Assessing Consumer Valuation of Fuel Economy in Auto Markets

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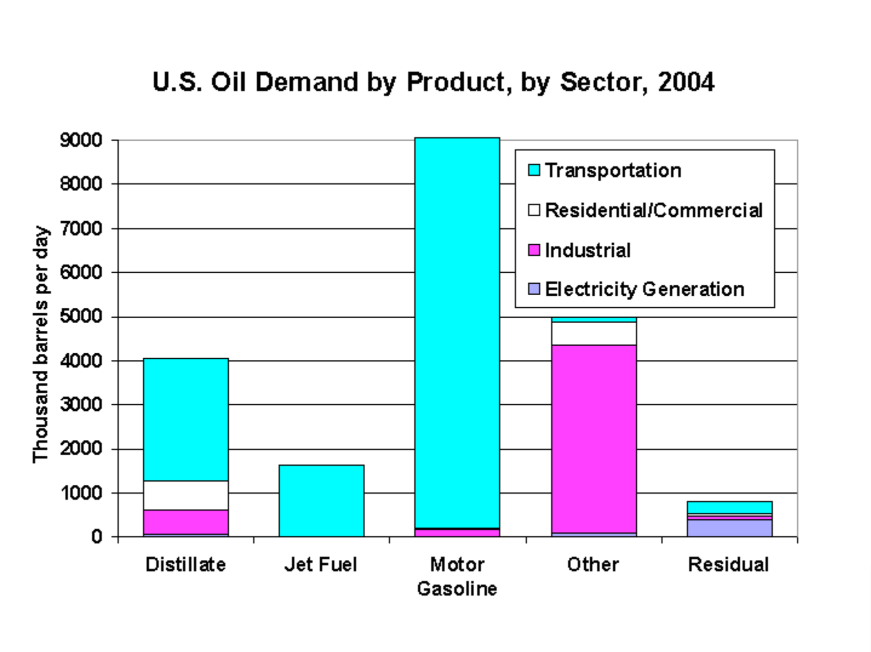
Introduction

Oil Demand and Automobiles:

Improving vehicle efficiency could have dramatic effects on oil demand and Greenhouse Gas (GHG) emissions

- •Transportation creates 13% of global GHG emissions [IPCC]
- •Gasoline accounts for 45% of U.S. oil consumption [EIA]



Legislating Efficiency - Carbon Tax v. CAFE Standards:

Currently, **Corporate Average Fuel Economy (CAFE)** standards require a minimum average fuel efficiency for automobile manufacturers

Some argue that a **tax on carbon emissions** is more robust and cost-effective than CAFE [Fischer (2004)]

- •CAFE fails to account for "rebound effect": Improved fuel economy spurs increased vehicle miles traveled (VMT) [Small and Van Dender (2006)]
- •A carbon tax creates incentives for all energy sectors, while CAFE only affects transportation sector

Unlike CAFE, a carbon tax assumes that consumers **rationally and correctly** value fuel economy when making purchasing decisions [Gerard (2003)]

- •Under a carbon tax, if consumers undervalue fuel efficiency, auto firms receive incorrect willingness to pay (WTP) signals, which decreases incentives for welfare-improving innovation. Thus, CAFE could more effectively spur development in energy efficiency.
- •Past models yield mixed results in assessing consumer myopia [Kahn (1986); Kilian (2006); Sallee and West (2008); Espey(2004)]

Our Goal:

We use novel data to heterogeneously evaluate consumer rationality with respect to automobile fuel efficiency. These results have great implications about the need for and efficacy of fuel economy standards.

Theoretical Background

Consumer Cost Minimization Problem:

Consumers minimize the cost of their vehicle, which includes the price of the vehicle on the lot plus costs at the pump:

Cost = Price of the Vehicle + Present Value of Gasoline Costs

$$C = P_V(F, X) + \sum_{t=0}^{T} P_{F,t} F M_t \delta_t$$

C - the present value cost of owning and operating the vehicle
P_V - the price ($) of the vehicle
E - efficiency (mpg)
F - 1 / E or (gallons / mile), termed "fuel intensity"
X - a vector of all other vehicle attributes
P_f - the expected fuel price ($/gallon)
M_t - the expected vehicle miles traveled (miles/ year)
T - the expected vehicle lifetime (years)
δ_t - the discount factor for year t

First Order Conditions:

On the Margin,

Cost of fuel economy = Value of fuel savings

$$-\frac{dP_V}{dF} = \sum_{t=0}^{T} P_{F,t} M_t \delta_t$$

• Rationality predicts that, all else equal, consumers choose fuel intensity such that the incremental cost of a more fuel-efficient vehicle (i.e. vehicle price) is equal to the incremental present value of expected cost savings from lower operating costs (i.e. fuel costs) over the life of the vehicle.

