Pain at the Pump: The Differential Effect of Gasoline Prices on New and Used Automobile Markets*

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Abstract

Many durable goods are costly to use once they have been purchased. For example, automobiles need gasoline to drive, printers need cartridges to print, appliances need electricity to operate. In this paper we show that usage cost can have a dramatically different effect on the markets for a durable good, depending on whether the good is new or used. Using the automobile industry, 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

One of the distinctive features of durable goods is that they are often available in very similar versions–new and used–in two different markets. There is an extensive literature that has compared market outcomes (such as prices and sales) in markets for new and used durable goods, and how those outcomes are influenced by various features of the goods or the markets, including durability, asymmetric information, and obsolescence.

In this paper, we note that new and used markets can differ substantially in their market structure. New and used car markets are a good example. New cars are sold through networks of franchised dealers that are closely affiliated with oligopolistic car manufacturers. The manufacturers have no formal control over retail price, but a great deal of influence on retail prices through their decisions to offer or not offer rebates and promotions. Used cars on the other hand, are sold through a variety of channels, ranging from individual owners making private transactions, to independent used car dealers, to the used car divisions of the same franchised dealers that sell new cars. Operating in the background of all these used car retail channels are a large number of geographically ubiquitous, high volume, high frequency wholesale auctions.

Of course, this contrast is not unique to cars. Consumer electronics, music CDs, commercial equipment, and designer clothing are all sold in very different markets in their new and used versions. New versions are typically sold in a limited number of well-defined retail outlets where the patent-, brand-, or trademark-holder has a fair amount of formal or informal control. Used versions are much more likely to be sold in smaller, more independent outlets; by their current owners; or to be sold in auctions.

In this paper, we demonstrate how different the market outcomes can be in new and used markets by considering the effect of a change in usage cost on prices and sales of durable goods, distinguishing between variants of the goods that are more or less affected by the change. Our specific application examines changes in gasoline prices and how these affect prices and sales of low vs. high fuel efficiency cars in both the new and in used markets.

The qualitative effects we find are not surprising: higher gasoline prices lead to higher prices and market shares for fuel-efficient cars and lower prices and market shares for fuel-inefficient cars. What is noteworthy are the differences between the effects in new and used markets: gasoline prices have a larger effect on *market shares* in new markets than in used markets, but a much larger effect on *prices* in used markets than in new markets. The differences in the effect sizes are quite dramatic; the effects differ by an order of magnitude in many cases. We argue that differences in the market structures of new and used car markets lead to the effect of gasoline prices playing out primarily in the market shares of new cars, but in the prices of used cars.

The effect of gasoline prices on equilibrium outcomes in new and used *automobile* markets is of standalone interest. The past several years have been marked by some dramatic events relating to gasoline prices and customers' responses in terms of vehicle choices. Such events include retail gasoline prices reaching their highest real values ever (Energy Information Administration, *Short Term Energy Outlook*, January 2007); the Ford F150 pickup yielding its long-standing position as the highest selling car in the U.S. to the Honda Civic (Automotive News, June 5, 2008); and GM losing its status as the worldwide leader in new car sales to Toyota (Barron's, January 21, 2009). These changes have culminated into the severe financial distress of automobile manufacturers, leading to a multi-billion dollar bailout package and bankruptcy hearings for GM and Chrysler and Toyota's first annual profit loss in the history of the company. The detailed, transaction based data we use in this paper allow us to estimate with some precision the effect of gasoline prices on automobile transaction prices and on the market shares of particular classes of vehicles, thus adding to our understanding of how gasoline prices influenced these events.

Furthermore, while the environmental implications of our analysis are the not the focus of the paper, our results also add to our understanding of how increases in gasoline prices, through oil shocks or taxes, may also affect US fleet fuel economy. The U.S. EPA estimates that 20% of U.S. CO_2 emissions come from passenger cars and light duty trucks alone. One of the policies that has been suggested as a way to reduce greenhouse gas emissions from the transportation sector is either a tax on gasoline, or a more general carbon tax, which would raise the prices of gasoline and of other energy sources. In order to reduce greenhouse gas emissions, such a tax would have to either reduce how much people drive, or cause them to substitute more fuel efficient vehicles for the vehicles they are currently driving. Our results speak to the second effect.

