Pain at the Pump: How Gasoline Prices Affect Automobile Purchasing in New and Used Markets*

Meghan R. Busse

Northwestern University and NBER

Christopher R. Knittel

University of California, Davis and NBER

Florian Zettelmeyer

Northwestern University and NBER

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Addresses for correspondence: E-mail: m-busse@kellogg.northwestern.edu, crknittel@ucdavis.edu, f-zettelmeyer@kellogg.northwestern.edu

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Abstract

In this paper we investigate how gasoline prices affect equilibrium prices and market shares for cars of different fuel efficiencies in both the new and used car markets. We find that, in general, when gasoline prices increase, prices fall and market shares decrease for fuel-inefficent cars, and the reverse for fuel-efficient cars. However, the relative magnitudes of these effects differ dramatically between the new and used car markets: in the new car market, the adjustment is primarily in market shares, while in the used car market, the adjustment is primarily in prices. We explore reasons for these differences between the markets.

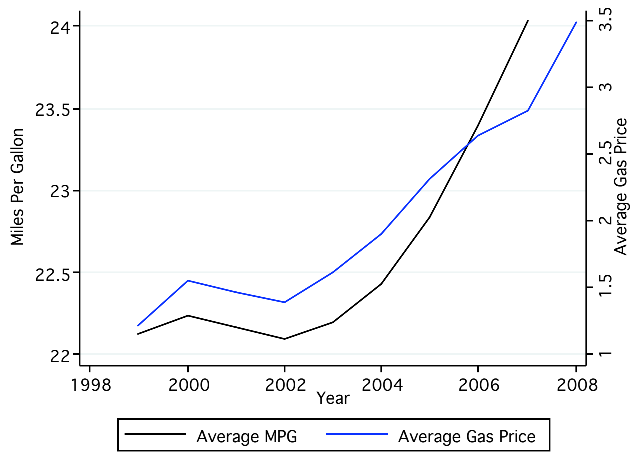
1 Introduction

Over the past several years, the automobile industry has been in a period of dramatic turbulence. There have been large movements in gasoline prices, taking retail prices to their highest real values ever (Energy Information Administration, *Short Term Energy Outlook*, January 2007). The Ford F150 pickup fell from its longstanding position as the highest selling car in the U.S. in favor of the Honda Civic (Automotive News, June 5, 2008), while GM lost its position to Toyota as the worldwide leader in new car sales (Barron's, January 21, 2009). Finally, the deteriorating financial situation of the major U.S. car manufacturers led to special hearings before Congress to consider a bailout package for the auto industry, an indicator of the importance of the car industry (from parts suppliers to neighborhood dealerships) in the U.S. economy. In this paper, we investigate a relationship in the car industry that connects all these events: the role of gasoline prices in influencing what cars people buy.

Because cars are durable goods, potential customers must consider not only the initial cost of acquiring a car, but also the ongoing costs of operating the car. These ongoing costs include insurance, fuel, maintenance, repair, depreciation, and financing. While the relative sizes of these costs will vary across car owners, fuel costs will be a large component for most. Fuel costs will also vary across vehicles. The larger and heavier a vehicle and the greater its horsepower, the greater its rate of fuel consumption will be. Various technologies can improve this tradeoff, but not eliminate it entirely. Thus, when gasoline prices increase, we expect that for many customers size and power will become less desirable features of a vehicle relative to fuel efficiency, and consequently we would expect to see changes in the equilibrium mix of models purchased. Figure 1 offers some coarse evidence of such a trade-off in the raw data. The blue line in Figure 1 shows the average gasoline price in the U.S. between 1999 and 2008, measured in dollars per gallon and scaled on the left axis. The black line graphs the sales-weighted average miles per gallon (MPG) of new cars purchased in the U.S. each year; the MPG scale is on the right axis. The two lines track each other quite noticeably. In this paper, we investigate the effects of gasoline prices on what cars customers buy and what prices they pay for them.

While the fortunes of the auto manufacturers will be affected most directly by what happens in the new car market, increasing gasoline prices will also affect markets for used cars, arguably the largest, most active, and most accessible of any durable good resale market. The two markets are linked not only on the demand side by the substitutability of new and used cars, but on the supply side, since many new car purchases are dependent on the ability of a

Figure 1: Average MPG of available cars by model year



customer to sell his or her existing car, either on the used car market or as a trade-in. There is a long literature that has investigated the interaction of new and used markets for durable goods, emphasizing primarily issues of dynamic consistency in pricing, optimal durability, obsolescence, and asymmetric information. (Hendel and Lizzeri (1999) model some similar issues to those in this paper. See Waldman (2003) for a survey.) In this paper, we investigate empirically how a change in ongoing usage costs affects the equilibrium outcomes in two markets (new and used), and whether it affects them differently.

As we describe in greater detail below, we find that gasoline prices affect both market shares and prices in both new and used markets, and that the effects vary according to the fuel efficiency of different cars. The results differ across the two markets, with the market share effect being larger in the new car market than in the used car market, and the price effect being much larger in the used car market than in the new.

This paper proceeds as follows. In the next section, we describe the intuition for how a change in gasoline prices might affect the new and used markets for cars. In Section 3, we describe the data used in the paper. Section 4 is the main body of the paper. It describes the empirical specifications used to investigate the effect of gasoline price on the prices and market shares in the new and used car markets, and reports the results of those estimations. Section 5 describes supporting evidence for our findings in Section 4, and Section 6 concludes.

2 Gasoline prices and new and used car markets

In this section, we discuss the intuition for what effect gasoline prices would be likely to have on the demand and the supply of both new and used cars.

2.1 Gasoline price and car demand

An increase in the price of gasoline will increase the usage costs for all automobiles, although the cost-per-mile increase will be greater for less fuel-efficient cars. If there were sufficiently attractive substitutes for cars as a whole, we might expect across-the-board increases in usage costs to decrease demand for all car models. For what is probably the vast majority of car owners, however, abandoning car ownership entirely and instead relying completely on other forms of transportation is unlikely to be a realistic choice.[1] If this is the case, we expect demand for cars in general to be inelastic to changes in fuel prices. Instead, we should see relative changes in demand for cars of different fuel efficiencies. Specifically, in both the new car and used car markets, we expect to see demand increase for fuel-efficient cars and decrease for fuel-inefficient cars when gasoline prices increase. This could lead, however, to very different equilibrium outcomes in the two markets because of differences on the supply side.

2.2 Gasoline price and new car supply

New cars are supplied by auto manufacturers via a network of legally separate but captive retail dealerships. Whether the increased demand for high-fuel efficiency cars and decreased demand for low fuel-efficiency cars will show up primarily in the prices or in the market shares of new cars depends on the elasticity of the combined response in this supply chain. There are several reasons to think that supply may not be perfectly inelastic, and that therefore at least part of the response will show up in quantities. First, automobile manufacturers and dealers both have the ability to absorb increases in inventory. While holding inventory of something as large as a car is costly—both in terms of storage costs and in terms of working capital—system-wide inventory routinely varies between 10 and 150 days of inventory (Automotive News Data Center).

Second, while many production costs are fixed in nature (such as model-specific production plants and labor contracts that pay employees nearly the same whether or not they are

[1] There are, of course, exceptions: customers in dense urban areas, who have access to public transportation or car-sharing arrangements such as ZipCar.

producing cars) production is still flexible to some degree, especially over a horizon of months. Bresnahan and Ramey (1994) found that on average, auto plants are shut down for almost seven weeks per year. While some of this is for model changeover, or accidental events such as fires, Bresnahan and Ramey estimate that 25-50% of the plant closures are for inventory adjustments.

Third, auto manufacturers are reluctant to cut prices on new cars. As Busse, Silva-Risso, and Zettelmeyer (2006) show, this does happen quite regularly via rebates offered by manufacturers either to customers or dealers. However, manufacturers are very concerned about how this affects customers' price image of a car, and what inferences customers might make about the quality of a car if a rebate is offered. Indeed, customer rebates are used least frequently by manufacturers whose cars have the highest reputation for quality and reliability (such as BMW, Audi, Porsche, Honda, and Toyota). Since car dealers have moderate margins on most new car sales, dealers often have limited scope for price-cutting without losing money on each transaction unless manufacturers offer rebates.

Part of the reason that new car manufacturers can choose to maintain prices on their new cars (and adjust market share instead) is that a manufacturer arguably has market power in the sale of a particular car. This means that the manufacturer should consider the elasticity of demand for that car before reducing prices. If there are enough inframarginal customers with inelastic demand for a low fuel efficiency vehicle, then the manufacturer may be better off leaving prices at their existing levels and losing the marginal sales when gasoline prices rise, rather than trying to lower prices in order to preserve sales volume. For example, if 85% of the buyers of a particular SUV continue to have the same willingness-to-pay, even if gasoline prices increase, it may be more profitable to keep prices at the original level than to lower prices in order to retain the marginal 15% of customers who will be inclined to switch to another vehicle.[2]

While the elasticity of the supply response in new cars is an empirical question, these points all argue for why we may see a substantial response in market share to changes in gasoline price, instead of or in addition to a response in price.

[2] A simple linear example shows one version this intuition. Consider a monopolist with constant marginal cost c per unit who faces one of two possible demand curves, D_1 which is given by $P = a - b_1 Q$ and D_2 given by $P = a - b_2 Q$, where $b_2 > b_1$. In this case, the profit maximizing quantity will be lower when the monopolist faces demand curve D_2, but the profit-maximizing price will be the same in the two cases: $P^* = \frac{1}{2}(a + c)$. This example abstracts away from price discrimination; despite its incompleteness, however, the intuition remains.

2.3 Gasoline price and used car supply

Supply in the used car market is very different from supply in the new car market. Used cars are supplied by current car owners who decide to trade-in or sell their car, often in conjunction with buying a replacement car (either new or used). In the used car market, therefore, the supply decision will depend on how sensitive individual consumers are to the price of gasoline, and how that affects a customer's relative valuations of the car that he or she currently owns and a different car that he or she might buy. In considering the effect of gasoline prices on the equilibrium in the used car market, we therefore have to consider the effects on both potential suppliers and potential buyers of used cars.

One might expect the effects on buyers and suppliers to be symmetric: for both the current owner and a potential buyer of a particular used car, the increased cost of usage for the current owner of that car if he or she keeps the car will exactly equal the increased cost of usage for the potential buyer, if the two have similar driving habits. In other words, one might expect an increase in gasoline prices to reduce the willingness-to-pay for a particular car by about the same amount that it reduces a potential supplier's willingness-to-accept for that car. This would imply that the demand curve for a used car and the supply curve for that car would shift down by approximately the same amount. If this were the case, then the prices of a particular used car should adjust to reflect the value of the fuel expenditure disadvantage (or advantage) that car has, given the new gasoline prices.[3]

This explains why we would see large effects of gasoline price changes on the prices of used cars. What market share effects should we expect to find? In used cars, we might expect to see rather small market share effects for the following reason. An owner of a low fuel efficiency car may wish to respond to an increased gasoline price by selling her current car and replacing it with a high fuel efficiency car. Alas, the price that the owner can obtain for the low fuel efficiency car will have fallen just at the time that she wishes to sell the car or trade it in. This increases what she has to spend in order to replace her low fuel efficiency car with a high fuel efficiency car; in equilibrium, we might expect the price differential to be approximately equal to the fuel expenditure savings she can obtain. If that is the case, we should see little trade on the used car market for gasoline price motivated reasons, resulting in only small, if any, market share changes in conjunction with gasoline price changes.

[3] If customers are heterogeneous in driving habits, then this need not be true. However, the more similar are the marginal customers, the more we would expect to see the primary effect of fuel price changes in price rather than in quantity.

An additional difference between the supply of new cars and the supply of used cars is that there is arguably market power in the supply of new cars (manufacturers have an ability to set prices for new cars), where there is arguably not in the supply of used cars. This is particularly the case because of the large volume of used cars traded weekly at auction throughout the country. Auctions are a major clearinghouse for wholesale used cars and are ubiquitously available throughout the country. (For example, Manheim, which is the largest operator of used car auctions in the U.S., has about 100 sites throughout the U.S.) This means that for car dealers, used cars are convertible into cash, and thereby into different used cars, at auction-determined prices on a weekly basis. This mechanism should help move the prices of used cars sold at car dealerships fairly quickly to a new, market clearing equilibrium price that reflects changes in gasoline prices. While this may not happen as quickly in sales between private parties, the data used in this paper are from used car sales at car dealerships, making that the relevant distribution channel here. The ready accessibility of auto auctions as a market-clearing mechanism is another reason for the adjustment to higher gasoline prices to show up more in prices of used cars than in market shares.

2.4 Literature review

There is a long-standing literature investigating the determinants of automobile sales. (The earliest papers we have found pre-date World War II.) There is also a large literature, dating from the first energy crisis that investigates the relationship between fuel efficiency and gasoline prices. Our paper is also related to more recent literatures on automobile demand estimation, and on the role of gasoline prices in car choices. Our results with respect to market shares are closely related to estimation of demand for automobiles. A number of discrete choice demand models exist for which mileage, or an estimate of dollars per mile, is a characteristic in the indirect utility function.[4] Typically, the influence of gasoline prices is not the focus of these papers. Two exceptions are Klier and Linn (2008) and Sawhill (2008). Klier and Linn (2008) estimate an aggregate data logit model using monthly sales data from 1970 to 2007. Consistent with our results, they find that fuel economy increases by 1.08 MPG for a dollar increase in gas prices. Sawhill (2008) estimates the implicit discount rate that consumers use when trading off upfront costs with future fuel costs. Using aggregate market share data, he finds significant heterogeneity in this utility parameter; however it is uncertain whether the heterogeneity is

[4]For example, see such seminal papers as Goldberg (1995) and Berry, Levinsohn, and Pakes (1995).

also measuring the variation in miles driven across consumers.[5] Langer and Miller (2008) capture one component that is related to our price results. They look at how automobile incentives respond to gasoline prices. They have data on listed rebates and incentives, but do not observe the extent to which consumers take advantage of these incentives or how they are shared between consumers and dealers.

3 Data

We have combined several types of data for this analysis. Our main data contains automobile transactions from a sample of 15-20% of all dealerships in the U.S. from September 1, 1999 to June 30, 2008. The data were collected by a major market research firm, and include every new car and used car transaction within the time period for the dealers in the sample. For each transaction we observe the exact vehicle purchased, the price paid for the car, the dealer's cost of obtaining the car from the manufacturer, information on any trade-in vehicle used, and (census-based) demographic information on the customer. We will discuss in detail the variables used in each specification later in the paper.

