The Impacts of the Rebound Effect on U.S. CAFE Standards for Light-Duty Vehicles

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BACKGROUND

Many scientists believe that the effects from anthropogenic activities are the primary contributors to variations in global temperatures and climate patterns. Economists have a preference for more market-based approaches, like a CO_2 tax, to incentivize the necessary reductions in carbon dioxide and other greenhouse emissions. More recently, politicians have rebuffed their recommendations. Their focus has now shifted toward policies supporting a higher fuel economy. On July 29, 2011, President Barack Obama announced plans for an increase in existing fuel economy standards (CAFE) to 54.5 miles per gallon by model year 2025 for cars and light-duty trucks, doubling current average fuel economy levels. His plan requires annual 5% increases from 2017-2025. For light-duty automobiles, there is an annual 3.5% rise in fuel efficiency from 2017-2021, pushing upward to 5% from 2022-2025.

REBOUND EFFECT

The rebound effect refers to increases in energy consumption due to the increased energy efficiency from CAFE standards with no increase in fuel cost. It is driven mainly by consumer behavior and declines in the real costs of energy service. A lower service costs entices consumers to partake in more of the service (Binswanger 2001). In the case of the transportation sector, which has been observed by a number of studies (A. Greening, Greene et al. 2000; Small and Dender 2006; Sorrell, Dimitropoulos et al. 2009), improvements in fuel efficiency may actually urge motorists to drive more than expected given that short-term driving costs have fallen. The scale or magnitude of the effect plays an important role in measuring its consequences. It is imperative that the potential for rebounding is acknowledged as a consequence of these policies – especially since the transportation sector is responsible for roughly 33% of domestic CO_2 emissions.

OBJECTIVES

- Properly implement and observe the consequences of the rebound effect on the energy system and service demands by light-duty vehicles given changes to CAFE regulations.
- Establish a total system CO_2 tax generating emissions levels equivalent to the CAFE-MED policy scenario.
- Determine short-run average fuel costs per vehicle across each of the four scenarios. This will give insight into the additional vehicle costs incurred by consumers caused by additional consumption of vehicle miles related to the rebound effect.
- Isolate key differences between the results of the CAFE-MED and CAFE-RBND scenarios. Our findings should suggest that the rebound effect has the potential to partially erode benefits gained by increases in the fuel economy.
- Compare the impacts of increases in CAFE standards, with the more efficient carbon tax.

METHODOLOGY

U.S. EPA MARKAL Model

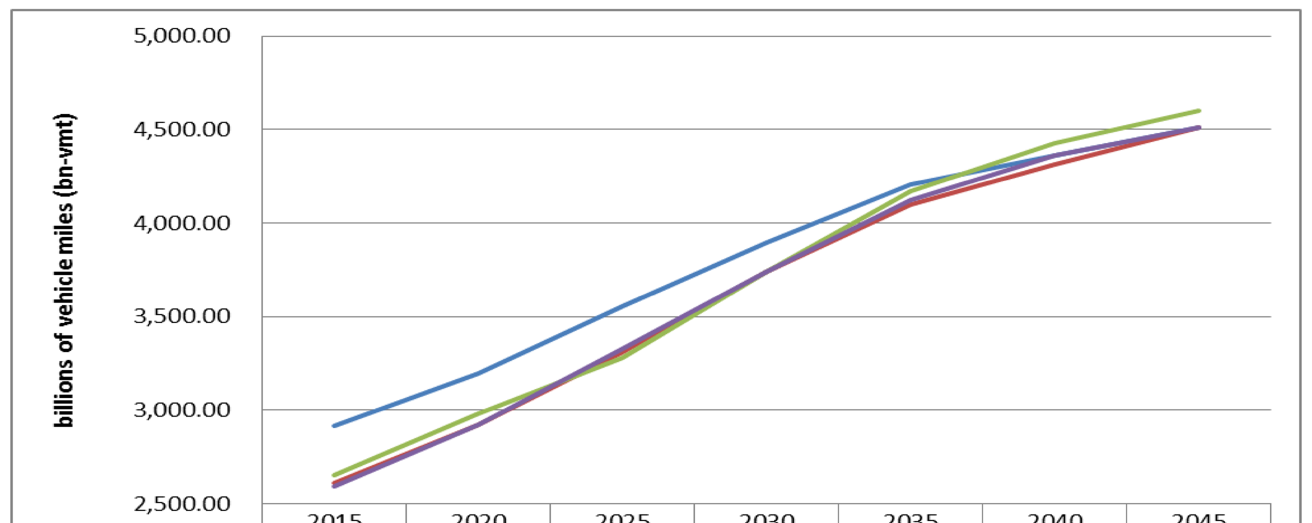
We utilize an elastic version of the U.S. EPA MARKAL model – a bottom-up, linear programming (LP), and partial equilibrium model – to replicate and compare the policies aligned with our interests. The 2010 U.S. EPA National MARKAL Database (EPANMD) used provides the appropriate data for the five primary U.S. sectors (e.g. transportation, commercial, residential, industrial, and electricity generation), as well as characterizations of hundreds of technologies spanning the entire energy system. MARKAL minimizes costs by determining the most efficient, cost-effective set of resources and usage rates for specified technologies over time. (Shay, DeCarolis et al. 2006).