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 investigates the robustness of our base results. Section 6 provides supporting evidence for our findings in Section 4, and Section 7 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

Because cars are durable goods, potential customers must consider in their purchase decision not only the initial cost of acquiring a car, but also the ongoing costs of operating the car. While the relative sizes of the ongoing costs (such as insurance, fuel, maintenance, repair, depreciation, and financing) will vary across car owners and across car models, fuel costs will be a non-negligible component for most drivers and for most models. An increase in the price of gasoline will therefore increase the usage cost for all (gasoline-powered) automobiles.[1] Exactly how much the cost-per-mile increases for a particular model, however, depends on the characteristics of the model. The larger and heavier a vehicle and the greater its horsepower, the greater effect a given gasoline price increase will have on its costs of usage. 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.[2] If this is the case, we expect demand for cars in general to be inelastic to changes in gasoline 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 would expect to see demand increase for fuel-efficient cars and decrease for fuel-inefficient cars when gasoline prices increase.

Figure 1 offers some coarse evidence of such a correlation in the raw data on new car sales. The dotted 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 solid 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.

While we might expect gasoline prices to have a similar effect in both new and used markets on the *demand* for cars of different fuel efficiencies, a change in gasoline prices could nevertheless

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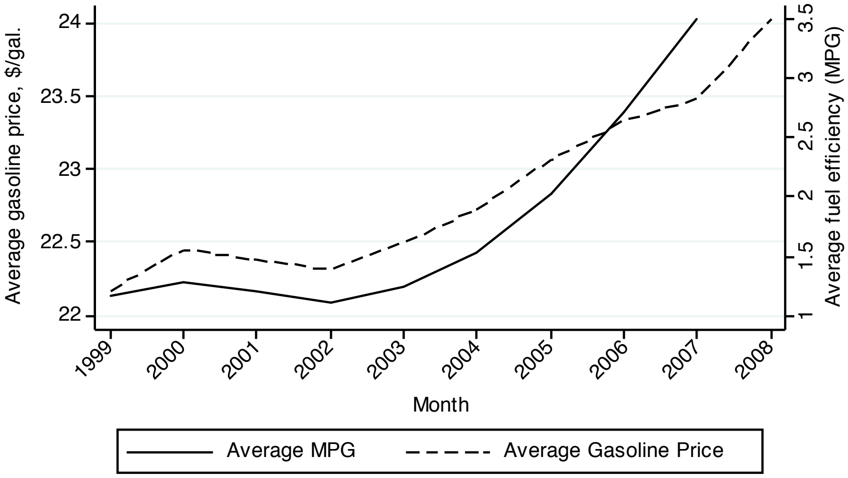
[1] Exceptions include a very small number of vehicles that are solely electric, natural gas-powered, or are operated solely on a biofuel such as ethanol or biodiesel.

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

Figure 1: Average MPG of available cars by model year



lead to very different equilibrium outcomes in the two markets because of differences between the two markets on the *supply* side. We next compare supply in new and used car markets, starting with new car supply.

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. The equilibrium effects of a gasoline price on new car sales and prices depend on the combined response in this supply chain. In other words, the observed equilibrium effects at the retail level represent the net effect of the manufacturer and dealer responses together. In this paper, we estimate short-run equilibrium effects. For the car industry, the short-run horizon is measured in months, a time frame during which a manufacturer's offering of models is fixed, its model-specific production capacity is largely fixed, as are a number of input arrangements (labor contracts, in particular). Over a longer horizon, say a year or two, some of these aspects become more flexible (models can be tweaked, some capacity can be altered). Only over a long-run horizon (several years), can a manufacturer introduce fundamentally different models into its product offering.