We have supplemented these transaction data with data on car models' fuel consumption and data on gasoline prices. The fuel consumption data are from the Environmental Protection Agency (EPA). We define the fuel consumption of each car model as the "EPA Combined Fuel Economy" which is a weighted average of the EPA Highway (45%) and City (55%) Vehicle Mileage. As shown in Figure 2, the average MPG of models available for sale in the United States showed a pattern of slow decline in the first part of our sample period, and some increase in the latter part.[6] Overall, however, the average MPG of available models (not sales-weighted) stayed between 21.5 and 22.5 miles per gallon for the entire decade.[7]

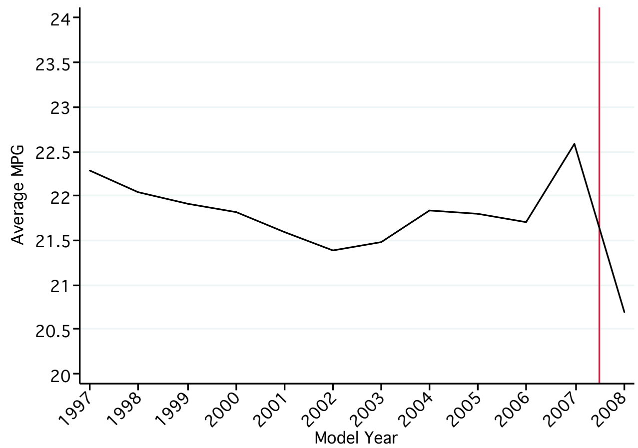
The gasoline price data are from OPIS (Oil Price Information Service) and cover January 1997 to June 2008. OPIS obtains gasoline price information from credit card and fleet fuel card "swipes" at a station level. We purchased monthly station level data for stations in 15,000 ZIP codes. Ninety-eight percent of all new car purchases in our transaction data are made

[5]Sawhill (2008) has data on the distribution of miles driven across the population which allows him to match a population moment, however he is not able to match correlations between a consumer's discount rate and miles driven.

[6]The sharp decline in MPG observed in 2008 coincides with a change in how the EPA calculates MPG.

[7]While *cars* changed fairly little in terms of average fuel efficiency over this period, this does not mean that there was no improvement in technology to make *engines* more fuel efficient. The average horsepower of available models increased substantially over the sample years, a trend that pushed toward higher fuel consumption, working against any improvements in fuel efficiency technology.

Figure 2: Average MPG of available cars by model year



by buyers who reside in one of these ZIP codes. In order to create ZIP-code level gasoline prices, we average the prices for basic grade over all stations in each 4-digit ZIP code. We use 4-digit ZIP codes as our level of aggregation instead of 5-digit ZIP codes in order to increase the number of stations going into the calculation of each average.[8] (In the remainder of the paper, "ZIP code" should be understood to imply 4-digit ZIP code, even if it is not explicitly specified as such.) As shown in Figure 3, there is substantial variation in gasoline prices in our sample period. Between 1999 and 2008 average national gasoline prices were as low as $1 and as high as $4. While gasoline prices were generally trending up during this period there are certainly months where gasoline prices were lower than in months prior.

There is also substantial regional variation in gasoline prices. The left hand side of Figure 4 illustrates this by comparing California and Oklahoma average monthly gasoline prices (with the national average as a reference). Not only are California gasoline prices substantially higher than prices in Oklahoma, there is also variation in how much higher California prices are. There is also substantial dispersion of gasoline prices within states. The right hand side of Figure 4 shows the distribution of monthly gasoline prices in California.

More formally, to understand how much of the variation in gasoline prices comes from regional variation as opposed to variation over time, we decompose the standard deviation into between and within components. The overall mean of gasoline prices between January 1999

[8] In our data, the median 4-digit ZIP code reports data from 11.5 stations on average over the months of the year. The 25th percentile 4-digit ZIP code reports data from 5.5 stations on average over the year, and the 75th percentile 4-digit ZIP code from 21.8 stations.

Figure 3: Monthly national average gasoline prices

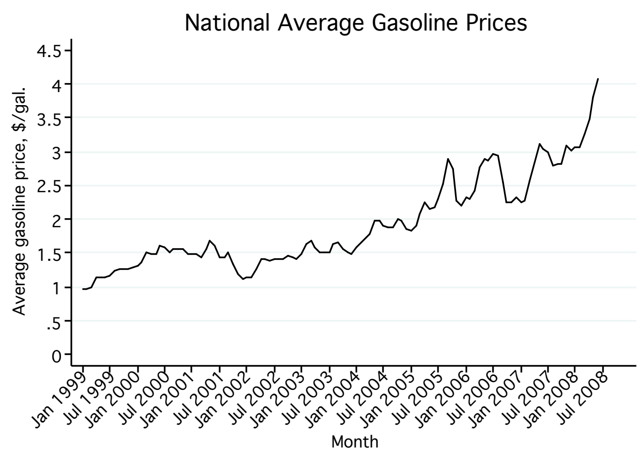


Figure 4: Examples of gasoline prices variation

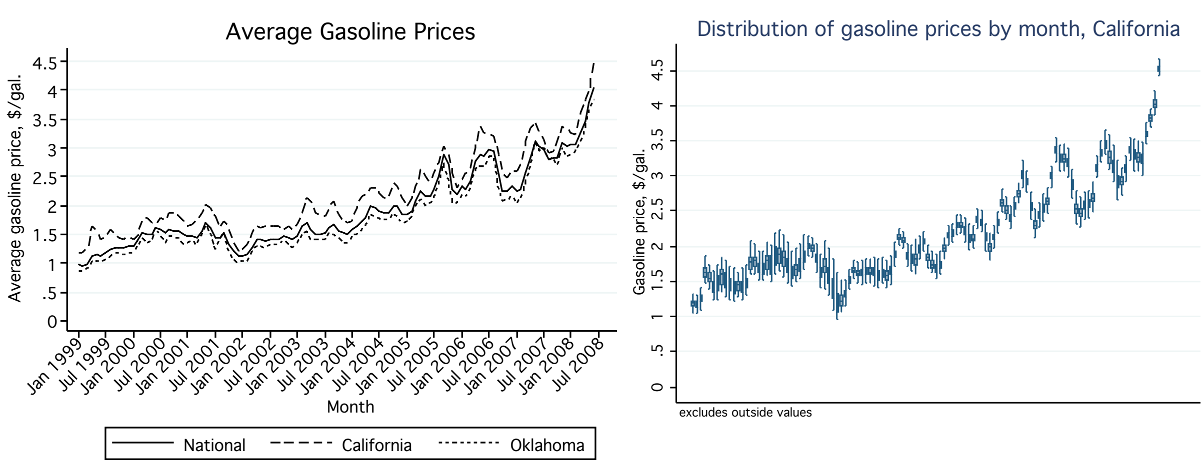
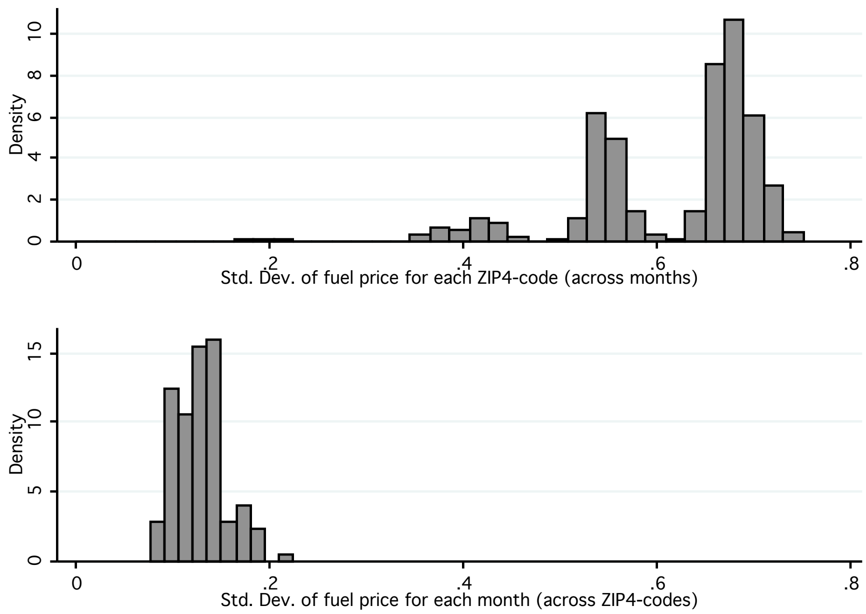


Figure 5: Variation in gasoline prices across and within region



and June 2008 is $1.90. The overall standard deviation is 0.66 whereas the "between" ZIP code standard deviation is 0.42 and the "within" ZIP code standard deviation is 0.62. A second approach to assess the variation in the data is to calculate (1) for each 4-digit ZIP code in the sample the standard deviation of gasoline prices across months and (2) for each month in the sample the standard deviation of gasoline prices across 4-digit ZIP codes. Figure 5 shows a histogram of the two sets of standard deviations. The figure suggests that while more variation in the gasoline data occurs over time, there is also substantial geographic variation.

To create our final datasets we draw a 10% random sample of all transactions. After combining the three datasets this leaves us with a new car dataset of 1,866,366 observations and a used car dataset of 1,264,092 observations. Tables 1 and 2 present summary statistics for the two datasets.

4 Main Results

In this section, we estimate the effect of gasoline prices on the market shares of cars of different levels of fuel efficiency, and the associated equilibrium price effects. We estimate these effects first for the new car market, and then for the used car market.

4.1 New car market shares

We first investigate the effect of gasoline prices on new car market shares.

4.1.1 Specification and variables

At the most basic level, our approach is to model the effect of covariates on equilibrium price and quantity outcomes. We do this using a reduced form approach. In completely generic terms, this would mean regressing observed quantities (Q) on demand covariates (X^D) and supply covariates (X^S):

$$Q = \alpha_0 + \alpha_1 X^D + \alpha_2 X^S + \nu \tag{1}$$

In this case, the estimated $\hat{\alpha}$'s would neither estimate parameters of the demand curve nor of the supply curve, but would instead estimate the effect of each covariate on the equilibrium Q, once demand and supply responses were both taken into account.

What we estimate in practice is a variant of this. First, we choose to focus on market share as an outcome variable rather than unit sales because this controls for the substantial aggregate fluctuation in car sales over the year. Our demand covariates are gasoline prices (the chief variable of interest), customer demographics, and variables describing the timing of the purchase, all described in greater detail below. We also include year fixed effects, and region-specific month-of-year effects. Supply covariates should presumably reflect costs of production of new cars (raw materials, labor, energy, etc.). We expect that these vary little within the year and region $\times$ month-of-year fixed effects already included in the specification. Furthermore, short- to medium-run manufacturing and pricing decisions for automobiles are not made on the basis of small changes to manufacturing costs. While we realize that almost any model of profit maximization an economist would write down would have pricing and production depend on costs, our interactions with executives responsible for these decisions at car manufacturers indicate that this is not the way short- to medium-run pricing and manufacturing decisions are made in practice.

This leaves us with the following specification. We estimate the effect of gasoline prices on market shares of models of different fuel efficiencies using a series of linear probability models that can be written as:

$$I_{irt}(j \in K) = \gamma_0 + \gamma_1 \text{GasolinePrice}_{it} + \gamma_2 \text{Demog}_{it} + \gamma_3 \text{PurchaseTiming}_{jt} + \tau_t + \mu_{rt} + \epsilon_{ijt} \tag{2}$$

$I_{irt}(j \in K)$ is an indicator that equals 1 if transaction i in region r on date t for car type j

was for a car in class K. We will consider a series of different classes in this section, namely fuel efficiency quartiles, segments (e.g., midsize, SUV, compact), and subsegments (e.g., entry compact, premium compact, mini SUV, compact SUV). The variable of primary interest is *GasolinePrice*, which is specific to the month in which the vehicle was purchased and to the 4-digit ZIP code of the buyer.

We use an extensive set of controls. First, we control for a wide range of demographic variables ($Demog_{it}$), namely the income, house value and ownership, household size, vehicles per household, education, occupation, average travel time to work, English proficiency, and race of buyers by using census data at the level of "block groups," which, on average, contain about 1100 people.[9] We also control for a series of variables that describe purchase timing ($PurchaseTiming_{jt}$). These variables include: a dummy variable *EndOfYear* that equals 1 if the car was sold within the last 5 days of the year; a dummy variable *EndOfMonth* that equals 1 if the car was sold within the last 5 days of the month and a dummy variable *WeekEnd* that specifies whether the car was purchased on a Saturday or Sunday. If there are volume targets or sales on weekends, near the end of the month or the year, we will pick them up with these variables. Finally, we control for the year (τ_t), and the month of the year (μ_{rt}) in which the purchase was made. We allow the latter to vary by the geographic region (29 throughout the U.S.) in which the car was sold. This takes into account that the seasonal preference for specific car classes may vary by region of the country.

Because we are estimating a reduced form, our estimate of γ_1 will be a compound of the effect of gasoline prices on the demand for automobiles and the effect of gasoline prices (if any) on the supply of automobiles. Supply can affect the estimates of γ_1 in two ways, through the price elasticity of the supply relationship, or because gasoline prices affect supply directly, through costs, for example. One might believe that direct marginal cost effects to be small since gasoline is, in fact, not a particularly significant input into the manufacture of automobiles. Of course, one reason gasoline prices fluctuate is because of fluctuation in oil prices. Oil is, to some extent, an upstream input of cars (through plastics, for example). However, this may also not be a significant effect in the short- to medium-run because, as described above, pricing and production decisions in this time frame are not based on small production cost changes.

[9] One might argue that our specification should not hold the demographics of buyers constant for the following reason: Any change in market shares of fuel-efficient vs. fuel inefficient cars due to changes in demographics associated with fuel price changes can legitimately be considered to be part of the short-run equilibrium market share effect of changing gasoline prices. Therefore we have estimates all of our sales specifications without demographic covariates and find that our qualitative results are robust to the exclusion of the demographic variables.

Finally, note that our estimates should be interpreted as estimates of the short-run effects of gasoline prices. By "short-run" we mean effects on market shares and prices holding fixed the configuration of cars made available collectively by car manufacturers. Persistently higher gasoline prices would presumably cause manufacturers to change the kinds of vehicles they choose to produce, as U.S. manufacturers did in the 1970s at the time of the first oil price shock.[10] The nature of our data, its time span, and our empirical approach are all unsuited to estimating what the long-run effects of gasoline price would be on market shares and prices. The short-run estimates are nevertheless useful, we believe, both because short-run effects are important in the short-to-medium term (especially if financial solvency is an issue) and because they yield some insight into the size of the pressures to which manufacturers are responding as they move towards the long run.

4.1.2 Market share results

We first consider the effect of gasoline prices on the market shares of different classes of fuel efficiency. Specifically, we classify all transactions in our sample by the fuel efficiency quartile (based on the EPA Combined Fuel Economy MPG rating for each model) into which the purchased car type falls. Quartiles are re-defined each year based on the distribution of all models *offered* in that year. The table below reports the quartile cutoffs and mean MPG within quartile for all years of the sample. (Note that the effect of the change in the EPA rating system can be seen in the abrupt change between 2007 and 2008. Our estimates include fixed year effects which will capture level shifts in the EPA rating system.)