SCENARIOS

- ***BASE***: The CAFE regulations in this scenario are the existing regulations prior to increases established by President Obama in 2011. Light-duty demands for energy services (i.e. vehicle miles) are calibrated relative to EIA's 2010 Annual Energy Outlook report.
- ***CAFE-MED***: Short for CAFE MARKAL Elastic Demands, this scenario captures Obama's 2011 increases to existing fuel economy regulations, such that by model year 2025, average fuel economy levels will reach 54.5 miles per gallon for automobiles and light-duty vehicles.
- ***CAFE-RBND***: In addition to CAFE regulations, the rebound effect due to a lower variable driving costs is included. We draw upon estimates from the literature (Greene, Kahn et al. 1999; Small and Van Dender 2005; Small and Van Dender 2007) for short-run rebound estimations. They suggest that a rebound estimate of approximately 10% should be appropriate for modeling consumer behavior. Modeling the rebound effect requires modification of capacity utilization rates within the MARKAL framework for those vehicles susceptible to the rebound effect.
- ***CO2-TAX***: This scenario covers the application an economy-wide tax to achieve a similar level of emission reductions as the CAFE-MED case. The carbon tax does not specifically target the transportation sector emissions like the CAFE-based scenarios.

RESULTS

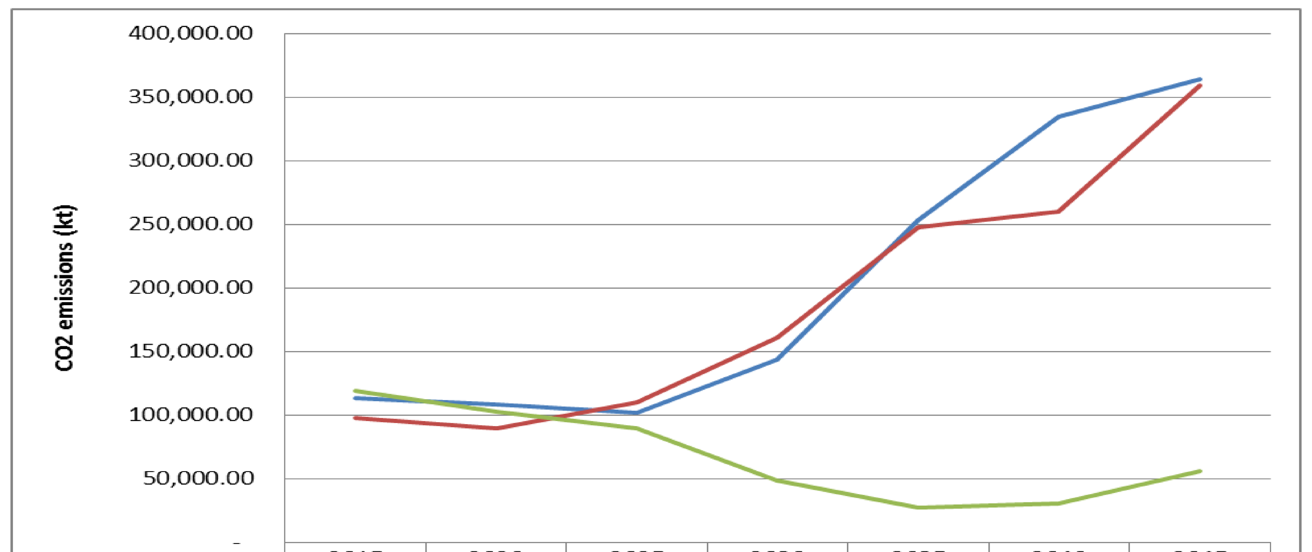
Figure 1: Demands for Vehicle Miles Traveled (VMT) for LDVs



	2015	2020	2025	2030	2035	2040	2045
BASE	2,916.73	3,194.18	3,556.05	3,893.98	4,206.66	4,359.05	4,511.44
CAFE-MED	2,610.48	2,922.67	3,307.12	3,738.22	4,101.50	4,315.46	4,511.44
CAFE-RBND	2,651.78	2,981.36	3,279.92	3,742.75	4,170.55	4,425.29	4,602.18
CO2-TAX	2,595.89	2,922.67	3,324.90	3,738.22	4,122.53	4,359.05	4,511.44

The new CAFE standard (CAFE-MED) leads to a decline in the VMT demands by light-duty vehicles. However, accounting for the rebound effect drives up consumption for vehicle miles beginning in policy year 2035 - after the completion of Obama's increases to CAFE regulations. Our results suggest that a lower fuel cost per vehicle mile given a higher fuel economy does in fact induce additional driving by consumers. A carbon tax leads to higher driver costs relative to both the CAFE scenarios. This can be seen through lower levels of VMT consumption relative to the alternative case.

