The Cost of Reducing Gasoline Consumption

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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 gas tax and Corporate Average Fuel Economy (CAFE) standards.\(^1\) Two influential recent reports find that increasing the gas tax would attain a given reduction in gas consumption at lower cost than would tightening CAFE standards (National Research Council, 2002; Congressional Budget Office, 2003). 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 gas per mile driven.

We also compare the costs of the gas tax and CAFE standard but take into account interactions with preexisting tax distortions. Many papers examine the effects of these tax interactions in other contexts, but to our knowledge none of them considers the CAFE standard (see e.g., Lars Bovenberg and Ruud de Mooij, 1994; Ian Parry, 1995; Lawrence Goulder, 1995; Bovenberg and Goulder, 1996; Parry et al., 1999; Don Fullerton and Gilbert Metcalf, 2001). These interactions reduce the cost of the gas tax but increase the cost of CAFE, thus 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.\(^2\) Rather, this result 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 estimate a consumer demand system using data from the Consumer Expenditure Survey and the California Air Resources Board 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, it discourages labor supply and yields 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 gas 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 percent, while increasing the marginal cost of CAFE by nearly 60 percent. 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 gas consumption have been seriously underestimated.

I. A Framework for Comparing Policy Costs

The model is similar to that used by West and Williams (2004a), except that in that paper gasoline consumption appears directly as a term in enhancing revenue-recycling effect, they produce smaller increases in product prices 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.
household utility. Here 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). As in West and Williams (2004a), this model includes many households, each consisting of one or more individuals who divide their time endowments between labor (\(L\)) and leisure (\(\ell\)). Household utility depends on the leisure consumed by each individual, on the number of miles driven, and on the amount of all other goods consumed. The government taxes both gas consumption and labor income, with the labor tax rate (\(\tau_L\)) adjusted to keep total government revenue fixed.\(^3\) In this model, the elasticity of gas demand with respect to the gas price can be expressed as

\[ e_G = \frac{dG}{dp_G} \left( \frac{p_G}{G} \right) \]

\[ = e_{\text{MPG}} - e_{\text{MPG}p_G} + (1 - e_{\text{MPG}p_G}) \sum_h \left[ \frac{\partial^2 M^h}{\partial p_M^h} \left( \frac{p_M^h}{M^h} \right) \right] \]

where \(p_G\) is the average gas price, \(G\) is the total amount of gas consumed, \(M^h\) and \(p_M^h\) are the number of miles driven and the cost of gas per mile for household \(h\), and \(e_{\text{MPG}} \cdot p_G\) is the elasticity of MPG with respect to the price of gas.\(^4\) 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. 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.

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

\[ \text{MC}_G = \eta \tau_G + \frac{1 - e_{\text{MPG}p_G}}{e_G} \frac{dG}{dp_G} \]

where \(\tau_G\) is the gas tax rate and \(\eta\) is the marginal cost of public funds (MCPF). Finally, the term \(\theta\) reflects the relative complementarity between miles driven and leisure, and is given by

\[ \theta = (\eta - 1) \]

\[ \frac{\sum_h \sum_i \left( \frac{\tau_L}{\text{MPG}^i} \frac{\partial \ell^h}{\partial p_M^i} \right)}{\sum G^h}. \]

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

In a first-best world (one without a distortionary labor tax), \(\eta\) equals 1, and the marginal cost equals the tax rate. The presence of a distortionary labor tax, however, affects the marginal cost in two ways. First, if miles driven are an average substitute for leisure, interactions with the tax distortion cause the marginal cost curve to pivot upward: the marginal cost is equal to the MCPF times the tax rate. This effect 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.

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 gas tax increases the price per mile; if miles are relatively complementary to leisure, raising the gas tax will encourage labor supply, leading to a second-best welfare gain that reduces the marginal social cost. If miles are relatively substitutable, then a higher gas price will discourage labor supply, increasing the marginal cost. This analysis assumes 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 by

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\(^3\) See West and Williams (2005) for more detail on our model, derivations, data and results. Unfortunately, space limitations prevent including that detail here.

\(^4\) As noted later in the text, our data do not facilitate estimation of this elasticity or for the cross-price elasticity between fuel efficiency and labor supply. Therefore we assume particular values for these elasticities and make the same assumption in the theoretical model for ease of exposition.
\[ (4) \quad \varepsilon_{GC} = \frac{dG}{dp_{GC}} \frac{p_{GC}}{G} \]

\[ \approx -e_{\text{MPG}} p_{CG} \sum_h \left( \frac{\partial M^h}{\partial p_M^h} \right) \]

where \( \tau_{GC} \) represents the tax-equivalent of the CAFE standard (the gas tax rate that would yield the same incentive to increase fuel economy) and \( p_{GC} \) is the corresponding implicit gas price. The first term represents the increase in fuel efficiency, and the second term is the effect of changes in miles driven. 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, offsetting some of the reduction in gas consumption from improved fuel efficiency (the well-known “rebound effect”).