Modelyear	MPG Q1 Mean	25th Pctile	MPG Q2 Mean	50th Pctile	MPG Q3 Mean	75th Pctile	MPG Q4 Mean
1999	16.0	18.3	20.1	22.2	23.3	24.7	27.7
2000	16.2	18.3	19.9	21.8	23.1	24.3	27.6
2001	16.0	17.7	19.3	21.2	22.7	24.2	27.7
2002	15.9	17.4	19.1	21.2	22.5	24.1	27.6
2003	15.8	17.4	19.3	21.3	22.6	24.1	27.7
2004	16.3	17.8	19.4	21.2	22.7	24.5	28.4
2005	16.2	18.3	19.8	21.6	22.8	24.5	28.3
2006	16.4	17.8	19.3	21.2	22.5	24.3	28.2
2007	17.1	18.7	20.4	21.8	23.4	25.3	29.4
2008	15.6	17.3	18.5	20.1	21.5	23.2	26.6

In order to estimate Equation 2 with car class defined by MPG quartile, we define four different dependent variables. The dependent variable in the first estimation is "1" if the

[10] As gas prices began to fall in the early 1980s, CAFE standards also affected manufacturer offerings.

purchased car is in fuel efficiency quartile 1, "0" otherwise. The dependent variable in the second estimation is "1" if the purchased car is in fuel efficiency quartile 2, "0" otherwise, and so on. To account for correlation in the errors due to either supply or demand factors, we cluster the standard errors at the level of the local market (as defined by Nielsen Designated Market Areas, or "DMAs" for short).

The full estimation results are reported in Table A-1. The gasoline price coefficient (γ_1) for each estimation are presented below.[11] We also report the standard errors of the estimates, and the average market share of each MPG quartile in the sample period. (Note that the quartiles are based on the distribution of available models while the market share is sales-weighted, which is why market shares need not be 25% for each quartile.) Combining information in the first and third column, we report in the last column the percentage change in market share that the estimated coefficient implies would result from a $1 increase in gasoline prices.

Fuel Efficiency	Coefficient	SE	Mean market share	% Change in share
MPG Quartile 1 (least fuel-efficient)	-0.037**	(0.0077)	20.9%	-17.7%
MPG Quartile 2	-0.019**	(0.0051)	21.2%	-9.0%
MPG Quartile 3	-0.0046	(0.0033)	23.7%	-1.9%
MPG Quartile 4 (most fuel-efficient)	0.06**	(0.0088)	34.2%	17.5%

These results suggest that a $1 increase in gasoline price will decrease the market share of cars in the least fuel-efficient quartile by 3.7 percentage points, or 17.7%. Conversely, we find that a $1 increase in gasoline price will increase the market share of cars in the most fuel-efficient quartile by 6 percentage points, or 17.5%. This provides evidence that higher gasoline prices are associated with the purchase of more fuel-efficient cars. [12] Notice that these estimates do not simply reflect an overall trend of increasing gasoline prices and increasing fuel

[11] We do not restrict the γs to sum to zero; the sum equals 0.0006.

[12] In these results, and in all the results that follow, we use as our measure of *GasolinePrice* the gasoline price for the month of the transaction in the buyer's 4-digit ZIP code. There are a variety of other measures we could choose. We have repeated all of the main results in Section 4 using *GasolinePrice* interacted with indicators for whether the gasoline price falls in the range "< $1.50," "$1.50-$2.50," "$2.50-$3.50," or ">$3.50." The purpose is to see whether there is an inflection point of gasoline prices at which the effects suddenly kick in, or at which they grow much larger. Summarizing over many results, gasoline prices do have somewhat different effects at different price levels, but there is little evidence of a sudden inflection. See Tables A-12 and A-13 for a summary of these results; full results are available from the authors. We have also repeated the main results of this section interacting *GasolinePrice* with whether gasoline prices went up monotonically in the previous three months, went down monotonically in the previous three months, or had some kind of mixed pattern. These results also show some differences, but do not have a consistent enough pattern to draw conclusions about systematic differences in effects under the three conditions. See Tables A-14 and A-15 for a summary of these results; full results are available from the authors. Another approach is to use a variable that represents gasoline price expectations, perhaps based on futures prices for crude oil. One might argue on theoretical grounds that this is the price customers should use in calculating the usage cost of a durable good. In practice, futures prices for crude oil at any point in time are quite highly correlated with current gasoline prices. As a result, we have not undertaken this approach.

efficiency; since we control for year fixed effects, all estimates rely on within-year variation in gasoline prices and associated purchases.[13]

Next we consider the effect of gasoline prices on the market shares of different car classes as defined by industry segments. The industry uses a standard classification of eight segments: "Compact Car" (e.g., Toyota Corolla), "Luxury Car" (e.g., Lexus LS430), "Midsize Car" (e.g., Honda Accord), "Pickup" (e.g., Ford F150), "Sport Utility Vehicle (SUV)" (e.g., Jeep Grand Cherokee), "Sporty Car" (e.g., Mitsubishi Eclipse), "Van" (e.g., Toyota Sienna) , and "Fullsize Car" (e.g., Ford Crown Victoria).[14] We estimate the specification in Equation 2 for each of seven segments (we exclude full-size cars since very few of them are sold). The dependent variable in the first estimation is "1" if the purchased car is a "Compact Car", "0" otherwise. We proceed similarly for the other segments.

The full estimation results are reported in Table A-2. The relevant estimates of the fuel price coefficient from these specifications are presented below. In addition to the coefficient estimates, the table reports the standard errors (clustered again at the DMA level) and the average market shares of each segment over the sample period. The last column of the table presents the percent change in market share of each segment implied by a $1 increase in gasoline prices.

Segment	Coefficient	SE	Mean Market Share	% Change in Share
Compacts	0.036**	(0.005)	17.4%	20.7%
Midsize	0.013*	(0.0053)	20.3%	6.4%
Sporty Cars	0.0047**	(0.0018)	4.0%	11.8%
Luxury	0.00045	(0.0029)	9.4%	0.5%
SUVs	-0.031**	(0.0086)	28.0%	-11.1%
Pickups	-0.013**	(0.0037)	14.3%	-9.1%
Vans	-0.0099**	(0.0016)	6.7%	-14.8%

These results show an outflow of consumers from SUVs, pickups, and vans (which are the lowest fuel-efficiency segments; see Table 3). These segments lose 3.1, 1.3, and 1 percentage points of market share, respectively, which corresponds to 11.1%, 9.1%, and 14.8% reductions of the respective market shares. The largest segment market share change is the gain of 3.6 percentage points, a 20.7% increase, for compact cars, the most fuel-efficient segment. Midsize cars also increase their market share by 1.3 percentage points, a 6.4% gain. The market share of sporty cars also increases. While this might seem surprising, this category contains many small

[13] Nor are they due to seasonal correlations between gas prices and the types of cars purchased at different times of year, since the regressions control for region-specific month-of-year fixed effects.

[14] See Table 3 for more examples of cars in each segment.

2-door coupes, some with fuel efficiency close to that of compact cars. We find no statistically significant effect for luxury cars. One possibility is that luxury cars both gain and lose as a result of gasoline price changes. For example, one could imagine that some buyers opt for a luxury sedan instead of a luxury SUV if gasoline prices increase, while others substitute from a luxury sedan to a more economical midsize car in response to the same gasoline price increase. An alternative explanation is that fuel efficiency is simply not a decision criterion for the purchase of luxury cars, or that buyers who buy such cars are fairly insensitive to the price of gasoline, perhaps because they are wealthier than the average car buyer. Overall there is a meaningful shift in the composition of segment shares in response to a gasoline price change that is well within the magnitude of gasoline price changes seen in the last decade.

Finally, we look at a finer classification of cars. Specifically, we split each segment into two to four subsegments according to the standard industry definition of a subsegment (see Table 3 for a list of subsegments and examples of cars in each subsegment). This allows us to check whether gasoline price increases affect all cars in a segment equally. One might expect that it should not. For example, the pickup category contains both fuel-efficient compact pickups (e.g., Ford Ranger) and fuel-inefficient full-size trucks (e.g., Ford F150).

We estimate Equation 2 for each of 18 subsegments. The dependent variable in the first estimation is "1" if the purchased car is a "Entry Compact Car", "0" otherwise. We proceed similarly for the other subsegments.

The estimates of the fuel price coefficients, their standard errors, and the mean market shares of each subsegment are presented below.[15] As in the previous two tables, the last column reports the percent change in market share of each subsegment implied by a $1 increase in gasoline prices.

[15] The full estimation results are available from the authors.

Subsegment	Coefficient	SE	Mean Mkt Share	% Change in Share
Entry Compact Car	0.0057**	(0.00098)	1.54%	37.0%
Premium Compact Car	0.03**	(0.0045)	15.83%	19.0%
Entry Midsize Car	0.0089**	(0.0022)	3.63%	24.5%
Premium Midsize Car	0.0035	(0.004)	16.63%	2.1%
Entry Luxury Car	0.00042	(0.0019)	5.75%	0.7%
Mid Luxury Car	0.0017	(0.0012)	2.69%	6.3%
Premium Luxury Car	-0.0018**	(0.00046)	0.63%	-28.6%
Sporty Car	0.0025	(0.0017)	2.92%	8.6%
Premium Sports Car	0.0022**	(0.00063)	1.03%	21.4%
Luxury Sports Car	0.0001	(0.00029)	0.29%	3.4%
Entry SUV	-0.0039	(0.003)	8.85%	-4.4%
Midsize SUV	-0.0099*	(0.0045)	11.32%	-8.7%
Fullsize SUV	-0.012**	(0.0018)	4.14%	-29.0%
Luxury SUV	-0.0054*	(0.0024)	3.7%	-14.6%
Compact Pickup	0.0016	(0.0033)	5.35%	3.0%
Light Duty Fullsize Pickup	-0.014**	(0.0023)	8.9%	-15.7%
Compact Van	-0.0097**	(0.0015)	6.44%	-15.1%
Fullsize Van	-0.00025	(0.00026)	0.3%	-8.3%

This analysis reveals interesting variation that was obscured by the analysis based on the coarser segment classification. Starting with compact cars, we find that the sales of all subsegments increase, however, the increase in market share for premium compacts is greater than that of entry compacts. (Entry compacts experience the biggest percent change relative to their average market share of all the subsegments, but this is largely because the subsegment is such a small one.) We speculate that this may be driven by buyers substituting away from midsize cars who might be more likely to switch to a smaller but otherwise comparable vehicle (a premium compact) than to a “starter” car.

In the midsize segment, the subsegment results show that the entry midsize subsegment drive the segment results; the premium midsize subsegment, which is the larger of the two, shows no statistically significant effect. We speculate that one of the reasons for this is that the midsize segment represents a middle ground, gaining from SUVs and pickups when gasoline prices rise, and losing to compact cars. This would make the net effects in the segment (and even the subsegments) hard to predict.

Looking within the luxury and sporty segments, we find in each case that only the premium subsegment shows any statistically significant effect. For both sport and luxury cars, we would expect the premium subsegments to be gasoline price insensitive subsegments, so it is hard to know what to make of this.

We find that the larger the SUV (from entry to midsize to fullsize), the larger the decrease in market share in response to an increase in gasoline prices. Entry SUVs show no statistically significant effect, which may be the net result of inflow from larger SUVs and outflow to higher MPG segments. Luxury SUVs, a category that corresponds more to plushness than to size, also has decreased market share when gasoline prices rise.

The pickup segment is another segment in which the subsegment analysis is revealing. We find that the market share of full-size pickups decreases, while the market share for compact pickup trucks shows no statistically significant effect.[16] The absence of an effect for compact pickups may indicate that some pickup truck buyers stay within the pickup truck segments but downgrade to smaller pickup trucks. We speculate that this may be because a portion of truck buyers have a very strong taste preferences to stay within the pickup segment, or perhaps because there are commercial or recreational uses of full-size pickups for which a compact pickup may substitute, but for which another type of vehicle will not.

Our final finding is that the market share of compact vans (more commonly called minivans) decreases, but that of full-size (e.g., airport, commercial) vans does not. One explanation is that there is not a good substitute for commercial vans (or that higher gasoline prices increase demand for vanpools), while consumers can more easily switch from minivans to a car such as a station wagon as a substitute.

Summary

Overall, we find both statistically and economically significant effects of gasoline prices on new car market shares, particularly for cars in the most fuel-efficient and least fuel-efficient quartiles, where market share shifts by more that 17% in response to a $1 increase in gasoline prices. The shifts are largely what one would expect in terms of segments (compact and midsize gain, SUVs, pickups, and vans lose). However, looking at subsegments suggests some interesting patterns. Extreme subsegments (entry compacts, fullsize SUVs) show unambigious effects, while "transitional" subsegments (entry SUVs, premium midsize cars) exhibit more indeterminate effects.

4.2 New car prices

While market share is one important piece of the impact of gasoline prices on automobile manufacturers, price is necessary to complete the picture. Theoretically, the market share

[16] There is a third category of pickup trucks, "Heavy Duty Fullsize Pickups," however, for most of these vehicles, the EPA does not report MPG. While MPG data are not required for these specifications, to keep the samples consistent across market share and pricing models, we omit them from this analysis.

of low fuel-efficiency vehicles might be maintained at previous levels, but if this can only be accomplished by manufacturers and dealers offering very large price reductions on such cars, then gasoline price increases presumably have still had large effects on profits and on demand for particular types of vehicles. In this section, we investigate the effect of gasoline prices on the transaction prices paid by buyers for new cars of varying fuel efficiencies.

4.2.1 Specification and variables

As in section 4.1.1 our approach is to estimate the reduced form effect of gasoline prices on the equilibrium prices of new cars of different fuel efficiencies. The reduced form analog of Equation 1 for price is:

$$P = \beta_0 + \beta_1 X^D + \beta_2 X^S + \eta \tag{3}$$

In practice, we will estimate the following equation, which contains the same controls, with one addition, as we used in Equation 2:

$$\begin{aligned} P_{irjt} = \lambda_0 + \lambda_1(\text{GasolinePrice}_{it} \cdot \text{MPG Quartile}_j) + \lambda_2\text{Demog}_{it} + \\ \lambda_3\text{PurchaseTiming}_{jt} + \delta_j + \tau_t + \mu_{rt} + \epsilon_{ijt} \end{aligned} \tag{4}$$

The price variable recorded in our dataset is the pre-sales tax price that the customer pays for the vehicle, including factory installed accessories and options, and including any dealer-installed accessories contracted for at the time of sale that contribute to the resale value of the car.[17] Conceptually, we would like our price variable to measure the customer's total wealth outlay for the car. In order to capture this, we make two modifications to the price variable from our dataset. First, we subtract off the manufacturer-supplied cash rebate to the customer if the car is purchased under a such a rebate, since the manufacturer pays that amount on the customer's behalf. Second, we subtract from the purchase price any profit the customer made on his or her trade-in (or add to the purchase price any loss made on the trade-in). The price the dealer pays for the trade-in vehicle minus the estimated wholesale value of the vehicle (as booked by the dealer) is called the *TradeInOverAllowance*. Dealers are willing to trade off profits made on the new vehicle transaction and profits made on the trade-in transaction, which is why the *TradeInOverAllowance* can be either positive or negative. When a customer loses money on the trade-in transaction, part of his or her payment for the new vehicle is an in-kind

[17]Dealer-installed accessories that contribute to the resale value include items such as upgraded tires or a sound system, but would exclude options such as undercoating or waxing.

payment with the trade-in vehicle. By subtracting the *TradeInOverAllowance* we adjust the negotiated (cash) price to include this payment.