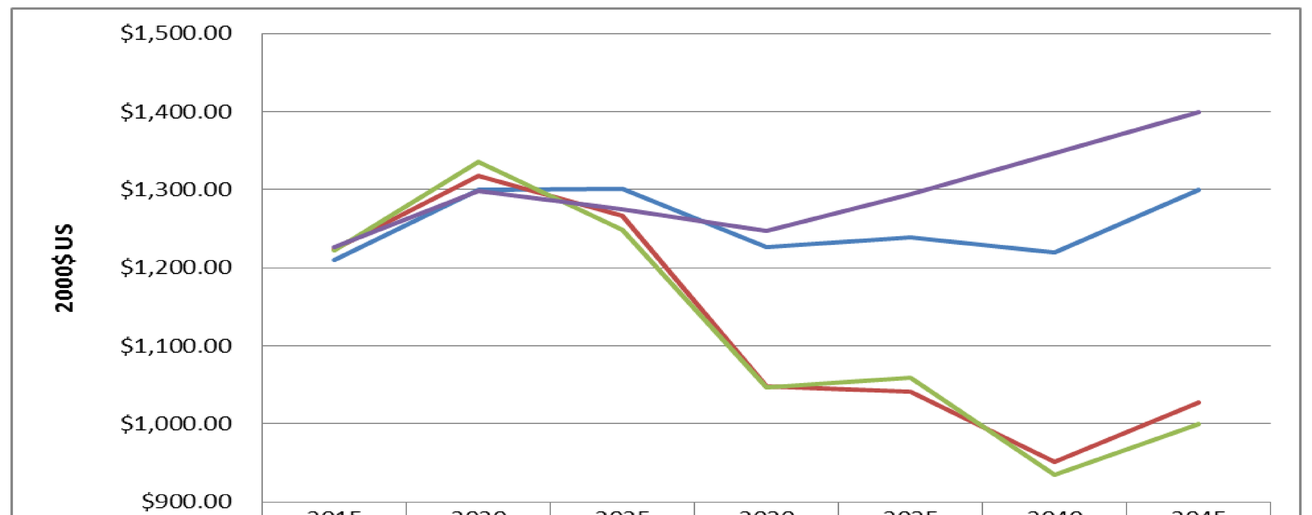
Figure 2: CO_2 Emissions Abatement (Transportation Sector)



	2015	2020	2025	2030	2035	2040	2045
CAFE-MED	113,217.3	108,513.4	101,824.8	143,214.6	253,568.7	334,749.8	364,272.9
CAFE-RBND	97,943.54	89,586.68	109,886.6	160,934.2	247,732.7	260,311.2	359,256.6
CO2-TAX	118,700.5	102,458.1	89,223.18	48,775.37	27,152.97	30,762.72	56,224.66

As expected, a tax on CO_2 generates the smallest reductions in transportation sector emissions since it does not target a specific sector. Figure 2 does reflect however lower abatement levels caused by the additional VMT consumption under the rebound case – offsetting reductions achieved under the CAFE-MED case. Compared to our CAFE-MED scenario, inclusion of the rebound effect lowers average fuel cost per vehicle (Figure 3). We find that increases in capacity utilization for vehicles eligible for rebound – more specifically, the hybrid vehicles – results in less overall gasoline consumption relative to CAFE-MED – thereby lowering overall fuel costs. In fact, advanced gasoline vehicles that are once used in the CAFE-MED case are no longer utilized in the rebound case, as hybrid vehicles become the preferred vehicles of choice.

Figure 3: Average Fuel Cost Per Vehicle



	2015	2020	2025	2030	2035	2040	2045
BASE	$1,210.15	$1,299.27	$1,300.56	$1,226.00	$1,239.13	$1,219.56	$1,299.37
CAFE-MED	$1,224.05	$1,317.85	$1,267.09	$1,048.06	$1,040.71	$951.37	$1,026.93
CAFE-RBND	$1,221.88	$1,335.66	$1,247.99	$1,046.79	$1,059.16	$935.41	$1,000.02
CO2-TAX	$1,225.93	$1,298.50	$1,274.87	$1,247.14	$1,293.71	$1,347.31	$1,399.75