• Given independent information on the variables in equation (2), our project compares the left- and right-hand-side of the equation to ascertain the degree to which consumers do in fact minimize present value costs.

References

Energy Information Agency. (2009). *Official Energy Statistics from the US Government*, 2009

Espey, M. a. S. N. (2004). Automobile Fuel Efficiency: What is it Worth? *Clemson Un, Clemson University*

Fischer, C. a. W. H. a. W. H. P. (2004). Should Automobile Fuel Economy Standards be Tightened? *Resources for the Future*.

Gerard, D. a. L. L. (2003). The Economics of CAFE Reconsidered: A Response to CAFE Critics and A Case for Fuel Economy Standards. *AEI - Brookings Joint Center for Regulatory Studies*.

Greene, D. a. J. G. a. M. D. (2009). Fuel Economy: The Case for Market Failure. In D. a. J. C. Sperling (Ed.), *Reducing Climate Impacts in the Transportation Sector*: Springer Science + Business Media.

Kahn, J. A. (1986). Gasoline Prices and the Used Automobile Market: a Rational Expectations Asset Price Approach. *The Quarterly Journal of Economics, 101*(2), 17.

Kilian, L. a. E. R. S. (2006). The Effects of Real Gasoline Prices on Automobile Demand: A Structural Analysis Using Micro Data. *Manuscript, University of Michigan*.

Sallee and West. (2008). Testing for Consumer Myopia: the effect of gasoline price changes on the demand for fuel economy used in vehicles. *Draft for 2009 ASSA meetings, San Francisco*.

Small and Ven Dender. (2007). Fuel Efficiency and Motor Vehicle Travel: the Declining Rebound Effect. *Energy Journal, 28*(1), 25-51.

Model

Hedonic Price Analysis:

$$\boxed{-\frac{dP_V}{dF}} = \sum_{t=0}^{T} P_{F,t} M_t \delta_t$$

•A **hedonic price function** isolates a consumer's willingness to pay for a more fuel efficient vehicle:

$$P_v = \beta_0 + F' * GenSegm\beta + DetailSegm'\phi + X'\gamma + Year'\lambda + Fid'\theta + \varepsilon$$

•Data

P *New Car Prices*
R.L. Polk and Co. Car Stock Guide

F *Fuel Intensity (1/fuel economy or 1/MPG)*
Fueleconomy.gov

•Hedonic Regression

- ***Car and SUV buyers have low willingness to pay***
  $87 for a .001 increase in fuel intensity (or a 1 MPG increase for a car with 30 MPG)
- ***Van and Truck buyers have high willingness to pay***
  $468 and $549

Table 1: Regress Vehicle Price on F

Variable	Coefficient.	Std Err	t-stat
vans*gpm	-468,153	103508.6	-4.52
pickups*gpm	-549,569	95167.13	-5.77
(cars+SUVs)*gpm	-87,349	40142.99	-2.18
hp	29.91	6.06	4.93
wt	7.61	0.51	14.85
displacemnt	3,954.07	406.95	9.72
airbags	138.27	447.02	0.31
DetailSegment Dummies			
Year Dummies			
Manufacturer Dummies			
_cons	-11244.6	3391.639	-3.32
Number of obs	2048		
F(54, 1993)	220.5		
Prob > F	0		
R-squared	0.8542		
Adj R-squared	0.8504		
Root MSE	5696.8		