In Equation 4, P_{irjt} is the above defined price for transaction i in region r on date t for car j, and the control variables are as described in section 4.1.1 (page 13). For the price specification, we also control for detailed characteristics of the vehicle purchased by including "car type" fixed effects (δ_j). A "car type" in our sample is the interaction of model year, make, model, trim level, doors, body type, displacement, cylinders, and transmission (for example, one "car type" in our data is a 2003 Honda Accord EX 4 door sedan with a 4 cylinder 2.4 liter engine and automatic transmission).

In this section, we are interested in estimating how gasoline prices affect the transaction prices paid for cars of different fuel efficiencies. One might think that since higher gasoline prices make car ownership more expensive, higher gasoline prices will lead to lower negotiated prices for all cars. However, this would ignore the results of the previous subsection, which show that as gasoline prices increase, some cars experience sales increases and others decreases. It would thus not be surprising if the transaction prices of the most fuel-efficient cars were to increase as a result of a gasoline price increase. To capture this, we estimate separate coefficients for the *GasolinePrice* variable, depending on the quartile of its segment into which car j falls; the quartiles are redefined each model year.

4.2.2 New car price results

The full results from estimating the specification in Equation 4 are presented in Table A-3. The gasoline price coefficients are as follows:

Variable	Coefficient/SE
GasolinePrice*MPG Quart 1	-222** (69)
GasolinePrice*MPG Quart 2	-87** (33)
GasolinePrice*MPG Quart 3	-12 (34)
GasolinePrice*MPG Quart 4	109* (47)

We find that a $1 increase in gasoline price is associated with a lower negotiated price of cars in the least fuel-efficient quartile (by $222) but a higher price of cars in the most fuel-efficient quartile by ($109). Overall, the change in negotiated prices appears to be monotonically related to fuel efficiency. Note that this is the equilibrium price effect: The price change is the net effect of the manufacturer price response, any change in consumers' willingness to pay, and the change in the dealers' reservation price for the car.

One way to think about the magnitude of the estimated effect is as following. The estimated coefficients imply that when gasoline prices increase by $1 the difference between the average prices for the most and least fuel-efficient quartiles grows by $331. The average MPG in the least fuel-efficient quartile during the sample period is 16.2, while the average MPG in the most fuel-efficient quartile is 27.9. In 12,000 miles of driving (a oft-used measure for annual mileage), a car with MPG of 16.2 would require 741 gallons of gasoline, while a car with MPG of 27.9 would consume 430 gallons, a difference of 311 gallons. Thus the estimated price difference between the two quartiles arising from a $1 increase in gasoline prices is very close to the difference in fuel expenditures between average vehicles in the two quartiles for *one year* of driving.

We also estimate Equation 4 separately for each segment. To estimate the effect of gasoline prices for cars of different fuel efficiencies, we interact gasoline price with *segment-specific* MPG quartiles for each model year (rather than quartiles defined over the entire set of cars available in the U.S. in a particular model year). The full results are reported in Table A-4. The gasoline price coefficients are as follows:

	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
GasolinePrice*MPG Quart 1	-24	44	-766**	279*	-245**	-312**	313+
	(65)	(78)	(223)	(141)	(69)	(97)	(188)
GasolinePrice*MPG Quart 2	63	79*	-153+	183	-355**	-193*	-327**
	(43)	(35)	(90)	(125)	(60)	(77)	(120)
GasolinePrice*MPG Quart 3	-74*	50	21	-418**	36	108+	-91
	(29)	(42)	(82)	(125)	(60)	(59)	(76)
GasolinePrice*MPG Quart 4	218**	-143**	345**	-183*	218**	-25	29
	(49)	(51)	(69)	(84)	(50)	(81)	(74)

One might expect to find the same pattern segment by segment as we found in Table A-3, namely that new car prices decrease the most for the least fuel-efficient quartile (Quartile 1), and less for more fuel-efficient cars, with the most fuel-efficient cars' prices perhaps rising. This is roughly the pattern we see for most of the segments, especially if we confine ourselves to comparing by above- and below-median fuel efficiency. For compact cars, prices increase in the most fuel-efficient segment of compact cars by $218 when gasoline prices go up by $1, and fall or have no statistically significant effect for other quartiles. The prices of luxury cars, SUVs, and pickups all fall for vehicles in the bottom half of the fuel efficiency distribution for their respective segments, by as much as $766 per $1 increase in gasoline prices (Quartile 1 luxury cars). The most fuel-efficient luxury cars and SUVs see their prices rise by $345 and $218, respectively, in response to a $1 price increase, while pickups have no statistically significant effect for above-median fuel efficiency pickups. Midsize and sporty cars do not match this pattern. Prices for midsize cars in the most fuel-efficient quartile *fall* by $143 when gasoline prices increase by $1, and fall by $418 and $183 in the two above-median fuel efficiency quartiles for sporty cars. Furthermore, prices *rise* by $279 in the least fuel-efficient quartile of sporty cars. While we argued in a previous section that midsize cars may be a segment that sees both inflows and outflows when gasoline prices rise, making net effects difficult to predict, we do not have an explanation why sporty cars show such opposite results to what we expected. Finally, vans behave as expected in three out of four quartiles (prices are unaffected in the most fuel-efficient quartiles, and fall by $327 in quartile 2). However, prices show some weak signs of being higher in the least fuel-efficient quartile when gasoline prices increase by $1 (an increase of $313 estimated at a 10% confidence level). This may be due to increased usage of carpooling vans in response to increased gasoline prices.

Summary

Overall, we find that prices for fuel-efficient new cars generally (although not universally) rise when gasoline prices increase and that prices for fuel inefficient cars fall. The difference in the average change in new car price between the most and least fuel-efficient quartiles when gasoline price increases by $1 is about $300 when we look at all cars together, and $500 or less when we look within segment (except for luxury cars where the difference is larger). The difference in new car prices when we look at all cars together is close to the difference between one year's worth of the fuel expenditure increases between the most and least fuel-efficient quartiles implied by a $1 gasoline price increase.

4.3 Used car market shares

In this subsection, we begin by considering the effect of gasoline prices on used car market shares. In the next subsection, we will consider the effect on used car prices. We will estimate the same specifications as we used to estimate the new car results, namely Equation 2 in this subsection and Equation 4 in the next, but using data from used car transactions at the same dealerships at which we observe new car transactions. As in Section 4, we will look at the market share effects of gasoline prices first by MPG quartiles, then by segments, and then by subsegments.

The full results of market share effects of gasoline prices by MPG quartiles are reported in

Table A-5. The gasoline price coefficients are as follows:

Fuel Efficiency	Coefficient	SE	Mean share	% Change in share
MPG Quartile 1 (least fuel-efficient)	-.0074	(.0085)	24.1%	-3.1%
MPG Quartile 2	-.019*	(.007)	21.0%	-9.0%
MPG Quartile 3	.024+	(.013)	25.9%	9.2%
MPG Quartile 4 (most fuel-efficient)	.0018	(.0083)	28.9%	6.2 %

The first thing to note is that the results are both smaller in magnitude and weaker in statistical significance than the analogous results for new cars. For new cars, market share changes were quite consistently related to gasoline price, with the least fuel-efficient quartile showing the largest decrease and the most fuel-efficient quartile showing an increase in conjunction with gasoline price increases. For used cars, the most and least fuel-efficient quartiles show no statistically significant effect of gasoline price changes; the estimated coefficients, although of the same sign, are only 20-30% the magnitude of the corresponding new car coefficients. For used cars, the second quartile is the only quartile that shows a statistically significant market share effect, a decrease of 1.9 percentage points, or 9% of market share, in response to a $1 gasoline price increase.

If we look at market share effects by segment, we also find smaller and statistically weaker results for used cars than we found for new cars. The full estimation results are reported in Table A-6. The fuel price coefficients from the segment-based regressions are as follows.

Segment	Coefficient	SE	Mean Mkt Share	% Change in Share
Compact Car	-0.0013	(0.0041)	13.98%	-0.9%
Midsize Car	0.031**	(0.01)	25.59%	12.1%
Luxury Car	-0.0073	(0.0045)	10.31%	-7.1%
Sporty Car	-0.0042**	(0.0013)	4.71 %	-8.9%
Sport Utility Vehicle (SUV)	-0.0072	(0.0097)	24.53%	-2.9%
Pickup	-0.011*	(0.0045)	14.07%	-7.8%
Van	0.0004	(0.005)	6.81 %	0.6%

In the used car results, compact cars and SUVs—which had the largest market share effects for new cars—show no statistically significant effect of gasoline prices on market shares. Nor do vans and luxury cars. There are three segments that do show statistically significant effects. Midsize cars show an increase of 3.1 percentage points in response to an increase in gasoline price of $1, a 12.1% increase in market share. This is substantially larger than the effect estimated for *new* midsize cars. Sporty cars are estimated to lose 0.42 percentage points of market share, an 8.9% loss. This is an effect of comparable magnitude to the effect for new sporty cars, but of opposite sign. Finally, pickups are estimated to lose 1.1 percentage points, or 7.8% of their market share, when gasoline prices rise by $1. This is the only segment whose new and used results are quite close.[18]

Summary

Overall, we find much less evidence among used cars of adjustment in market shares of cars of different fuel efficiencies in response to fuel prices than we found among new cars. A particularly striking aspect of the contrast is the absence of a significant effect at the extremes of fuel efficiency—for the first and fourth quartiles when the data are categorized by quartile, and for compact cars and SUVs when the data are categorized by segment. These were the classes in which the results were largest for new cars. In Section 2, we speculated that we might see little market share response to gasoline prices because there is so much volume of used cars that goes through a market-clearing auction mechanism, and because this price adjustment would counteract the gain to customers of trading cars of different fuel efficiencies in order to reduce fuel expenditures. A second prediction of this hypothesis is that we ought to see much greater adjustment in price in the used car market than in the new car market. It is to this we turn next.

4.4 Used car prices

In this section, we estimate the effect of gasoline prices on the transaction prices of used cars. We do so by estimating the same specification we used for new car prices, namely Equation 4, on our used car transaction data. All the control variables are the same, except that the "car type" fixed effects correspond to the used car being purchased. We observe all the same car characteristics for used cars that we do for new cars, so the "car type" definition is the same. The definition of the dependent variable is almost the same as that used for new cars. A customer who is buying a used car can use a trade-in in the transaction, just as a buyer of a new car can, so the price definition subtracts the *TradeInOverAllowance* just as it does for new cars. However, used cars never have customer rebates offered, so there is no need to subtract that amount from the reported transaction price. As we did for new cars, we begin by estimating the effect of gasoline prices on used car prices separately by the MPG quartile of the used car being purchased. The full results are reported in Table A-8. The gasoline price

[18]In Table A-7 in the Table Appendix, we report the used car market share results by subsegment. The results show that the midsize effect is concentrated in premium midsize cars, that mid luxury and premium luxury cars lose market share when gasoline prices increase, that the sporty car effect is concentrated in entry sporty cars, that midsize SUV market share falls when gasoline prices increase, and that the pickup segment effect is concentrated in light duty fullsize pickups.

coefficients are as follows:

Variable	Coefficient/SE
GasolinePrice*MPG Quart 1	-1072** (43)
GasolinePrice*MPG Quart 2	-948** (62)
GasolinePrice*MPG Quart 3	65 (81)
GasolinePrice*MPG Quart 4	1572** (64)

The estimated coefficients imply that when gasoline prices increase by $1, the transaction prices of the least fuel-efficient quartile of used cars falls by $1072. This is almost five times the size of the $222 effect estimated for new cars. Prices in the next least fuel-efficient segment are estimated to fall by nearly as much, namely $948. On the other end of the fuel efficiency distribution, the prices of the most fuel-efficient quartile of used cars is estimated to increase by $1572 for each $1 increase in gasoline prices, an effect that is fourteen times the size of the effect estimated for new cars ($109).

In Section 4.2.2, we calculated that the increase in the price difference between the most and least fuel-efficient quartiles of cars associated with a $1 increase in gasoline prices was very close to the difference in increased fuel expenditure between the most and least fuel-efficient quartiles of cars for a single year of driving. If we perform the same calculation for the estimated price effects for used car, we could translate the $2644 increase in the difference between the most and the least fuel-efficient quartile of cars into the equivalent of the increased fuel expenditure associated with driving the average car in the least fuel-efficient quartile instead of the average car in the most fuel-efficient quartile for 8.44 years.

The fact that the magnitude of the effects of gasoline price on car prices is so much larger for used cars than for new cars provides evidence for the final piece of our supposition in Section 2; namely that we would see a response to gasoline prices primarily in *market shares* for new cars (and less in prices) and primarily in *prices* for used cars (and less in market shares). The reasons we anticipated that we might see a large response in prices for used cars were twofold. First, used cars can be easily traded at high-volume, widely available, auction markets, promoting rapid price adjustment. Second, the change in the willingness-to-accept of the sellers of used cars (who are themselves the current drivers of those used cars) is likely to be similar to the change in willingness-to-pay of the buyers of used cars (who will become the drivers of those used cars), as long as the marginal buyer and seller have similar driving habits.

Next, we look within segments. The full results are reported in Table A-9. The gasoline price coefficients are as follows:

	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
GasolinePrice*MPG Quart 1	-966**	-197	-3545**	-600**	-1846**	-871**	1153**
	(69)	(123)	(256)	(200)	(81)	(66)	(124)
GasolinePrice*MPG Quart 2	245**	16	102	140	101+	-558**	976**
	(40)	(34)	(125)	(98)	(60)	(48)	(76)
GasolinePrice*MPG Quart 3	223**	121**	374**	661**	802**	10	-75
	(38)	(37)	(127)	(91)	(71)	(49)	(64)
GasolinePrice*MPG Quart 4	345**	457**	943**	660**	1461**	1608**	-177**
	(39)	(47)	(150)	(75)	(74)	(67)	(64)

Here we see the same results within segment as we saw for used cars as a whole. Namely, for most of the segments, used car prices fall by the most for the least fuel-efficient cars in the segment, and rise by the most for the most fuel-efficient cars in the segment. This is true for the compact segment; for the luxury car segment (where the results show the greatest contrast between quartiles: prices for the least fuel-efficient luxury cars fall by \$3545 and rise by \$943 for the most fuel-efficient cars); for the sporty cars; for SUVs (which show the second largest contrast of all the segments, with prices for the least fuel-efficient SUVs falling by \$1846, prices in the third quartile rising by \$802, and prices in the most fuel-efficient quartile rising by \$1461 for every \$1 increase in gasoline prices); and finally, for pickups. The only exception to this pattern is vans, where prices actually *rise* for cars of below median fuel efficiency. We speculate that part of this result is do to increased demand for commercial vans for the purpose of carpooling.

Summary

Overall, we see a very large effect of gasoline price changes on used car prices. The pattern that prices fall the most for the least fuel-efficient cars and rise the most for the most fuel-efficient cars appears quite strongly whether we look at all used cars together, or look within segments. Furthermore, the effects are much larger than the effects for new car prices, from five to fourteen times as large, depending on which results are compared.

5 Supplementary Evidence

In the previous section of the paper we established the main result of the market share and price effects of gasoline price changes in both the new and used car markets. In this section, we explore supplementary evidence that sheds some additional light on what is happening in each of these markets. The supplementary evidence comes from looking at dealer inventories and trade-ins.

