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# Fuel price increases and the timing of changes in household driving decisions

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ABSTRACT

Using the oil price increase of 1979 as a natural experiment and several event study specifications, this paper finds evidence that the oil spike induced significant decreases in carbon emissions on both the intensive (miles driven) and extensive (auto fuel efficiency) margins. Further, it appears that substitution on the intensive margin occurred instantaneously whereas extensive margin substitution occurred with a significant lag. Given the timing of the changes, the results appear robust to the implementation of Corporate Average Fuel Economy (CAFE) standards over the same time period. These findings have important implications for estimating demand elasticities for durable goods with respect to energy prices and the price elasticity of fuels themselves.



## 1. Introduction

In order to develop a portfolio of national policies aimed at reducing energy use and greenhouse gas (GHG) emissions, there is significant interest in identifying the mechanisms through which firms and consumers decide to purchase new, more energy efficient durable goods. Some economists have recently proposed the use of temporary taxes as an impetus for inducing "greener" capital purchases at the firm level [1]. Smart meters relaying real time data on household energy use patterns inform the optimal granularity of energy policy. The speed and degree that households respond to energy price changes is an important question that relies on household beliefs about future energy price time paths. One set of household durable goods receiving immense attention due to their contribution to GHG and particulate matter emissions are passenger vehicles. According to the EPA, over 27% of GHG emissions originated in the transportation sector in 2009.

In order to better understand how households would respond to a potential government policy designed to induce more energy efficient consumption patterns, significant attention is given to how consumers alter their driving behavior and car purchases in response to changes in gasoline prices and how consumers perceive future gas prices [21,13,19,24,29,2–5,15]. Recent work has examined how households decisions to purchase new cars respond to changes in fuel prices. Edelstein and Kilian [13] use a VAR specification to estimate how unexpected energy shocks have historically affected the composition of new auto sales. They find that households substitute to more fuel efficient cars and that total expenditures on new domestic autos fall relative to baseline due to decreased effective purchasing power. Klier and Linn [23] use within model year gasoline price fluctuations to identify the effect of gasoline price increases on the composition

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of new car purchases and, like Edelstein and Kilian [13], find that on average, gasoline price increases induce consumers to purchase relatively more fuel efficient cars. Li et al. [25] find that households respond more strongly to increases in gasoline prices due to changes in tax policy than increases due to equivalent but transitory changes driven by market conditions and offer expectations uncertainty as one potential explanation. A related question is the speed with which consumers purchase those more fuel efficient vehicles when gasoline prices change. If gasoline prices increase unexpectedly, the timing of household purchases of more fuel efficient vehicles is an important question dependent on switching costs, gasoline price expectations, and the certainty of those expectations. This paper builds on [23], which examines the average response of households to increases in fuel prices on the extensive margin, by asking how the timing of household responses to increases in fuel prices differ at the intensive and extensive margins.

Using an event study design for the oil price shock of 1979–1981 and data from the Environmental Protection Agency, Federal Highway Administration, and Energy Information Administration, this paper tests how an increase in gasoline prices affected the magnitude and timing of a fall in emissions from passenger vehicles. The oil price shock of 1979 is a plausible natural experiment to identify whether households respond to increases in gasoline prices differentially at the intensive and extensive margins. First, prices were relatively stable for years until April 1979 when they increased significantly and persisted at high levels over the next several years. Further, the oil price increase was largely predetermined with respect to US household behavior [19]. Our event study design identifies a significant effect of the oil price increases on both total passenger vehicle emissions and passenger vehicle emissions per mile driven. We find that households respond immediately by driving less as represented by emissions (intensive margin) when prices begin to rise, but they delay their decisions to make more fuel efficient driving decisions as represented by emissions per vehicle miles traveled (the extensive margin) by a significant amount.[1] These findings are robust to several specifications including robustness checks for the implementation of CAFE standards on new vehicles and macroeconomics fluctuations over the event time horizon.

It is important to note that the main contribution of this paper is using the 1979 oil price increase as a natural experiment to identify differential timing of intensive and extensive margin household responses to fuel price increases. Levels of responses on those margins, while important, are not the primary focus of this paper insofar as it matters for policy today. Specifically, Hughes et al. [16] and Edelstein and Kilian [13] show that households responded more inelastically in the short run to oil prices increases in the 2000s than in the late 1970s. However, we are not aware of any work that explicitly attempts to identify the relative timing of substitution on the intensive versus extensive margins in response to fuel price increases, nor a change in the timing of such responses across time.[2] The central finding in this study, asymmetric timing of intensive versus extensive margin substitution patterns, has modeling implications for household durable good purchases. As a result, this paper contributes to a larger literature identifying the mechanisms through which households alter their driving decisions. These mechanisms include the strength of household response to fuel price changes due to differential causes (e.g., policy changes versus changing market conditions), household perceptions of future energy prices, and the various mechanisms affecting intensive versus extensive margin driving decisions [25,5,15].

The remainder of the paper is as follows: a simple theoretical model shows that if oil prices follow a random walk, then consumers will immediately switch to a more costly vehicle that gets higher miles per gallon. Section 3 introduces the empirical specification, data, and estimates. The subsections discuss the findings and perform some robustness checks. Section 4 briefly concludes.

## 2. Theoretical model

This section develops a simple theoretical model which highlights the implications of increased fuel prices on the timing of changes in household driving patterns. We do not wish to characterize the universe of possible driving behaviors but rather draw attention to the theoretical implications of an increase in fuel prices on substitution along the intensive versus extensive margins through two main channels: miles driven and average MPG ratings of the auto fleet.[3]

Consider a model in which a representative household gains utility from a composite consumption good, $c$, and driving, $d$. Assume that utility is strictly concave in driving. Each household is endowed with some wealth level, $W_i$, and initially has a budget constraint $W_i = c + P_d d$. The price of driving is the quotient of the price of gasoline and vehicle miles per gallon (MPG): $P_d = P_g/\text{MPG}_0$. Assume that each household has the option of buying a new car with higher gas mileage, $\text{MPG}_1 > \text{MPG}_0$, for a fixed price of $K$ in every period.[4] If the household were to purchase the new car, they would maximize utility subject to the budget constraint $W_i - K = c + (P_g/\text{MPG}_1)d$. As a result, the household's indirect utility function can be

[1] Throughout the paper we claim that emissions per vehicle mile travel is a good measure of fleet fuel efficiency due to GHG emissions being directly proportional to gallons of gasoline consumed.

[2] To be clear, many studies attempt to control for various timing issues between margins, but they do not explicitly attempt to identify these margins.

[3] A referee made the very astute point that there are several channels that could affect miles driven and MPG of the fleet in ways beyond the scope of the model developed here, such as carpooling or more fuel efficient driving behavior. These are valid additional channels to consider but leave a more complete theoretical model to future work.

[4] This assumption is tantamount to assuming perfectly functioning credit markets.