The fixed nature of many of the costs to production implies that, for production levels below capacity, marginal costs are likely to be relatively flat (and small). Because we analyze a period of rising gasoline prices, a flat marginal cost is an accurate description of the new vehicle marginal cost curve. Manufacturers thus must trade-off reductions in price with reductions in sales.

There are some specific reasons why automakers might prefer to allow sales to fall when demand decreases rather than adjust prices to clear the market at normal sales levels. One is that auto manufacturers are reluctant to cut prices on new cars for reputation reasons. Although Busse, Silva-Risso, and Zettelmeyer (2006) show that manufacturers do offer discounts regularly via rebates to customers or dealers, they are nevertheless 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).

Because auto manufacturers and car dealers are separate entities, the final transaction price a customer pays is determined in a negotiation with the dealer. Nominally, this gives car dealers a lot of flexibility in setting prices. However, car dealers have moderate margins on most new car sales, which means that they often have limited scope for adjusting prices downward—at least 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, as well as the flexibility of production, 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.[3]

While the responsiveness of new car supply to gasoline prices 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.

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[3] 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 $P = a - b_1Q$ and D_2 given by $P = a - b_2Q$, 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 for two reasons. One is that the fundamental source of used cars is individual drivers, not firms. Second is the institutional characteristics of the the upstream market.

In order for a car to make its way into the used car market, that car's current owner has to decide to sell it, trade it in, or return it rather than keeping it at the end of a lease. In most cases, the current owner replaces his or her current car with another car, either from the new or used market. As a consequence, the used car supply decision depends in part on how sensitive individual drivers are to the price of gasoline, and on how that affects their relative valuations of the cars they currently own and cars that they might buy instead. 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.

Consider a potential seller and a potential buyer of a particular fuel-inefficient used car currently owned by the seller. If the gasoline price increases by a particular amount, then the *per-mile* cost of driving that particular car increases by the same amount for both drivers.[4] If the two drivers have approximately the same driving habits, then one might expect the effect of the gasoline price increase on the buyer and the seller to be symmetric: for both the current owner and the potential buyer, 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 he or she buys the car. 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. Taking this logic one step further, if most drivers have similar driving habits (or if a large enough number of marginal buyers and sellers have similar driving habits), then the demand curve for a used car and the supply curve for that car should shift down by approximately the same amount (at least in the area of the demand and supply curves where equilibrium occurs). 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.

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

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[4] Technically, fuel consumption per mile can be affected by how aggressively a driver drives a car, but we abstract from such differences here.

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.

What would we expect to see if drivers instead are very heterogeneous in their usage intensities? It would still be the case that an increase in gasoline prices would increase the *per-mile* driving costs of any given car by the same amount for all drivers. However, the valuation of a particular car would change by different amounts for different drivers. For a driver with a long daily commute, the costs of owning a large fuel-efficient SUV would rise by much more than the costs of owning that same vehicle would rise for a non-commuter. Similarly, the advantage of owning a smaller, more fuel-efficient car relative to the large SUV would increase by more for that same long-commuting driver than for the non-commuter. If there is enough such heterogeneity, and if the usage cost changes are large enough relative to the transactions costs of a used car transaction, then an increase in gasoline prices might cause a substantial increase in used car transactions, especially at the extremes of the fuel price distribution where the gains to trade are the largest.

A second difference between the supply of new cars and the supply of used cars is that a large fraction of wholesale transactions in used cars go through independent auctions, unaffiliated with the car manufacturers who are the upstream suppliers (and price-setters) in the new car market. 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.) They generally hold auctions every week, at which 1,000 cars might be transacted in a typical week. This means that for car dealers, used cars are convertible into cash, and vice versa, at auction-determined prices on a weekly basis. One might expect that such a mechanism would reflect changes in equilibrium market conditions quite quickly, and would thereby help move the prices of used cars sold at car dealerships fairly quickly to a new, market clearing equilibrium price that reflected changes in gasoline prices. While this adjustment in the transaction prices of used cars 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.