5.1 Inventories

We first consider how gasoline prices affect dealer inventories. If our description in Section 2 of the operation of new and used car markets is correct, then we should see quite different reactions of dealer inventories of new cars and of used cars to changes in gasoline prices.

For new cars, we have shown that consumers are buying fewer fuel inefficient cars when gasoline prices rise. This raises the question of what is happening to these cars. Bresnahan and Ramey (1994) show that between 25 and 50% of the plant closures are for inventory adjustments. This allows manufacturers to reduce production of fuel inefficient cars when gasoline prices increase. Nonetheless, we expect dealer inventories for new cars to change with gasoline prices. This is for two reasons. First, dealers order cars from manufacturers 45 to 90 days before receiving cars. During that time they cannot significantly change their order. Hence, any sales change in response to changes in gasoline prices is likely to have some short-run effect on inventory levels at the dealership. Second, production changes are not instant.

For used cars, on the other hand, we have shown that there is little evidence of adjustment in market shares of cars of different fuel efficiencies in response to fuel prices. We have speculated that this is because there is a large volume of used cars goes through a market-clearing auction mechanism. The implication is that we should observe little change in used car inventory levels at the dealership. The auction is always an available remedy for high used car inventories.

5.1.1 Specification and variables

We do not observe production data with the same detail as transactions. However, we know for every car that was sold how long the car was on the dealership lot. This is a key inventory proxy used in the industry and is referred to as "days to turn" (DTT). The longer days to turn, the higher the inventory of the dealer relative to sales of a particular vehicle.

Our inventory specification for both new and used cars is as follows:

$$\begin{aligned} DTT_{irdjt} = \omega_0 + \omega_1(\text{GasolinePrice}_{it} \cdot \text{MPG Quartile}_j) + \omega_2\text{Demog}_{it} + \\ \omega_3\text{PurchaseTiming}_{jt} + \delta_{dj} + \tau_t + \mu_{rt} + \nu_{ijt} \end{aligned} \tag{5}$$

DTT_{irdjt} measures days to turn for transaction i in region r at dealer d on date t for car

j. If market share changes affect inventory levels, we would expect that the inventory levels of the least fuel-efficient cars should increase when gasoline prices are high and that the inventory levels of the most fuel-efficient cars should decrease as a result of a gasoline price increase. To capture this, we estimate separate coefficients for the *GasolinePrice* variable, depending on MPG quartile into which car j falls within the MPG distribution of cars available for sale in the United States.

We use the same extensive set of controls we have used in the market share specification (see page 13) with one addition. To control for the fact that different dealerships may have different inventory policies we now include car type × dealer fixed effects (δ_{dj}).

5.1.2 Inventory results

The full results from estimating the specification in Equation 5 are presented in Table A-10. The coefficients of interest are as follows:

	New Cars			Used Cars		
Variable	Coefficient (SE)	DTT sample mean	% Change % DTT	Coefficient (SE)	DTT sample mean	% Change % DTT
GasolinePrice * Quart. 1 (least fuel-efficient)	11** (2.3)	68.3	16.1%	1.8+ (.96)	47.8	3.8%
GasolinePrice * Quart. 2	2.8** (0.92)	61.4	4.6%	2.3** (0.82)	47.3	4.9%
GasolinePrice * Quart. 3	0.16 (0.86)	57.2	0.3%	0.83 (0.99)	49.1	1.7%
GasolinePrice * Quart. 4 (most fuel-efficient)	-7** (0.9)	50.2	-14.0%	-0.25 (1.2)	45.4	-0.6%

We find much larger changes in days to turn in response to gasoline price changes for new than for used cars. For new cars, the estimated coefficients imply that a $1 increase in gasoline price is associated with an *increase* in days to turn for cars in the least fuel-efficient quartile. These cars remain 11 days longer on the lot, a 16.1% increase from the sample mean of 68.3 days. Conversely, we find that the same gasoline price increase *reduces* by 7 days the time that a car in the most fuel-efficient quartile remains in the lot. Since cars in this quartile remain on average 50.2 days on the lot before selling, this is a 14% decrease.

In contrast, for used cars, higher gasoline prices have no statistically significant effect on days to turn for either the least or the most fuel-efficient quartile. The only statistically significant change in days to turn occurs for used cars in the second most fuel inefficient MPG quartile; days to turn increase by 2.3 days, or 4.9%.

These results are consistent with our description in Section 2 of the operation of new and used car markets and thus complements our earlier market share and price results.

5.2 Comparison of purchased cars and trade-in MPG

One of the unique features of our data, among papers addressing similar topics, is that we observe transactions for individual cars, including what car—if any—was traded in as part of the transaction. This means that for the approximately 40% of new and used transactions that involve a trade-in, we can see what a customer purchases compared to what that same customer purchased at some point in the past. This allows us to perform analysis that is in the spirit of a within customer analysis.[19] We do this by estimating the effect of gasoline prices on the MPG of the newly purchased car, conditioning on the trade-in car used in the transaction.

5.2.1 Specification and variables

Conceptually, we are interested in estimating how the difference between the MPG of the newly purchased car and the MPG of the trade-in vary with gasoline prices. In practice, we regress the MPG of the newly purchased car on gasoline prices, our standard set of controls, and fixed effects for the *trade-in* car. It is this last element that makes this a "quasi-within-customer" analysis.

Our specification is as follows:

$$\text{MPG}_{irjt} = \beta_0 + \beta_1 \text{GasolinePrice}_{it} + \beta_2 \text{Demog}_{it} + \beta_3 \text{PurchaseTiming}_{jt} + \delta_k + \tau_t + \mu_{rt} + \xi_{ijkt} \quad (6)$$

MPG_{irjt} is the MPG of the car of car type j sold in transaction i in region r on date t for which car k was traded in during that transaction. The variable of primary interest is *GasolinePrice*, which is specific to the month in which the vehicle was purchased and to the 4-digit ZIP code of the buyer.

We use a set of controls similar to what we have used in the market share specification (see page 13), except that we control for car type fixed effects of the *trade-in* (δ_k) instead of car type fixed effects for the purchased car (δ_j in previous specifications). In addition to conditioning on the MPG of a previously purchased car, including trade-in fixed effects controls

[19] We cannot do an exact within customer model because we do not observe multiple new car purchases by the same customer. We also do not know when a trade-in was purchased because a given model year is usually available for long over a year (as long as 18 months is not uncommon). Furthermore, we cannot tell if the trade-in was originally purchased new or used.

for unobservable characteristics of the buyer that are not accounted for by demographics, but which might be correlated not just with a car the buyer has purchased in the past, but with the car purchased in the current transaction. We estimate Equation 6 separately for new and used cars.

5.2.2 Purchased cars vs. trade-in results

The full results for new and used cars are reported in Table A-11 (columns 1 and 2). The gasoline price coefficients are as follows:

	New Car MPG	Used Car MPG
GasolinePrice	.82**	.41**
	(.074)	(.054)

The first column reports the effect of gasoline prices on the fuel efficiency of the new car relative to the trade-in for new car transactions. We find that higher gasoline prices are associated with greater fuel efficiency of the new car relative to the trade-in. The estimated coefficient implies that a $1 increase in the gasoline price leads customers to increase the fuel efficiency of their new car relative to their trade-in by 0.82 miles per gallon.[20] To put this into perspective, the interquartile range of MPG is 17.8 to 24.3 miles per gallon, which means that the estimated effect is about 13% of the interquartile range.

The second column reports the same results for the used car transactions. In this sample we find that a $1 gas price increase increase the fuel efficiency of the newly purchased used car relative to the trade-in by 0.45 miles per gallon.

In terms of the previous results, this tells us, we believe, something about the demand for new and used cars. In Section 4.1 we showed that the market share of new cars shifted generally away from fuel-inefficient cars and towards fuel-efficient cars. The results of this subsection suggest that part of the reason for this is that, when gasoline prices increase, customers choose to purchase more fuel-efficient new cars relative to cars they have purchased in the past. Similarly, while we did not observe very consistent market share changes for used cars, we did observe in Section 4.4 that prices for used cars shifted quite reliably to higher prices for fuel-efficient cars and lower prices for fuel-inefficient cars when gasoline prices increased. These results suggest

[20]Notice that our coefficient of interest is not picking up changes in consumers' MPG tastes over time. For example, it could be that in this period, net of gasoline price effects, most consumers would prefer a new car that is increasingly less fuel-efficient than their existing car. Such effects should be largely captured by our year fixed effects. Instead, the gasoline price coefficient solely captures the part of the MPG change from trade-in to new car that can be explained with a variation in gasoline prices.

that part of the reason for this is that used car buyers are choosing more fuel-efficient used cars when gasoline prices increase relative to cars they have purchased before.

5.3 Actual cash value of trade-ins

A third piece of evidence we can examine are the amounts that dealers book as the "actual cash value" of trade-ins they receive. As described in Section 4.2.1, when a customer uses a trade-in as part of his or her payment for a newly purchased car, the dealer and customer negotiate over the price of the trade-in just as they negotiate over the price of the car to be purchased. The dealer is willing to manipulate the price paid to the customer for the trade-in if that helps the negotiation; for example, the dealer may inflate the price of the trade-in if he thinks that he can inflate the price of the new car by at least as much.

This means that the price the dealer pays the customer for a trade-in may not reflect the dealer's assessment of the real value of the trade-in. However, in our data we observe, in addition to the price the dealer pays for the trade-in, the amount the dealer books as his assessment of the "actual cash value" of the trade-in. This is an internal number for the dealership, and there is no incentive to treat it strategically. In this number, the dealer is trying to approximate the price for which he could have purchased the car at auction.

We are interested in how the "actual cash value" of cars of different fuel efficiencies varies with gasoline prices. This yields some information about how the cost to sellers of used cars changes when gasoline prices change.

5.3.1 Specification and variables

In order to estimate the effect of gasoline prices on the "actual cash value" of trade-ins of different fuel efficiencies, we use the following specification:

$$\begin{aligned}\text{ACV}_{ikrt} = \beta_0 + \beta_1 \text{GasolinePrice}_{it} \cdot \text{MPG Quartile}_k + \beta_2 \text{Odometer}_{ikt} + \beta_3 \text{Demog}_{it} + \\ \beta_4 \text{PurchaseTiming}_{jt} + \delta_k + \tau_t + \mu_{rt} + \xi_{ikrt}\end{aligned} \tag{7}$$

ACV_{ikrt} is the actual cash value booked in transaction i for trade-in car k in region r on date t. The primary variable of interest is *GasolinePrice*, which is interacted with indicators for the quartile of the MPG distribution in which trade-in car k falls. We add a new control variable to this specification, which is the odometer reading of the trade-in car; cars with higher odometer readings have experienced greater depreciation and should be booked at lower actual cash values, all else equal. In the specification, we include the demographic characteristics of the buyer; these should not have a direct effect on the average cash value, but may be correlated with unobservable quality characteristics ("wear and tear") of the trade-in car. We also include the purchase timing of the transaction, in case cars are assigned different actual cash values on, for example, weekend days, when there is typically higher transaction volume. Finally, we include detailed "car type" fixed effects for the trade-in, as well as our year and region × month-of-year fixed effects.

5.3.2 Results

The full results of estimating Equation 7 are reported in Table A-11 (columns 3 and 4). We estimate Equation 7 separately for actual cash values of trade-ins used to purchase new cars, and to purchase used cars. The gasoline price coefficients are as follows:

	New Car Trade-in Actual Cash Value	Used Car Trade-in Actual Cash Value
GasolinePrice*MPG Quart 1	-1177**	-1010**
	(44)	(29)
GasolinePrice*MPG Quart 2	-894**	-609**
	(45)	(45)
GasolinePrice*MPG Quart 3	162**	200**
	(60)	(50)
GasolinePrice*MPG Quart 4	1258**	758**
	(50)	(47)

The first column reports the new car transactions. These results show that the actual cash values booked for trade-in cars in the least fuel-efficient quartile fall by $1177 when gasoline prices rise by $1, and by $894 in the next least fuel-efficient quartiles. Prices rise for trade-in cars that are above median fuel efficiency when gasoline prices rise; by $162 per $1 gasoline price increase in the third quartile, and by $1258 for the most fuel-efficient trade-in cars. The results for trade-ins used to buy used cars show the same qualitative pattern, although the magnitudes are smaller in three of the four quartiles. For these trade-ins, prices fall by $1010 in the least fuel-efficient quartile and by $609 in the next quartile, and rise by $200 in the third quartile and by $758 for the most fuel-efficient cars when gasoline prices increase by $1.

These results are quite similar to the results obtained for the gasoline price effect on used car prices, reported on page 25. The first three quartiles of the actual cash value results are in almost all cases within $100-200 of the used car price results.[21] This result is consistent

[21] There is one interesting exception to actual cash values and used transaction car prices showing very similar adjustment, which is the most fuel-efficient quartile of trade-in cars. There the estimated effects of gasoline price

with our argument that prices adjust fairly rapidly in the used car market, thanks to a well-functioning wholesale market, and that used car buyers and sellers may well adjust their values of particular used cars quite similarly since both care about the change in usage costs. In the results we have reported, we have seen that prices for used car retail transactions and for dealer's estimated cost of traded-in cars adjust similarly to gasoline prices. If we had access to data on auction transactions, we would expect to see similar adjustments in those prices.

6 Concluding remarks

In this paper we have investigated the effect of gasoline prices on market shares and prices of cars of different fuel efficiencies in both the used and new car markets. We have found statistically and economically significant effects in both markets. In new car markets, we find the largest effects in market shares. We estimate the market share of the least fuel-efficient quartile to decrease by 17.7% when gasoline prices increase by $1, and the market share of the most fuel-efficient quartile to increase by 17.5%. Furthermore, we estimate market shares of very fuel-efficient or very fuel inefficient segments to adjust by 10-20% when gasoline prices increase by $1, and of very fuel-efficient or very fuel inefficient subsegments to change market share by amounts approaching 30%. Transaction prices for new cars also change in response to gasoline prices, typically on the order of several hundred dollars, generally increasing for fuel-efficient cars while decreasing for fuel inefficient cars. In one benchmarking calculation, we showed that the predicted difference in transaction prices arising from a gasoline price increase was approximately the size of one year's worth of fuel expenditure savings from buying a more fuel-efficient car.

In used car markets, we also estimate that market shares and prices of used cars respond to changes in gasoline prices, but the relative magnitude is very different. In used car markets, our estimates of the effect of gasoline prices on market shares is much less consistently statistically significant. Notably, the most extreme quartiles and segments in terms of fuel efficiency usually show no statistically significant effect of gasoline prices on market shares; even for segments and quartiles that are statistically significant, the effects are in most cases smaller than 10% changes in market share. Used car prices, on the other hand, show much larger effects on

on actual cash values are $300 (in the new car column) to $800 (in the used car column) below the estimated effects on used car transaction prices. One story that would explain this would be that when gas prices rise, customers are particularly interested in buying a good, fuel-efficient used car from dealers, and that dealers are able to mark up such cars in their retail transactions above what the actual market (auction) price is for such cars.

prices than do new car prices; in many cases, by an order of magnitude. When looking at all cars together, the transactions prices of the least fuel-efficient cars are estimated to fall by more than \$1000 when gasoline prices rise by \$1, while the prices of the most fuel-efficient cars are estimated to rise by more than \$1500, a difference of more than \$2500. This difference is equivalent to more than eight years' worth of fuel expenditure savings from driving the average car in the most fuel-efficient rather than least fuel-efficient quartile. If we look within segment, this same pattern holds across almost all the segments, in some cases with even larger price effects.