Present Value of Avoided Gas Cost:

$$-\frac{dP_V}{dF} = \boxed{\sum_{t=0}^{T} P_{F,t} M_t \delta_t}$$

•Calculation of vehicle lifetime fuel costs

• Data

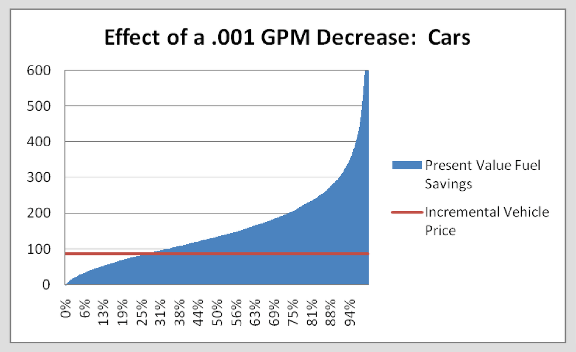
P *Fuel Costs*
ACCRA Cost of Living Index

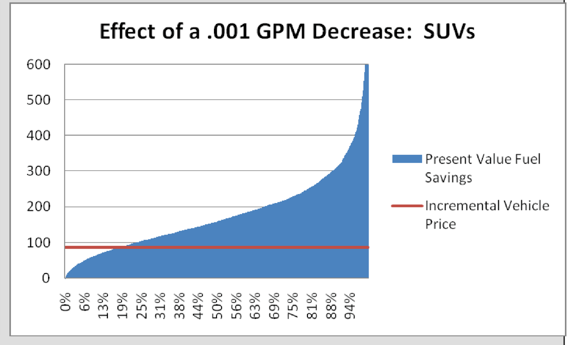
M *Driving Behavior (Annual vehicle miles travelled)*
National Highway Transportation Survey

δ *Discount Rate*
3% and 7% low/high-end assumptions

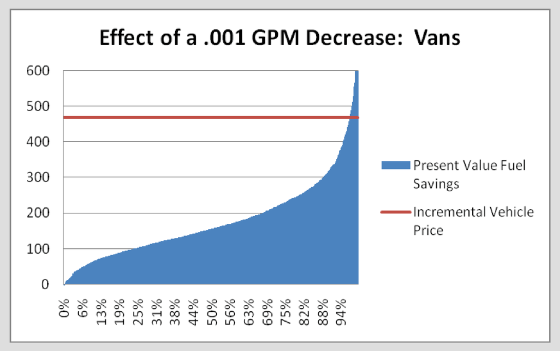
Results

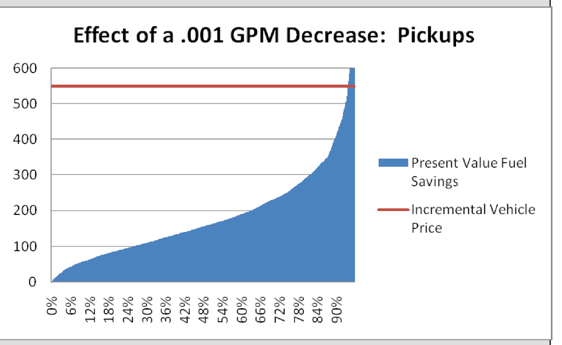
19-27% of car and 12-18% of SUV buyers overpay for their investment in fuel economy (above red line)





94-97% of van and 95-98% of truck buyers overpay





Why?

- ***Truck and Van markets may not be "dense"***
  - Trucks and vans are chosen for functionality (e.g. large truck beds, extra seats) which may be at technological odds with greater fuel economy.
  - Current technology does not allow the market to provide the greater fuel economy demanded.
- ***SUVs and Cars are not as often selected for specific functional requirements (other than transportation)***
  - Easily substitutable for greater fuel economy
  - Cars & SUVs often built on same chassis: technology - cost relationships are similar
- ***Risk aversion under uncertainty*** *(Greene, 2009)*
  - Car and SUV buyers are unwilling to pay a great upfront cost with so much uncertainty about the cost minimization problem

Conclusions

• Based on the price signals from consumer willingness to pay (WTP), manufacturers determine the fundamental relationship between efficiency technologies and cost.

• Low WTP for Cars and SUVs signals that consumers are not willing to take a bet on higher fuel economy

⟶ **CAFE standards are necessary for Car and SUV markets**

•High WTP signals for Truck and Vans should cause increased fuel economy without CAFE standards

⟶ **Technological / cost barriers (not manufacturer decisions) prevent efficiency in Truck and Van markets**

⟶ **CAFE not necessary for Trucks and Vans. A carbon tax could be more efficient.**