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.[5] 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 gasoline 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 also measuring the variation in miles driven across consumers.[6] 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 combine several types of data for this analysis. Our main data contain 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

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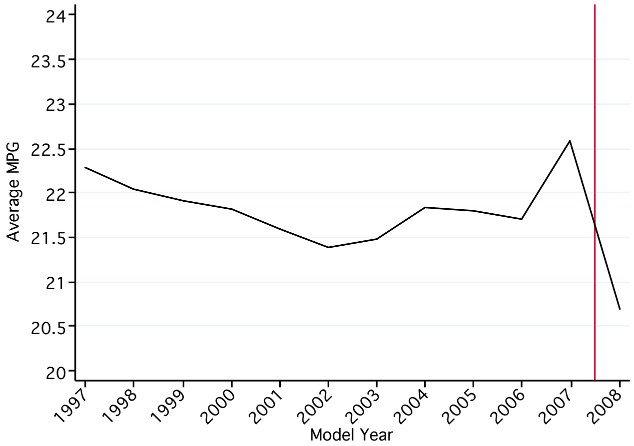
[5] For example, see such seminal papers as Goldberg (1995) and Berry, Levinsohn, and Pakes (1995).

[6] 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.

Figure 2: Average MPG of available cars by model year



cost of obtaining the car from the manufacturer, information on any trade-in vehicle used, and (census-based) demographic information on the customer. We discuss in detail the variables used in each specification later in the paper.

We supplement 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 show a pattern of slow decline in the first part of our sample period, and some increase in the latter part.[7] Overall, however, the average MPG of available models (not sales-weighted) stay between 21.5 and 22.5 miles per gallon for the entire decade.[8]

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 by buyers who reside in one of these ZIP codes.

While we know the ZIP-code of each buyer, it is not obvious that we should aggregate

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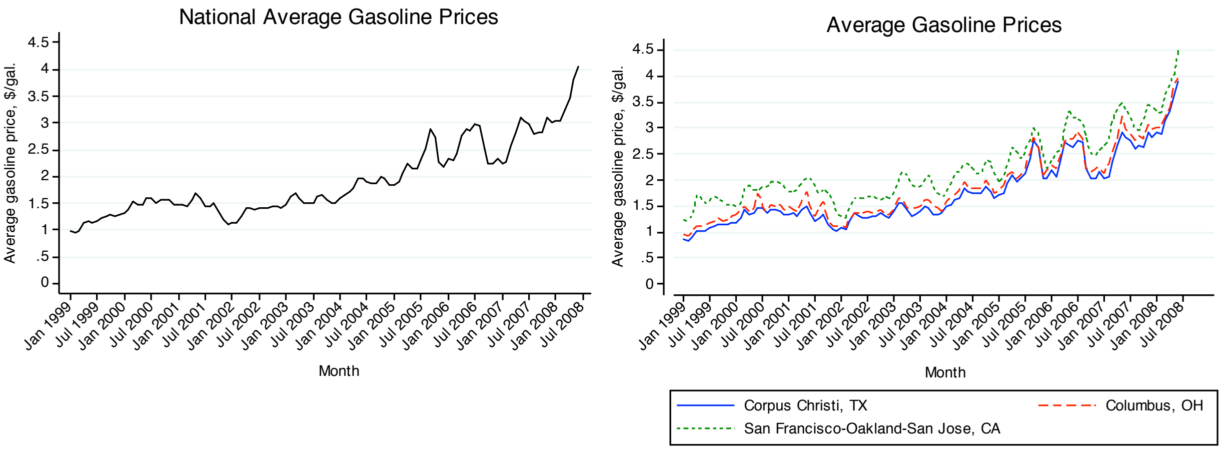
[7] The sharp decline in MPG observed in 2008 coincides with a change in how the EPA calculates MPG.

[8] 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. Knittel (2009) analyzes the rate of technological progress and these trade-offs from 1980 to 2006.