We believe that there are several things we learn from these results. First, these results help us understand at least part of what has happened in the U.S. auto industry over the past several years to bring it into its current state of difficulty. One might argue that the auto industry has experienced a "perfect storm" that included a credit crunch and a major recession as well as historically large increases in gasoline prices. While this paper cannot address all of these contributing factors, we believe we have learned something about the role of gasoline prices. We have shown that the industry has responded with fairly small price adjustments, which has meant that market shares have fallen, especially for the large SUVs and pickups that have recently been the most profitable vehicles for manufacturers. We have seen this effect not only in transactions, but also in dealer inventories, which have shifted in the same direction as transaction market shares; this indicates that the price effect is not being absorbed entirely by production changes.

Second, our results show a contrast between how markets for new and for used durable goods respond to differences in the ongoing usage costs of the good. There are two differences between the markets that we think are most salient. One, the suppliers of new cars have market power, at the manufacturer level especially, while there is little market power in used cars, in part due to the ubiquity of high-volume wholesale auctions. Two, supply of used cars arises fundamentally from used car owners, whose outside option if they do not sell a car is to keep it and drive it themselves. For the suppliers of new cars, there is no value to the car other than the profit opportunity of selling it. The decision of a used car seller will thus take into account the difference in the operating costs of the car currently owned and a different car that could be purchased, and also the price the potential seller can expect to receive for the car currently owned, relative to the price for a different car that could be purchased.

We think that the results we find are consistent with what we should expect given these differences the two markets. In new car markets, changes in usage costs result in market share changes rather than price changes, because manufacturers have the ability to—if they so choose—maintain prices at their former levels, although they must accept changes in market share as a consequence. Prices in used markets adjust because there are many independent buyers and sellers who trade using a well-functioning auction mechanism. Market shares adjust little because the equilibrium price adjustment reduces the potential gains from changing vehicles in the used car market in response to fuel price changes. We believe that these are interesting general insights into the functioning of new and used markets for durable goods when there is a change in ongoing usage costs.

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Table 1: New Cars: Summary Statistics

Variable	N	Mean	Median	SD	Min	Max
GasolinePrice	1866366	2	1.8	0.67	0.77	4.8
MPG	1866366	23	22	5.7	10	65
Price	1866366	25515	23295	10876	2576	195935
DaysToTurn	1801528	58	27	78	1	3859
PctWhite	1866366	0.72	0.82	0.26	0	1
PctBlack	1866366	0.082	0.024	0.16	0	1
PctAsian	1866366	0.05	0.02	0.087	0	1
PctHispanic	1866366	0.12	0.053	0.18	0	1
PctLessHighSchool	1866366	0.15	0.12	0.13	0	1
PctCollege	1866366	0.38	0.36	0.19	0	1
PctManagment	1866366	0.16	0.15	0.082	0	1
PctProfessional	1866366	0.22	0.22	0.097	0	1
PctHeath	1866366	0.016	0.012	0.018	0	1
PctProtective	1866366	0.02	0.016	0.021	0	1
PctFood	1866366	0.041	0.035	0.031	0	1
PctMaintenance	1866366	0.028	0.021	0.029	0	1
PctHousework	1866366	0.027	0.024	0.021	0	1
PctSales	1866366	0.12	0.12	0.046	0	1
PctAdmin	1866366	0.15	0.15	0.053	0	1
PctConstruction	1866366	0.049	0.042	0.039	0	1
PctRepaitn	1866366	0.036	0.033	0.027	0	1
PctProduction	1866366	0.063	0.049	0.053	0	1
PctTransportation	1866366	0.051	0.044	0.038	0	1
Income	1866366	58130	53199	26246	0	200001
MedianHHSize	1866366	2.7	2.7	0.52	0	9.4
MedianHouseValue	1866366	178431	144800	131866	0	1000001
VehPerHousehold	1866366	1.8	1.9	0.38	0	7
PctOwned	1866366	0.72	0.8	0.23	0	1
PctVacant	1866366	0.062	0.042	0.076	0	1
TravelTime	1866366	27	27	6.7	0.91	200
PctUnemployed	1866366	0.047	0.037	0.043	0	1
PctBadEnglish	1866366	0.044	0.016	0.078	0	1
PctPoverty	1866366	0.084	0.057	0.085	0	1
Weekend	1866366	0.25	0	0.44	0	1
EndOfMonth	1866366	0.25	0	0.43	0	1
EndOfYear	1866366	0.022	0	0.15	0	1
TradeActualCashValue	796759	8619	6800	8107	-5350	198000
TradeOdometer	632689	71181	64224	44632	1	250000

Table 2: Used Cars: Summary Statistics

Variable	N	Mean	Median	SD	Min	Max
GasolinePrice	1264092	2.1	1.9	0.69	0.77	4.7
MPG	1264092	22	22	4.8	9.9	65
Price	1264092	15582	14468	8504	1	181000
DaysToTurn	1211535	47	25	74	1	6055
PctWhite	1264092	0.7	0.81	0.28	0	1
PctBlack	1264092	0.11	0.028	0.2	0	1
PctAsian	1264092	0.038	0.013	0.07	0	1
PctHispanic	1264092	0.13	0.051	0.19	0	1
PctLessHighSchool	1264092	0.18	0.14	0.13	0	1
PctCollege	1264092	0.33	0.3	0.18	0	1
PctManagment	1264092	0.14	0.13	0.075	0	1
PctProfessional	1264092	0.2	0.19	0.092	0	1
PctHeath	1264092	0.019	0.014	0.02	0	1
PctProtective	1264092	0.021	0.017	0.021	0	1
PctFood	1264092	0.046	0.04	0.033	0	1
PctMaintenance	1264092	0.032	0.025	0.031	0	1
PctHousework	1264092	0.028	0.025	0.022	0	1
PctSales	1264092	0.12	0.11	0.045	0	1
PctAdmin	1264092	0.16	0.16	0.054	0	1
PctConstruction	1264092	0.056	0.049	0.041	0	1
PctRepaitn	1264092	0.04	0.037	0.027	0	1
PctProduction	1264092	0.075	0.061	0.059	0	1
PctTransportation	1264092	0.059	0.053	0.039	0	1
Income	1264092	50826	46580	22231	0	200001
MedianHHSize	1264092	2.7	2.7	0.51	0	8.5
MedianHouseValue	1264092	145079	121674	102666	0	1000001
VehPerHousehold	1264092	1.8	1.8	0.39	0	7
PctOwned	1264092	0.7	0.77	0.24	0	1
PctVacant	1264092	0.067	0.047	0.075	0	1
TravelTime	1264092	27	26	6.8	1	200
PctUnemployed	1264092	0.053	0.041	0.046	0	1
PctBadEnglish	1264092	0.045	0.014	0.08	0	1
PctPoverty	1264092	0.1	0.072	0.095	0	1
Weekend	1264092	0.26	0	0.44	0	1
EndOfMonth	1264092	0.21	0	0.41	0	1
EndOfYear	1264092	0.017	0	0.13	0	1
TradeActualCashValue	495083	5295	3000	6081	-3402	150000
TradeOdometer	385625	93150	89903	48514	1	250000

Table 3: Examples of cars in segments and subsegments

Segment	Avg. MPG	Subsegment	Avg. MPG	Example
Compact Car	29.1	Entry Compact Car	30.7	Hyundai Accent, Toyota Yaris
		Premium Compact Car	28.8	Honda Civic, Ford Focus
Midsize Car	24.4	Entry Midsize Car	25.0	Pontiac G6, VW Jetta
		Premium Midsize Car	24.1	Honda Accord, Ford Fusion, Nissan Altima
Luxury Car	21.4	Entry Luxury Car	22.4	BMW 3-Series, Acura TSX
		Mid Luxury Car	21.3	BMW 5-Series, Volvo V70
		Premium Luxury Car	18.7	BMW 7 Series, Lexus LS Series
Sporty Car	23.4	Sporty Car	24.2	VW Golf GTI, Ford Mustang
		Premium Sports Car	21.2	Chevrolet Corvette, Porsche 911
		Luxury Sports Car	18.8	BMW 6 Series, Mercedes SL-Class
SUV	18.6	Entry SUV	21.0	Honda CRV, Ford Escape
		Midsize SUV	18.1	Toyota 4Runner, Dodge Durango
		Fullsize SUV	15.2	GMC Yukon, Toyota Sequoia
		Luxury SUV	16.8	Acura MDX, Cadillac Escalade
Pickup	17.6	Compact Pickup	18.9	Ford Ranger, Dodge Dakota
		Light Duty Fullsize Pickup	16.2	Ford F150, Chevrolet Silverado 1500
Van	19.2	Compact Van	20.2	Honda Odyssey, Dodge Grand Caravan
		Fullsize Van	15.5	Dodge Ram Van 2500, Ford Club Waron E-150

Table Appendix

Table A-1: New Cars: Market share results, fuel efficiency quartiles†

	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice	-.037**	-.019**	-.0046	.06**
	(.0077)	(.0051)	(.0033)	(.0088)
PctLessHighSchool	.031*	.022*	-.025*	-.029
	(.016)	(.011)	(.012)	(.019)
PctCollege	-.056**	.016	.017	.022
	(.013)	(.012)	(.011)	(.018)
Income	4.0e-09	3.1e-07**	2.4e-07*	-5.6e-07**
	(8.6e-08)	(1.1e-07)	(1.1e-07)	(1.2e-07)
MedianHHSize	.017**	.0067*	-.0056	-.018**
	(.0036)	(.0028)	(.0047)	(.0067)
MedianHouseValue	7.3e-08*	3.1e-08+	1.3e-08	-1.2e-07**
	(3.0e-08)	(1.8e-08)	(9.5e-09)	(4.2e-08)
VehiclePerHH	.048**	.0031	-.029**	-.022
	(.014)	(.004)	(.0058)	(.019)
TravelTime	.000012	-.0003**	-.0003*	.00058*
	(.00021)	(.00011)	(.00013)	(.00027)
Year 2000	.0036	-.0073	.0061	-.0023
	(.0049)	(.0058)	(.0038)	(.0069)
Year 2001	-.025**	.0007	.011*	.014+
	(.0072)	(.0079)	(.0041)	(.0069)
Year 2002	-.018*	-.0052	-.0089*	.032**
	(.0071)	(.0063)	(.0043)	(.0059)
Year 2003	.0046	-.0092+	-.019**	.024**
	(.0072)	(.0052)	(.0048)	(.0067)
Year 2004	.012	-.013*	.0031	-.0027
	(.0085)	(.006)	(.0058)	(.0092)
Year 2005	.0034	.014+	-.015**	-.0022
	(.01)	(.0074)	(.0059)	(.012)
Year 2006	-.0073	.00058	.009	-.0023
	(.012)	(.0085)	(.0066)	(.013)
Year 2007	-.029*	.028**	-.0012	.0021
	(.013)	(.011)	(.0072)	(.015)
Year 2008	-.036*	.042**	-.023*	.018
	(.016)	(.015)	(.0098)	(.019)
Weekend	-.019**	-.0039*	-.0013	.024**
	(.0019)	(.0018)	(.0017)	(.0023)
EndOfMonth	.0035**	.0028*	.0042**	-.01**
	(.00098)	(.0013)	(.0011)	(.0015)
EndOfYear	-.0037	-.0053*	-.0018	.011**
	(.0027)	(.0023)	(.0026)	(.0037)
Constant	.49**	.22**	.15**	.14+
	(.071)	(.063)	(.037)	(.081)
Observations	1866366	1866366	1866366	1866366
R-squared	0.028	0.006	0.008	0.031

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-2: New Cars: Market share results, segments†

	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
GasolinePrice	.036**	.013*	.00045	.0047**	-.031**	-.013**	-.0099**
	(.005)	(.0053)	(.0029)	(.0018)	(.0086)	(.0037)	(.0016)
PctLessHighSchool	-.03	-.021	.064**	-.019**	-.017	.039*	-.015**
	(.023)	(.017)	(.011)	(.0045)	(.013)	(.015)	(.0057)
PctCollege	.01	-.032*	.054**	-.0051	.072**	-.11**	.0086
	(.017)	(.013)	(.0099)	(.0036)	(.017)	(.017)	(.0054)
Income	-2.9e-07**	-3.5e-07**	8.9e-07**	7.3e-08*	2.7e-07**	-4.7e-07**	-1.2e-07**
	(1.1e-07)	(8.8e-08)	(1.2e-07)	(3.0e-08)	(9.9e-08)	(1.2e-07)	(2.6e-08)
MedianHHSize	-.0092+	-.0051	-.033**	-.00058	.014**	.014**	.02**
	(.0051)	(.0041)	(.0024)	(.001)	(.0038)	(.0034)	(.0036)
MedianHouseValue	-5.7e-08+	-1.1e-07**	2.0e-07**	-8.2e-09	4.6e-08	-5.4e-08**	-1.9e-08**
	(3.0e-08)	(1.4e-08)	(2.1e-08)	(5.7e-09)	(3.1e-08)	(1.2e-08)	(6.6e-09)
VehiclePerHH	-.0052	-.023**	-.022**	.0056**	.0055	.046**	-.0063+
	(.013)	(.0068)	(.0053)	(.0015)	(.0085)	(.007)	(.0035)
TravelTime	.00035	.0003	-.00082**	.000015	.00014	.00013	-.00012+
	(.00024)	(.00019)	(.00017)	(.000089)	(.00019)	(.00017)	(.000069)
Year 2000	-.002	-.015**	-.0064	.0014	.017**	.0041	.0014
	(.0039)	(.0048)	(.0041)	(.0016)	(.0064)	(.0038)	(.0017)
Year 2001	.0023	-.03**	-.0065	-.00087	.048**	-.0011	-.012**
	(.0038)	(.0049)	(.0045)	(.0024)	(.0057)	(.0045)	(.0022)
Year 2002	.0057	-.04**	-.0017	-.0068**	.062**	-.0032	-.016**
	(.004)	(.0055)	(.004)	(.0026)	(.0058)	(.0046)	(.0028)
Year 2003	-.0035	-.052**	-.0032	-.016**	.094**	-.00025	-.02**
	(.0044)	(.0072)	(.0039)	(.003)	(.0063)	(.0048)	(.003)
Year 2004	-.017**	-.064**	.0014	-.016**	.1**	.0081	-.016**
	(.0054)	(.0084)	(.0047)	(.0033)	(.0075)	(.0061)	(.0031)
Year 2005	-.022**	-.067**	.0014	-.012**	.1**	.012	-.016**
	(.0063)	(.0098)	(.0058)	(.004)	(.01)	(.0075)	(.0032)
Year 2006	-.018*	-.07**	.002	-.017**	.12**	-.0038	-.01*
	(.0075)	(.011)	(.0066)	(.0044)	(.012)	(.0088)	(.0041)
Year 2007	-.0089	-.054**	.0055	-.029**	.15**	-.045**	-.018**
	(.0084)	(.012)	(.0078)	(.0046)	(.014)	(.011)	(.0045)
Year 2008	.000057	-.048**	-.0036	-.03**	.14**	-.032**	-.026**
	(.01)	(.014)	(.01)	(.0069)	(.018)	(.012)	(.0053)
Weekend	.012**	.011**	-.013**	-.002*	.004**	-.01**	-.0021**
	(.0016)	(.0021)	(.002)	(.00086)	(.0013)	(.0021)	(.00058)
EndOfMonth	-.013**	.00099	.0097**	-.0026	.0043*	-.0014	.0018**
	(.0015)	(.0018)	(.0014)	(.0016)	(.0019)	(.001)	(.00067)
EndOfYear	.0042+	.012**	-.013**	-.0056**	.0017	.0009	-.00028
	(.0025)	(.0031)	(.0023)	(.0019)	(.0033)	(.0023)	(.0015)
Constant	.13*	.17**	.087*	.047+	-.012	.58**	-.0039
	(.059)	(.064)	(.034)	(.026)	(.051)	(.067)	(.023)
Observations	1866366	1866366	1866366	1866366	1866366	1866366	1866366
R-squared	0.023	0.014	0.048	0.004	0.016	0.054	0.008

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.

