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Energy policies for passenger motor vehicles

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ABSTRACT

This paper assesses the costs and effectiveness of several energy policies for light-duty motor vehicles in the United States, using a version of the National Energy Modeling System. The policies addressed are higher fuel taxes, tighter vehicle efficiency standards, and financial subsidies and penalties for the purchase of high- and low-efficiency vehicles (*feebates*). I find that tightening fuel-efficiency standards beyond those currently mandated through 2016, or imposing feebates designed to accomplish similar changes, can achieve by 2030 reductions in energy use by all light-duty passenger vehicles of 7.1–8.4%. A stronger feebate policy has somewhat greater effects, but at a significantly higher unit cost. High fuel taxes, on the order of $2.00 per gallon (2007$), have somewhat greater effects, arguably more favorable cost-effectiveness ratios, and produce their effects much more quickly because they affect the usage rate of both new and used vehicles. Policy costs vary greatly with assumptions about the reason for the apparent myopia commonly observed in consumer demand for fuel efficiency, and with the inclusion or exclusion of ancillary costs of congestion, local air pollution, and accidents.

1. Introduction

The significant role of motor vehicles used for passenger travel in greenhouse gas emissions and petroleum consumption is well known. Consequently, most analysts believe that serious strategies to address climate change or energy dependence will require significant reductions from this sector.

This paper undertakes an assessment of effectiveness and costs of various policies aimed at such reductions in the United States. It does so by defining specific measures as input parameters to a version of the National Energy Modeling System (NEMS), a comprehensive model of energy sectors used by the Energy Information Administration (EIA) for its regular projections and analyses (EIA, 2009b). The paper is part of a larger suite of studies at Resources for the Future using its own particular adaptation of NEMS, known as NEMS–RFF, and other tools to analyze a wide variety of energy and greenhouse gas (GHG) policies in a consistent manner facilitating comparison (Krupnick et al., 2010).

The specific policies addressed here are aimed directly at fuel consumption by light duty vehicles: higher fuel taxes, tighter vehicle efficiency standards, and financial subsidies and penalties for the purchase of high- and low-efficiency vehicles (*feebates*). These are among the most prominently discussed policies, but of course are only a subset of those that can be considered; for example, I do not examine transit subsidies or policies aimed at changing urban land use patterns, mainly because other studies suggest they are either too weak or too long-term to compete with these more direct policies in terms of medium-term cost-effectiveness. Two other direct policies are the subjects of other studies in the larger effort just described: subsidies to hybrid vehicles, which are found to be mostly redundant if a policy aimed at fuel efficiency is in place, and natural gas trucks, which appear potentially promising. Yet another policy worth considering, but not examined here, is

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natural gas for light-duty vehicles; this policy has lost favor due to the significant loss of storage space to fuel canisters, but it probably merits a reexamination now that newly cheap natural gas, including much produced within the US, has emerged on the world market.

For each policy modeled, the effects are determined with respect to a baseline scenario. The baseline is a variant of the NEMS simulation (to 2030) contained in the updated *Annual Energy Outlook 2009* scenario of EIA (2009a), which includes the 2009 federal stimulus package; that simulation is further modified here to incorporate the National Fuel Efficiency Policy as announced by the President in May 2009. In the latter program, GHG standards have been developed for passenger vehicles and integrated with fuel-efficiency standards.

Estimating the social costs of such policies is more difficult than it might appear. A model that is fully derived from a single formulation of well-defined utility and profit functions, such as that by Bento et al. (2009), would contains all of the information needed for rigorous welfare analysis; but it would have the disadvantage of a limited range of mathematically tractable demand functions and market interactions. In contrast, a model such as NEMS–RFF, containing many empirically based components, can be more realistic but does not permit a direct calculation of consumer utility; instead, the components of social cost must be inferred from the empirical demand and cost relationships. Doing so is complex because of the many interacting dimensions of behavior involved. Furthermore, certain well-established behavioral regularities represented in NEMS–RFF, such as consumers' use of short time horizons for their purchase decisions, are at least superficially inconsistent with standard assumptions of economic theory, and therefore require auxiliary assumptions to determine changes in well-being.

