50.8¢ to \$3.34 per gallon.<sup>10</sup>

At this point it is worth noting that the NRC's (2002) estimated the marginal benefit from reducing gasoline consumption at 26¢ per gallon, and noted that "estimates as high as \$0.50/gal or as low as \$0.05/gal are not implausible" (p. 86). Even the top of this "not implausible" range is less than the bottom of our estimated 95% confidence interval for the initial marginal cost of reducing gasoline consumption by tightening the CAFE standard. While we are inclined to think that the NRC report underestimated the benefits, our results still suggest that any tightening of the CAFE standard will very likely reduce welfare, unless the benefits were drastically underestimated (or our methodology is seriously flawed).

In contrast, we cannot reject the hypothesis that the marginal cost of the gas tax could be negative even for more than a 10% reduction in gasoline consumption. And while the point estimate for the marginal cost is roughly equal to the NRC report's central case estimate for benefits, studies suggest that the marginal benefit from a particular reduction in gas consumption is substantially greater if that reduction is achieved via the gas tax rather than a CAFE standard (even ignoring the difference in costs).<sup>11</sup> This is because the externalities associated with miles driven,

such as accident and congestion costs, are estimated to be much larger than those associated with gasoline consumption itself. This suggests that a large reduction—as much as 20%—in gas consumption would likely enhance welfare, and we cannot reject the hypothesis that even a reduction much larger than that would be efficient.

## **V. Conclusions**

This paper's results suggest that interactions with the tax-distorted labor market cause the cost advantage of the gasoline tax over a CAFE standard to be dramatically larger than prior work had suggested. This implies that increasing the gas tax would very likely lead to a welfare gain, whereas tightening the CAFE standard would almost certainly lead to a welfare loss. Given the magnitude of these results—and all of the prior research that suggests that the gas tax is more efficient than the CAFE standard—it seems highly unfortunate that policymakers have focused on CAFE, and that higher gas taxes seem to be politically infeasible.

However, our results should be interpreted with some caution, given the limitations of our approach. The simplified model used in this paper does not consider the supply side of the automobile or gasoline markets, the dynamic aspects of the problem, or the discreteness of households' choice over different vehicles. And given the available data, we cannot accurately estimate the elasticity of MPG with respect to the gas price or the effect of MPG on labor supply, nor is there a good way to correct for the potential endogeneity that MPG choice might induce in the cost per mile. Where possible, we have chosen assumptions that work against our results—for example, choosing a value for the elasticity of MPG at the high end of the range of prior estimates, which raises the estimated cost of the gas tax while lowering the estimated cost of CAFE—and thus we have confidence that the direction of the paper's results is correct, even though the magnitude may well be substantially over- or under-estimated.

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<sup>1</sup> While changes have been made to neither the federal gas tax nor CAFE standards for cars, light duty truck standards have been raised, effective for model year 2005.

<sup>2</sup> This literature on these effects is too extensive to summarize here, but important papers include Sandmo (1975), Bovenberg and De Mooij (1994), Parry (1995), Goulder (1995), Bovenberg and Goulder (1996 and 1997), Goulder *et al.* (1999), Parry *et al.* (1999), and Fullerton and Metcalf (2001).

<sup>3</sup> As noted by Goulder *et al.* (1999), while performance standards (such as CAFE) do not raise revenue, and thus cannot generate an efficiency-enhancing revenue-recycling effect, they have the offsetting advantage of producing smaller increases in product prices (relative to the direct costs of the policy) than do corrective taxes, and thus, *ceteris paribus*, the ratio of the net effect of tax interactions to the direct cost of the policy will be similar to that for a corrective tax. Fullerton and Metcalf (2001) provide an alternative explanation of this issue in terms of scarcity rents.

<sup>4</sup> A more rigorous exposition of the model and derivation of the expressions for marginal cost is available from the second author upon request. Unfortunately, space limitations prevent including that detail here.

<sup>5</sup> As noted later in the paper, our data are not well suited for estimating policy-induced changes in fuel efficiency. Since we cannot estimate this elasticity, we simply assume a particular value, and make the same assumption in the theoretical model for ease of exposition. We do the same for the cross-price effect between fuel efficiency and labor supply.

<sup>6</sup> We exclude households with adults over the age of 65.

<sup>7</sup> For more detail and summary statistics, see West and Williams (2004a and b).

<sup>8</sup> Fuel efficiency regression results are available from the authors upon request.