Not reported: Region × month-of-year fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-3: New Cars: Price results, fuel efficiency quartiles†

Variable	Coefficient/SE
GasolinePrice*MPG Quart 1	-222** (69)
GasolinePrice*MPG Quart 2	-87** (33)
GasolinePrice*MPG Quart 3	-12 (34)
GasolinePrice*MPG Quart 4	109* (47)
PctLessHighSchool	189* (74)
PctCollege	38 (54)
Income	.0011** (.00035)
MedianHHSize	24* (11)
MedianHouseValue	.00017* (.000077)
VehiclePerHH	-121** (37)
TravelTime	-.32 (.9)
Year 2000	-1087** (29)
Year 2001	-2403** (51)
Year 2002	-3963** (63)
Year 2003	-5661** (79)
Year 2004	-7277** (96)
Year 2005	-8748** (110)
Year 2006	-10240** (131)
Year 2007	-11475** (157)
Year 2008	-12989** (179)
Weekend	-10+ (5.9)
EndOfMonth	-136** (4.4)
EndOfYear	-84** (17)
Constant	33214** (337)
Observations	1866366
R-squared	0.957

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects and car type fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-4: New Cars: Price results, fuel efficiency quartiles by segment†

	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
GasolinePrice*MPG Quart 1	-24	44	-766**	279*	-245**	-312**	313+
	(65)	(78)	(223)	(141)	(69)	(97)	(188)
GasolinePrice*MPG Quart 2	63	79*	-153+	183	-355**	-193*	-327**
	(43)	(35)	(90)	(125)	(60)	(77)	(120)
GasolinePrice*MPG Quart 3	-74*	50	21	-418**	36	108+	-91
	(29)	(42)	(82)	(125)	(60)	(59)	(76)
GasolinePrice*MPG Quart 4	218**	-143**	345**	-183*	218**	-25	29
	(49)	(51)	(69)	(84)	(50)	(81)	(74)
PctLessHighSchool	330**	75	-211	-41	1.0e+02	385**	23
	(96)	(98)	(202)	(280)	(129)	(121)	(170)
PctCollege	-187**	-17	-17	-378*	222*	-43	-138
	(46)	(57)	(168)	(161)	(88)	(134)	(122)
Income	.00069	-.00086*	.0012	.002	.0017**	.0019*	.0012
	(.00045)	(.00039)	(.00097)	(.0017)	(.00049)	(.00075)	(.0011)
MedianHHSize	-9.7	67**	-71+	-64	40+	59**	35
	(11)	(16)	(36)	(48)	(24)	(21)	(24)
MedianHouseValue	.00016	-.000066	.00029*	.00057**	.00017	-.00012	.00032
	(.00011)	(.0001)	(.00014)	(.00016)	(.00012)	(.00013)	(.00021)
VehiclePerHH	-96**	-139**	20	-39	-165**	-174**	-95+
	(23)	(46)	(84)	(63)	(56)	(38)	(53)
TravelTime	.045	-.048	-3.6+	.35	.9	2.5+	2.4
	(.67)	(1)	(1.9)	(1.9)	(1.1)	(1.3)	(1.8)
Year 2000	-538**	-942**	-1944**	-1229**	-1375**	-916**	-916**
	(32)	(30)	(92)	(80)	(47)	(53)	(67)
Year 2001	-1065**	-1967**	-4283**	-2602**	-3005**	-2205**	-2208**
	(45)	(46)	(109)	(117)	(92)	(66)	(81)
Year 2002	-1977**	-3405**	-6907**	-4082**	-4507**	-3988**	-3869**
	(58)	(68)	(141)	(159)	(108)	(75)	(129)
Year 2003	-3055**	-4790**	-9580**	-5993**	-6382**	-5519**	-5810**
	(77)	(84)	(158)	(223)	(132)	(88)	(153)
Year 2004	-3840**	-6080**	-12085**	-8108**	-8200**	-7298**	-7414**
	(86)	(89)	(197)	(279)	(145)	(117)	(177)
Year 2005	-4386**	-7158**	-14590**	-9796**	-10069**	-9069**	-8780**
	(95)	(110)	(258)	(338)	(152)	(148)	(209)
Year 2006	-5035**	-8345**	-16912**	-11508**	-11965**	-10542**	-9946**
	(109)	(134)	(324)	(367)	(169)	(168)	(238)
Year 2007	-5724**	-9359**	-19313**	-12688**	-13448**	-11401**	-11331**
	(121)	(144)	(343)	(395)	(211)	(216)	(270)
Year 2008	-6374**	-10686**	-21931**	-13903**	-15172**	-13384**	-12628**
	(133)	(156)	(401)	(420)	(246)	(256)	(280)
Weekend	-18*	11	-13	-17	-22**	7.5	-32*
	(8.2)	(8.9)	(18)	(24)	(7.4)	(15)	(16)
EndOfMonth	-86**	-113**	-222**	-123**	-138**	-154**	-162**
	(8)	(8.8)	(16)	(35)	(9.3)	(11)	(14)
EndOfYear	-56*	-95**	-46	-61	-121**	-61	-48
	(24)	(25)	(49)	(85)	(38)	(47)	(50)
Constant	20162**	28104**	55518**	35917**	38210**	30882**	32423**
	(463)	(407)	(1221)	(858)	(356)	(419)	(622)
Observations	324084	378077	174609	73688	522809	267335	125764
R-squared	0.860	0.822	0.959	0.968	0.935	0.849	0.800

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects and car type fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-5: Used Cars: Market share results, fuel efficiency quartiles†

	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice	-.0074 (.0085)	-.019** (.007)	.024+ (.013)	.0018 (.0083)
PctLessHighSchool	.013 (.018)	.037* (.015)	-.033 (.028)	-.017 (.024)
PctCollege	-.038+ (.02)	.0077 (.019)	-.013 (.021)	.043+ (.022)
Income	-5.8e-07** (1.4e-07)	3.8e-07** (8.3e-08)	6.5e-07** (1.7e-07)	-4.5e-07** (1.5e-07)
MedianHHSize	.014** (.0045)	-.0036 (.0039)	-.0048 (.0035)	-.0059 (.0046)
MedianHouseValue	4.6e-08* (1.9e-08)	1.0e-07** (1.3e-08)	-4.8e-08* (2.1e-08)	-9.9e-08** (2.9e-08)
VehiclePerHH	.048** (.011)	-.0067 (.0065)	-.037** (.0071)	-.0037 (.014)
TravelTime	.00017 (.00028)	-.00037* (.00017)	-.00033 (.00026)	.00053 (.00036)
Year 2000	.011** (.004)	.0056 (.0043)	-.0097+ (.0059)	-.0065 (.0051)
Year 2001	.016** (.0038)	.0068 (.0043)	-.014* (.0059)	-.009 (.0054)
Year 2002	.013** (.0037)	.016** (.004)	-.017** (.005)	-.012** (.0045)
Year 2003	.02** (.0045)	.017** (.0052)	-.028** (.0072)	-.0095+ (.0056)
Year 2004	.017** (.0063)	.018** (.0065)	-.036** (.01)	.00072 (.0079)
Year 2005	.011 (.0095)	.025** (.0086)	-.045** (.015)	.0088 (.011)
Year 2006	.0031 (.012)	.031** (.01)	-.046* (.019)	.012 (.013)
Year 2007	-.0032 (.013)	.032** (.011)	-.049* (.021)	.02 (.015)
Year 2008	-.02 (.015)	.024 (.017)	-.006 (.027)	.0022 (.029)
Weekend	-.0071** (.0024)	-.0089** (.0025)	.0052 (.0033)	.011** (.0033)
EndOfMonth	.0049 (.0035)	-.0023 (.0016)	.00018 (.0029)	-.0028 (.0026)
EndOfYear	-.015** (.0047)	.0045 (.0041)	.0053 (.0045)	.0056 (.0047)
Constant	.33** (.057)	.39** (.13)	.11* (.05)	.18* (.083)
Observations	1264175	1264175	1264175	1264175
R-squared	0.021	0.008	0.010	0.015

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-6: Used Cars: Market share results, segments†

	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
GasolinePrice	-.0013 (.0041)	.031** (.01)	-.0073 (.0045)	-.0042** (.0013)	-.0072 (.0097)	-.011* (.0045)	.0004 (.005)
PctLessHighSchool	-.019 (.016)	-.0051 (.02)	.061** (.019)	-.014** (.004)	-.025 (.02)	.023 (.017)	-.021* (.0092)
PctCollege	.024+ (.014)	-.037+ (.021)	.087** (.019)	-.0085+ (.0049)	.049** (.018)	-.092** (.017)	-.021** (.0073)
Income	-2.1e-07+ (1.3e-07)	-2.8e-07+ (1.6e-07)	1.1e-06** (9.5e-08)	1.3e-07** (3.9e-08)	-6.9e-08 (1.4e-07)	-5.8e-07** (7.9e-08)	-7.9e-08 (1.0e-07)
MedianHHSize	-.0022 (.0032)	.0023 (.0041)	-.035** (.0034)	.00093 (.001)	.011** (.0035)	.0074* (.0033)	.016** (.003)
MedianHouseValue	-8.6e-08** (1.8e-08)	-1.3e-07** (1.8e-08)	2.3e-07** (2.0e-08)	-5.3e-09 (4.3e-09)	7.6e-08** (2.4e-08)	-5.7e-08** (1.3e-08)	-2.9e-08* (1.3e-08)
VehiclePerHH	.0064 (.0092)	-.021* (.0085)	-.035** (.0046)	.0051* (.0023)	.00089 (.0082)	.051** (.0057)	-.0075 (.0059)
TravelTime	.00061* (.00027)	-.00024 (.00025)	-.00068** (.00013)	.00005 (.000057)	.00011 (.00024)	.0002 (.00015)	-.00006 (.00011)
Year 2000	-.0091* (.0038)	-.023** (.0049)	.00045 (.0045)	-.002 (.0019)	.024** (.0049)	.0071* (.0029)	.0026 (.0027)
Year 2001	-.015** (.0036)	-.037** (.0047)	-.0026 (.0045)	-.0036+ (.0019)	.05** (.0046)	.009** (.0029)	-.00085 (.0025)
Year 2002	-.02** (.003)	-.051** (.0045)	.00044 (.0041)	-.0074** (.002)	.068** (.004)	.011** (.0032)	-.00099 (.003)
Year 2003	-.022** (.0039)	-.067** (.0064)	.00016 (.0046)	-.0093** (.0023)	.087** (.006)	.016** (.0037)	-.0043 (.003)
Year 2004	-.021** (.0051)	-.086** (.0079)	.0062 (.005)	-.0089** (.0026)	.1** (.0078)	.017** (.0047)	-.0081+ (.0044)
Year 2005	-.018** (.0064)	-.1** (.012)	.013* (.0062)	-.0077* (.0031)	.11** (.012)	.014* (.0066)	-.01+ (.0058)
Year 2006	-.016* (.0073)	-.11** (.015)	.017* (.0074)	-.01** (.0035)	.12** (.014)	.0088 (.008)	-.008 (.0073)
Year 2007	-.0057 (.0083)	-.13** (.016)	.021* (.0085)	-.011** (.0038)	.13** (.016)	.0088 (.0087)	-.012 (.0081)
Year 2008	-.014 (.021)	-.1** (.014)	.016 (.015)	-.022** (.0046)	.14** (.017)	-.0099 (.015)	-.0049 (.01)
Weekend	.0048* (.0024)	.005 (.0038)	-.011** (.0022)	.00022 (.0005)	.0024 (.0025)	-.00068 (.0026)	-.00038 (.002)
EndOfMonth	-.0016 (.003)	-.0027 (.0036)	.0044** (.0013)	-.0012** (.00048)	.0052+ (.003)	-.0024 (.0018)	-.0016 (.0011)
EndOfYear	-.0019 (.005)	.0087+ (.0049)	.00051 (.003)	-.0043* (.0017)	.0016 (.0051)	-.0095** (.0029)	.0049* (.0022)
Constant	.084+ (.045)	.2* (.095)	.22** (.052)	.016 (.013)	-.02 (.052)	.48** (.13)	.025 (.029)
Observations	1264175	1264175	1264175	1264175	1264175	1264175	1264175
R-squared	0.011	0.019	0.043	0.005	0.016	0.036	0.010

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.

Not reported: Region × month-of-year fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-7: Used Cars: Market share results, subsegments†

Subsegment	Coefficient	SE	Mean Mkt Share	% Change in Share
Entry Compact Car	-0.0018	(0.0016)	0.95%	-18.9%
Premium Compact Car	0.00042	(0.004)	13.03%	0.3%
Entry Midsize Car	0.0024	(0.0046)	6.64%	3.6%
Premium Midsize Car	0.029*	(0.011)	18.95%	15.3%
Entry Luxury Car	-0.00015	(0.0025)	5.08%	-0.3%
Mid Luxury Car	-0.0056*	(0.0026)	4.07%	-13.8%
Premium Luxury Car	-0.0013*	(0.0006)	0.74%	-17.6%
Sporty Car	-0.0032**	(0.0011)	3.82%	-8.4%
Premium Sports Car	-0.00097	(0.00074)	0.9%	-10.8%
Luxury Sports Car	-0.00035	(0.00049)	0.43%	-8.1%
Entry SUV	0.0018	(0.0085)	5.66%	3.2%
Midsize SUV	-0.011*	(0.0049)	12.31%	-8.9%
Fullsize SUV	0.004	(0.007)	4.23%	9.5%
Luxury SUV	-0.0019	(0.0018)	2.33%	-8.2%
Compact Pickup	-0.0038	(0.0029)	5.7%	-6.7%
Light Duty Fullsize Pickup	-0.0074*	(0.0031)	8.27%	-8.9%
Compact Van	0.00029	(0.0051)	6.59%	0.4%
Fullsize Van	0.00011	(0.00031)	0.21%	5.2%

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
This table only reports the coefficients in gasoline prices.