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

\[ (5) \quad \text{MC}_C = \eta \tau_{GC} - e_{\text{MPG}} p_{CG} \theta \frac{p_{GC}}{\varepsilon_{GC}}. \]

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.

II. Elasticities

We modify the Almost Ideal Demand System from West and Williams (2004a, b) to estimate the demand for miles, leisure, and a composite of all other goods. We estimate one demand system for one-adult households and another for two-adult households with one adult male and one adult female, where each adult’s leisure is a separate good.

We use a sample of 9,706 households from the 1996–1998 Consumer Expenditure Surveys (CEX), to obtain weekly work hours, gasoline expenditures, spending on other goods, and household characteristics. Leisure equals time endowment minus work hours. We adjust the net wage for federal and state income taxes (including earned income and child tax credits) and correct for selectivity bias (James J. 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 cost-of-living index.

The CEX does not report fuel efficiency so we use data from the California Air Resources Board to estimate miles per gallon (MPG) as a function of engine size and vehicle vintage. Some households own no vehicles, so we apply a Heckman correction for MPG analogous to that for the wage: we assign a selectivity-corrected MPG to households with cars and a predicted MPG to those without. Because our data set 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 William C. 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. We use estimated parameters to calculate miles and labor elasticities separately for each household and then aggregate.

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.

III. Results

The status quo gas tax rate is 36.7 cents per gallon, and as in Congressional Budget Office (2003) we assume the status quo CAFE standard is nonbinding. In a first-best setting, this would also be the initial marginal cost per gallon reduction in gas consumption under either policy. But our results imply that the cost in a second-best setting is dramatically different. Our point estimate for the initial marginal cost of the gas tax is 26 cents per gallon, nearly 30 percent less than the first-best cost. In contrast, the initial marginal cost under the CAFE standard rises to 57.6 cents per gallon in a second-best setting, nearly 60 percent 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-percent confidence interval for the gas tax, over the range from a 0-percent to a 20-percent reduction in gas consumption from the status quo level. Figure 2 is an analogous plot for the CAFE standard, but it covers only a 0–10-percent reduction. Comparing the bias-corrected bootstrap confidence intervals for these estimates suggests that the difference is even larger: the 95-percent confidence interval for the initial marginal cost under the gas tax runs from −12.7 cents to 31.9 cents per gallon, while the same interval for the initial marginal cost under CAFE runs from 50.6 cents to $3.41 per gallon.

The National Research Council (NRC) (2002) estimated the marginal benefit from reducing gasoline consumption at 26 cents 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-percent confidence interval for the initial marginal cost of reducing gas consumption by tightening the CAFE standard. Even if 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-percent reduction in gas consumption. Furthermore, while the point estimate for the marginal cost is roughly equal to the NRC report’s central-case benefit estimate, studies suggest that the marginal

5 This is the federal gas tax rate plus the average state tax rate in our sample.

6 The confidence intervals are asymmetric because cost estimates are nonlinear functions of the estimated elasticities, which are themselves nonlinear functions of the estimated coefficients. Those nonlinearities induce a bias in the cost estimates and a skew in the bootstrap distributions. The estimated bias is small (initial marginal cost estimates are biased upward by 1.7 cents for the gas tax and downward by 3.4 cents for CAFE) but, together with the skewed bootstrap distribution, yields very asymmetric confidence intervals.
benefit from a given reduction in gas consumption is substantially greater if it is achieved via the gas tax rather than a CAFE standard (even ignoring the difference in costs). 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 gas consumption itself. This suggests that a large reduction (as much as 20 percent) in gas consumption would likely enhance welfare, and we cannot reject the hypothesis that even a reduction much larger than that would be efficient.

IV. Conclusions

This paper’s results suggest that interactions with the tax-distorted labor market cause the cost advantage of the gas 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 gas markets, the dynamic aspects of the problem, or the discreteness of households’ choice over different vehicles. Also, 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. Thus, we have confidence that the direction of the paper’s results is correct, though the magnitude may well be substantially over- or underestimated.

REFERENCES


Parry, Ian W. H.; Williams, Roberton C., III and Goulder, Lawrence H. “When Can Carbon Abatement Policies Increase Welfare? The

7 Parry and Kenneth Small (2005) estimate the marginal benefit of reducing gas consumption via the gas tax to be 83 cents/gallon (in year-2000 dollars), which is equivalent to 77 cents in 1997.


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4. Ian W. H. Parry, Margaret Walls, Winston Harrington. 2007. Automobile Externalities and Policies. Journal of Economic Literature 45:2, 373-399. [Abstract] [View PDF article] [PDF with links]