The results show that even aggressive versions of these policies achieve only modest reductions in petroleum use and greenhouse gas emissions. Stronger policies are possible, but at diminishing effectiveness and increasing costs. Policy costs are found to depend greatly on two factors that are empirically uncertain. First, if consumers' hesitancy to fully value fuel savings is because those savings are tied to amenity losses that are hidden to analysts, then the policy costs are much higher, especially for policies aiming directly at fuel efficiency. Second, including external costs raises the costs of fuel-efficiency policies, but lowers the costs of a fuel tax, making the latter negative. Finally, a fuel tax achieves its targeted policy gains much more quickly than fuel-efficiency policies because it relies more heavily on reductions in vehicle use, which apply to used as well as new vehicles.

2. Passenger highway transportation in the United States

The relative contribution of transportation to energy problems is quite different depending on which problem one considers. According to, light-duty vehicles (LDVs)—consisting of passenger cars, vans, sport utility vehicles, and pickup trucks—accounted for 44% of liquid fuels consumption but only 15% of all greenhouse gas emissions in 2008.[1] Energy consumption by LDVs grew by 70% from 1970 to 2007, although the path was punctuated by occasional declines (Fig. 1). The overall growth was a net result of two countering trends, also shown in the figure. Vehicle-miles traveled (VMT) rose dramatically, by 168%, while the fuel intensity of vehicles (i.e., the reciprocal of fuel efficiency), *declined* by 36%. Thus, vehicles became more efficient, but not enough so to overcome the huge increase in usage.

Looking more deeply into the decline in fuel intensity, it appears that it was caused mainly by improvements in the fuel efficiencies of individual vehicles, somewhat counteracted in more recent years by adverse changes in the size mix of vehicles. For example, between 1980 and 2008, the fuel economies of small cars and midsize sports utility vehicles (SUVs) rose by 21% and 76%, respectively. But the market shares of small cars and midsize SUVs went in opposite directions over that period, that of small cars declining (by 23 percentage points) and that of midsize SUVs rising (by 16 percentage points), thereby eroding some of the energy savings from the technology changes. The relevance of this example is confirmed by disaggregating all LDVs into 15 size classes, six of cars and nine of light trucks.[2] Had market shares of these size classes remained at 1980 values, the sales-weighted average fuel efficiency of new LDVs in 2008 would have been 27.3 mpg rather than 24.0 mpg as it actually was.[3]

Fuel prices have played a significant role in driving vehicle fuel efficiency, and they promise to continue to do so in the future. Real gasoline prices in the US declined sharply from 1982 through 1988, and remained low for a decade. A gradual rise began in 1999, accelerating sharply in 2003; but only in 2008 did it again reach its 1980–1982 value. The average fuel efficiency of new LDVs has moved inversely to these trends, as theory would predict. Studies that attempt to disentangle the effect of fuel price from other causes have generally found a consistent, though moderate, response of fleetwide fuel efficiency to price. This response is measured by Small and Van Dender (2007a, Table 5) as a long-run elasticity of fuel efficiency with respect to fuel price of 0.20, based on a cross-sectional time series of US states from years 1966–2001.[4]

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[1] Computed from EIA (2009d), Table 19, combined with the proportion of US greenhouse-gas emissions consisting of energy-related carbon dioxide, which is 5810/7049 = 82.4%, from EIA (2010), Table 12.1.

[2] In this paper, LDVs consist of cars and light trucks, the latter including vans, SUVs, and pickup trucks with gross weight less than 8500 lb. Vans, SUVs, and pickup trucks with gross weight 8500–10,000 lb—including the Hummer—are treated differently in NEMS-RFF and called "commercial light trucks," although elsewhere they are called "intermediate trucks" or "Class 2b vehicles".

[3] Calculated from data in Davis et al. (2009), Tables 4.7, 4.9.

[4] Small and Van Dender also measure a short-run (1-year) elasticity of 0.04. Li et al. (2009) obtain similar results (short- and long-run elasticities 0.02 and 0.20) using micro data in 20 US metropolitan areas for years 1997–2005; they find this arises almost all from new-car sales and very little from vehicle scrappage. More recent papers demonstrating similar responses include Busse et al. (2009) and Gillingham (2010).