Table A-8: Used Cars: Price results, fuel efficiency quartiles†

Variable	Coefficient/SE
GasolinePrice*MPG Quart 1	-1072** (43)
GasolinePrice*MPG Quart 2	-948** (62)
GasolinePrice*MPG Quart 3	65 (81)
GasolinePrice*MPG Quart 4	1572** (64)
PctLessHighSchool	129 (96)
PctCollege	94 (75)
Income	.0032** (.00077)
MedianHHSize	-55* (24)
MedianHouseValue	.00069** (.00017)
VehiclePerHH	-153** (31)
TravelTime	-1.5 (1.3)
Year 2000	-1385** (47)
Year 2001	-3272** (73)
Year 2002	-5266** (91)
Year 2003	-7687** (114)
Year 2004	-9551** (141)
Year 2005	-11207** (169)
Year 2006	-12991** (200)
Year 2007	-15007** (231)
Year 2008	-17714** (254)
Weekend	109** (13)
EndOfMonth	-82** (7.7)
EndOfYear	25 (26)
Constant	25660** (388)
Observations	1264092
R-squared	0.895

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects and car type fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-9: Used Cars: Price results, fuel efficiency quartiles by segment†

	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
GasolinePrice*MPG Quart 1	-966**	-197	-3545**	-600**	-1846**	-871**	1153**
	(69)	(123)	(256)	(200)	(81)	(66)	(124)
GasolinePrice*MPG Quart 2	245**	16	102	140	101+	-558**	976**
	(40)	(34)	(125)	(98)	(60)	(48)	(76)
GasolinePrice*MPG Quart 3	223**	121**	374**	661**	802**	10	-75
	(38)	(37)	(127)	(91)	(71)	(49)	(64)
GasolinePrice*MPG Quart 4	345**	457**	943**	660**	1461**	1608**	-177**
	(39)	(47)	(150)	(75)	(74)	(67)	(64)
PctLessHighSchool	229*	29	119	-249	269*	6.6	348+
	(89)	(115)	(249)	(330)	(130)	(136)	(204)
PctCollege	45	40	-.4	205	258+	79	141
	(77)	(81)	(204)	(246)	(134)	(119)	(160)
Income	-.0019**	-.0006	.0046**	.0023	.0039**	.00025	.0018
	(.00071)	(.00062)	(.0012)	(.0021)	(.00091)	(.0011)	(.0014)
MedianHHSize	18	-8.4	-253**	-23	-7.4	1.9	38
	(26)	(22)	(38)	(50)	(36)	(45)	(50)
MedianHouseValue	.00021	.00012	.00098**	.00094**	.00016	-.000058	.00019
	(.00014)	(.00012)	(.00018)	(.00027)	(.0002)	(.0002)	(.00024)
VehiclePerHH	-116**	-134**	-140+	-258**	-140**	-82+	-125+
	(30)	(37)	(71)	(79)	(40)	(47)	(65)
TravelTime	1.2	2.7*	-8.7**	-1.4	-1.1	.67	-1.9
	(1.2)	(1.1)	(3)	(2.6)	(1.4)	(1.5)	(1.8)
Year 2000	-882**	-1197**	-2240**	-899**	-2171**	-1287**	-1663**
	(43)	(55)	(86)	(78)	(72)	(50)	(68)
Year 2001	-1892**	-2703**	-5342**	-2424**	-5018**	-2840**	-3740**
	(59)	(64)	(121)	(105)	(90)	(64)	(92)
Year 2002	-3348**	-4490**	-8563**	-4345**	-7312**	-4511**	-6022**
	(64)	(68)	(165)	(115)	(107)	(76)	(109)
Year 2003	-5102**	-6619**	-12263**	-6736**	-10201**	-6475**	-8796**
	(77)	(81)	(205)	(147)	(124)	(98)	(121)
Year 2004	-6267**	-8180**	-15303**	-8593**	-12528**	-7895**	-10880**
	(98)	(98)	(240)	(169)	(160)	(114)	(155)
Year 2005	-6938**	-9305**	-18192**	-9919**	-14885**	-9349**	-12757**
	(106)	(117)	(293)	(194)	(188)	(130)	(171)
Year 2006	-7557**	-10452**	-21438**	-11259**	-17460**	-10837**	-14742**
	(111)	(140)	(335)	(230)	(223)	(144)	(200)
Year 2007	-8883**	-12149**	-25031**	-13461**	-19748**	-12258**	-16764**
	(126)	(155)	(373)	(274)	(256)	(163)	(217)
Year 2008	-10255**	-14096**	-29701**	-15989**	-23154**	-14806**	-19287**
	(147)	(161)	(436)	(316)	(275)	(193)	(242)
Weekend	78**	93**	149**	61+	129**	129**	85**
	(10)	(15)	(35)	(31)	(20)	(20)	(26)
EndOfMonth	-51**	-66**	-155**	-37	-121**	-86**	-51*
	(9.2)	(12)	(29)	(33)	(18)	(15)	(25)
EndOfYear	-2.7	21	-33	-7.4	75+	82	-62
	(37)	(36)	(1.0e+02)	(118)	(45)	(57)	(75)
Constant	15926**	20035**	41078**	24592**	33626**	23675**	24174**
	(403)	(380)	(1077)	(783)	(574)	(506)	(821)
Observations	176635	323523	130318	59585	310100	177888	86043
R-squared	0.859	0.860	0.899	0.930	0.886	0.866	0.831

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects and car type fixed effects. We also don't report house ownership, occupation, english proficiency, and race of buyers.

Table A-10: New and Used Cars: Inventory results, fuel efficiency quartiles†

	Days to Turn	Days to Turn
GasolinePrice*MPG Quart 1	11** (2.3)	1.8+ (.96)
GasolinePrice*MPG Quart 2	2.8** (.92)	2.3** (.82)
GasolinePrice*MPG Quart 3	.016 (.86)	.83 (.99)
GasolinePrice*MPG Quart 4	-7** (.91)	-.25 (.76)
Year 2000	80** (1.7)	-2.9* (1.2)
Year 2001	164** (2.6)	-7.8** (1)
Year 2002	242** (3.1)	-8.3** (1.2)
Year 2003	328** (4.2)	-10** (1.5)
Year 2004	412** (5.8)	-14** (1.6)
Year 2005	491** (6.8)	-20** (1.7)
Year 2006	574** (8.4)	-22** (1.9)
Year 2007	653** (9.5)	-23** (2.2)
Year 2008	736** (10)	-23** (2.8)
Constant	-350** (6.8)	70** (2)
Observations	1821158	1234880
R-squared	0.656	0.573

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects and car type × dealer fixed effects.

Table A-11: New and Used Cars: Trade-in results†

	New Car MPG	Used Car MPG	New Car Trade-in Booked Value	Used Car Trade-in Booked Value
GasolinePrice	.82** (.074)	.41** (.054)		
GasolinePrice*MPG Quart 1			-1177** (44)	-1010** (29)
GasolinePrice*MPG Quart 2			-894** (45)	-609** (45)
GasolinePrice*MPG Quart 3			162** (60)	200** (50)
GasolinePrice*MPG Quart 4			1258** (50)	758** (47)
Trade-in Odometer			-.041** (.00049)	-.03** (.00046)
PctLessHighSchool	-.19 (.19)	-.041 (.18)	25 (100)	189* (84)
PctCollege	-.026 (.19)	.18 (.13)	159 (98)	-15 (94)
Income	-1.6e-06+ (9.2e-07)	3.2e-06* (1.2e-06)	-.0023* (.001)	-.000087 (.00084)
MedianHHSize	-.32** (.035)	-.21** (.04)	-26 (17)	-16 (22)
MedianHouseValue	-2.4e-07 (2.8e-07)	-5.7e-07** (1.8e-07)	-.00047** (.000086)	-.00003 (.00011)
VehiclePerHH	-.26* (.1)	-.28* (.11)	205** (41)	130** (32)
TravelTime	.0018 (.0017)	.003 (.0021)	-2.5* (1.1)	-1.2 (.92)
Year 2000	.041 (.053)	-.16** (.039)	-547** (36)	-341** (39)
Year 2001	.31** (.058)	-.15** (.042)	-1381** (56)	-900** (38)
Year 2002	.64** (.07)	-.058 (.042)	-2352** (66)	-1581** (45)
Year 2003	.78** (.077)	-.066 (.052)	-3693** (87)	-2497** (58)
Year 2004	1** (.095)	.086 (.062)	-4623** (95)	-3117** (68)
Year 2005	1.4** (.11)	.26** (.077)	-5487** (104)	-3740** (77)
Year 2006	1.8** (.13)	.37** (.09)	-6514** (113)	-4451** (92)
Year 2007	2.8** (.15)	.68** (.1)	-7799** (138)	-5386** (104)
Year 2008	1.7** (.21)	.73** (.12)	-9411** (152)	-6626** (124)
Weekend	.0044 (.017)	-.016 (.02)	-49** (9.2)	-41** (9.1)
EndOfMonth	-.088** (.014)	-.0033 (.017)	-26+ (13)	-14 (10)
EndOfYear	.064 (.051)	.15** (.053)	-117** (32)	-98* (38)
Constant	19** (.69)	20** (.55)	15660** (398)	10728** (368)
Observations	731604	485470	580210	341966
R-squared	0.260	0.194	0.881	0.864

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
Not reported: Region × month-of-year fixed effects. We don't report trade-in car type fixed effects (columns 1 and 2 only). We also don't report house ownership, occupation, english proficiency, and race of buyers.
Please note that columns 1 and 2 exclude the 2008 model year due to the change in the EPA fuel efficiency formula. Some 2008 calender year transactions appear in the data, however.

Table A-12: New and Used Cars: Market share (quartile) results by gasoline price levels[†]

New Cars Results	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice (<1.5 dollar)	-.026*	-.017+	-.0056	.048**
	(.013)	(.0089)	(.0058)	(.014)
GasolinePrice (1.5-2.5 dollars)	-.027*	-.02**	.00077	.046**
	(.012)	(.0071)	(.0054)	(.013)
GasolinePrice (2.5-3.5 dollars)	-.03**	-.02**	.00023	.05**
	(.01)	(.0063)	(.0043)	(.012)
GasolinePrice (>3.5 dollars)	-.032**	-.015+	-.013**	.059**
	(.009)	(.0087)	(.0041)	(.011)

New Cars Results	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice (<1.5 dollar)	-.01	-.0034	.0077	.0059
	(.0095)	(.0069)	(.017)	(.012)
GasolinePrice (1.5-2.5 dollars)	-.0066	-.0017	.0067	.0015
	(.0088)	(.0067)	(.017)	(.013)
GasolinePrice (2.5-3.5 dollars)	-.0076	-.004	.0058	.0058
	(.0076)	(.0056)	(.015)	(.011)
GasolinePrice (>3.5 dollars)	-.0063	-.024**	.04*	-.01
	(.013)	(.0091)	(.017)	(.011)

[*] significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.

This table only reports the coefficients on gasoline prices.

Table A-13: New and Used Cars: Price results by gasoline price levels†

	New Cars, MPG Quartiles	Used Cars, MPG Quartiles
GasolinePrice(< 1.5)*MPG Quart 1	-283** (91)	-1331** (77)
GasolinePrice(1.5-2.5)*MPG Quart 1	-190+ (102)	-1137** (59)
GasolinePrice(2.5-3.5)*MPG Quart 1	-207* (81)	-1066** (51)
GasolinePrice(> 3.5)*MPG Quart 1	-362** (72)	-1396** (70)
GasolinePrice(< 1.5)*MPG Quart 2	-126* (49)	-1282** (114)
GasolinePrice(1.5-2.5)*MPG Quart 2	-80 (49)	-1146** (83)
GasolinePrice(2.5-3.5)*MPG Quart 2	-96* (40)	-1025** (78)
GasolinePrice(> 3.5)*MPG Quart 2	-79* (35)	-1043** (89)
GasolinePrice(< 1.5)*MPG Quart 3	-47 (47)	381** (117)
GasolinePrice(1.5-2.5)*MPG Quart 3	-29 (44)	389** (102)
GasolinePrice(2.5-3.5)*MPG Quart 3	-30 (38)	268** (88)
GasolinePrice(> 3.5)*MPG Quart 3	4.9 (35)	163 (146)
GasolinePrice(< 1.5)*MPG Quart 4	91 (64)	2420** (143)
GasolinePrice(1.5-2.5)*MPG Quart 4	60 (68)	2277** (136)
GasolinePrice(2.5-3.5)*MPG Quart 4	74 (56)	2035** (100)
GasolinePrice(> 3.5)*MPG Quart 4	141** (50)	1683** (94)

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
This table only reports the coefficients on gasoline prices.

Table A-14: New and Used Cars: Market share (quartile) results by gasoline price trends†

New Cars Results	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice (3 months up)	-.037** (.008)	-.021** (.0052)	-.0006 (.0036)	.058** (.0094)
GasolinePrice (3 months mixed)	-.034** (.0086)	-.02** (.0053)	.0019 (.0038)	.052** (.01)
GasolinePrice (3 months down)	-.036** (.0089)	-.024** (.0057)	.0045 (.0043)	.055** (.011)
Used Cars Results	**MPG Quartile 1**	**MPG Quartile 2**	**MPG Quartile 3**	**MPG Quartile 4**
GasolinePrice (3 months up)	-.0023 (.0083)	-.016* (.0068)	.017 (.011)	.00057 (.008)
GasolinePrice (3 months mixed)	.0024 (.0082)	-.01 (.0065)	.0075 (.01)	.00053 (.0081)
GasolinePrice (3 months down)	.004 (.0087)	-.012+ (.007)	.0088 (.01)	-.001 (.0088)

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
This table only reports the coefficients on gasoline prices.

Table A-15: New and Used Cars: Price results by gasoline price trends†

	New Cars, MPG Quartiles	Used Cars, MPG Quartiles
GasolinePrice(3 mo up)*MPG Quart 1	-266** (74)	-1041** (47)
GasolinePrice(3 mo mixed)*MPG Quart 1	-281** (84)	-1113** (51)
GasolinePrice(3 mo down)*MPG Quart 1	-329** (92)	-1241** (58)
GasolinePrice(3 mo up)*MPG Quart 2	-124** (37)	-917** (66)
GasolinePrice(3 mo mixed)*MPG Quart 2	-152** (40)	-987** (71)
GasolinePrice(3 mo down)*MPG Quart 2	-171** (44)	-1071** (76)
GasolinePrice(3 mo up)*MPG Quart 3	-49 (41)	78 (86)
GasolinePrice(3 mo mixed)*MPG Quart 3	-65 (47)	85 (83)
GasolinePrice(3 mo down)*MPG Quart 3	-92+ (53)	82 (90)
GasolinePrice(3 mo up)*MPG Quart 4	83 (56)	1558** (66)
GasolinePrice(3 mo mixed)*MPG Quart 4	74 (63)	1726** (72)
GasolinePrice(3 mo down)*MPG Quart 4	65 (68)	1854** (78)

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses.
This table only reports the coefficients on gasoline prices.