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<sup>9</sup> This is the federal gas tax rate plus the average state tax rate in our sample. The assumption that the status quo CAFE standard is nonbinding is common in the literature (e.g., CBO 2003)

<sup>10</sup> The strongly asymmetric confidence intervals result because the marginal cost estimates are nonlinear functions of the estimated elasticities, which are themselves nonlinear functions of the estimated coefficients. Those nonlinearities induce both a bias in the cost estimates and a skew in the bootstrap distributions. The bootstrap estimate of bias is relatively small for the point estimates (it suggests that the initial marginal cost estimate is biased upward by 1.7¢ for the gas tax and downward by 3.4¢ for CAFE), in combination with the skewed bootstrap distribution, it yields very asymmetric confidence intervals.

<sup>11</sup> See Parry and Small (2004), for example, which estimates the marginal benefit of reducing gas consumption via the gas tax to be 83¢/gallon (in year 2000 dollars), which is equivalent to 77¢ in 1997, the middle year of our sample.

Figure 1: Marginal Cost Under the Gasoline Tax

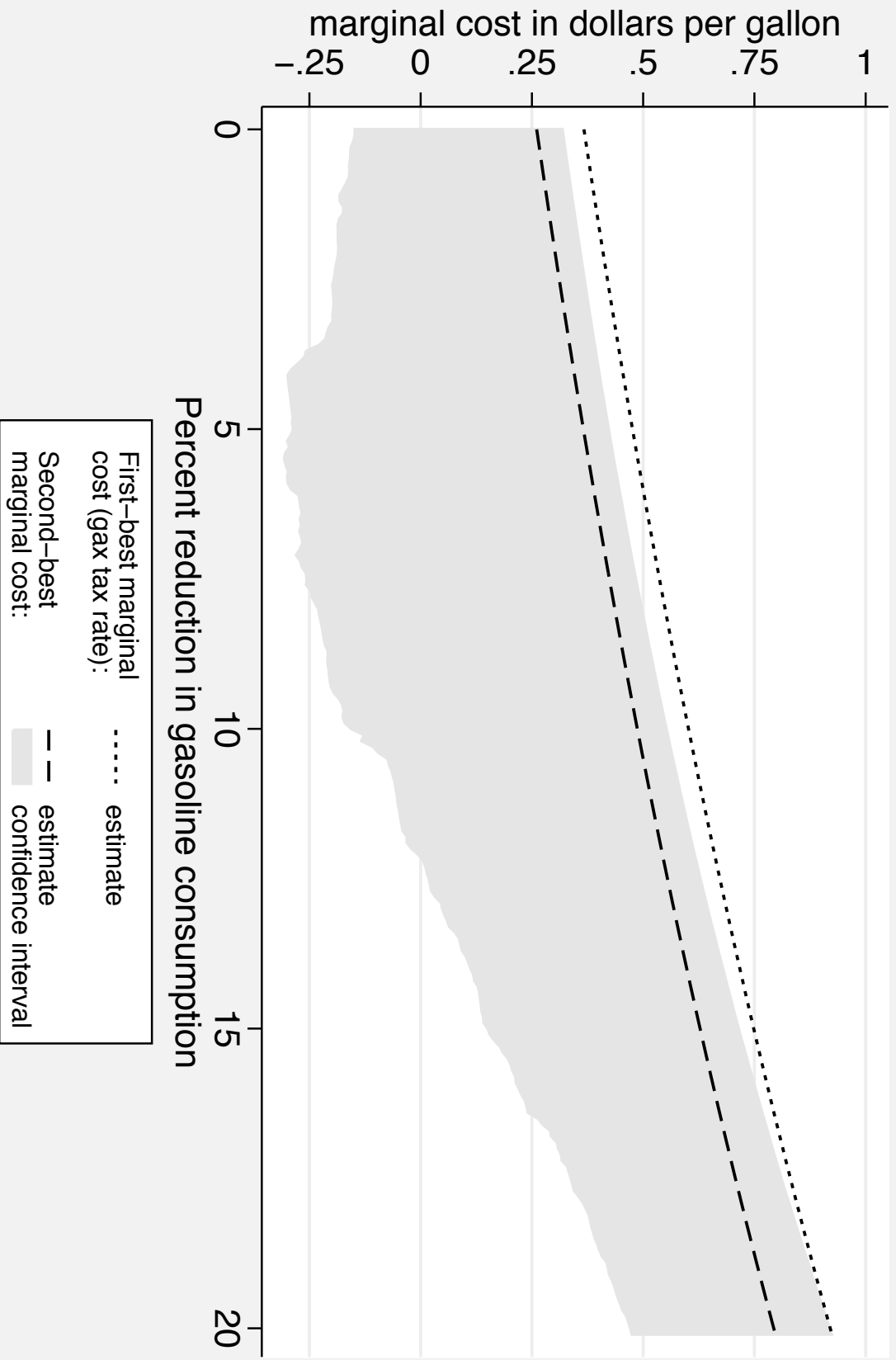


Figure 2: Marginal Cost Under the CAFE Standard