Figure 3: Monthly average gasoline prices (national and by DMA)



the station level data at the ZIP-code level. This is for two reasons. First, we only observe a small number of stations per ZIP-code, which may lead to measurement error.[9] Second, consumers are likely to react not only to the gasoline prices in their local ZIP-code but also to gasoline prices outside their local area. This is especially true if change to local prices, not also incorporated into more regional prices, are transitory in nature. As a result, we average the prices for basic grade over all stations in each local market (as defined by Nielsen Designated Market Areas, or “DMAs” for short). There are 210 DMAs. Examples are “San Francisco-Oakland-San Jose, CA,” “Charlotte, NC,” and “Ft. Myers-Naples, FL.” Later we investigate the sensitivity of our results to different ways of aggregating gasoline prices (see section 5.3).

To get a sense of the variability of gasoline prices, we graph monthly national average gasoline prices. As shown in Figure 3 (left panel), 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 right panel of Figure 3 illustrates this by comparing three DMAs, namely Corpus Christi, TX, Columbus, OH, and San Francisco-Oakland-San Jose, CA. California gasoline prices are substantially higher than prices in Ohio (which are close to the median) and Texas (which are low). Notice that there is also variation over time in how much higher California prices are.

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[9] In our data, the median ZIP code reports data from 3 stations on average over the months of the year. More than 25% of ZIP-codes have only one station reporting.

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 6 and 7 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) (or some function of 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 by 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:

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

$I_{irt}(j \in K)$ 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 consider two different classes in this section, namely fuel efficiency quartiles and segments (e.g., midsize, SUV, compact).[10,11] The variable of primary interest is *GasolinePrice*, which is specific to the month in which the vehicle was purchased and to the DMA of the buyer.[12]

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.[13] 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

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[10] In previous versions we have considered subsegments (e.g., entry compact, premium compact, mini SUV, compact SUV). These results are available from the authors.

[11] Our results do not depend on the linear probability specification; we obtain nearly identical results with a multinomial logit model (see section 5.5).

[12] Another potential 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, however, futures prices for crude oil at any point in time are quite highly correlated with current gasoline prices, reducing the statistical power from such an exercise. As a result, we have not undertaken this approach.

[13] 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. We have estimated all of our sales specifications without demographic covariates and find that our qualitative results are robust to the exclusion of the demographic variables.

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 pick them up with these variables. Finally, we include year, τ_{rt}, and the month-of-the-year, μ_{rt}, fixed effects describing when the purchase was made. Both year and month-of-the-year fixed effects are allowed to vary by the geographic region (29 throughout the U.S.) in which the car was sold. This takes into account that year-over-year and seasonal preferences for specific car classes may vary by region of the country. To examine the robustness of our results to the variation in the data identifying the effect of gasoline prices, we repeat our estimation with a series of different fixed effect specifications in Section 5.1.

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.[14] 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* (not sold) in that year. Table 8 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 capture level shifts in the EPA rating system.)

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

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[14] As gasoline 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 DMAs).

The full estimation results are reported in Table A-1. The gasoline price coefficient (γ_1) for each specification are presented below.[15] 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)	-.053**	(.0049)	20.9%	-25.4%
MPG Quartile 2	-.016**	(.004)	21.2%	-7.5%
MPG Quartile 3	-.0061*	(.0029)	23.7%	-2.6%
MPG Quartile 4 (most fuel-efficient)	.075**	(.005)	34.2%	21.9%

These results suggest that a $1 increase in gasoline price decreases the market share of cars in the least fuel-efficient quartile by 5.3 percentage points, or 25.4%. Conversely, we find that a $1 increase in gasoline price increases the market share of cars in the most fuel-efficient quartile by 7.5 percentage points, or 21.9%. This provides evidence that higher gasoline prices are associated with the purchase of more fuel-efficient cars. Notice that these estimates do not simply reflect an overall trend of increasing gasoline prices and increasing fuel efficiency; since we control for region specific year fixed effects, all estimates rely on within-year within-region variation in gasoline prices and associated purchases.[16]

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).[17] We estimate the specification in Equation 2 for each of

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[15] Two asterisks (**) signifies significance at the .01 level, * signifies significance at the .05 level and + at the .10 level. We do not restrict the γs to sum to zero; the sum equals -0.0001.

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

[17] See Table 9 for more examples of cars in each segment.

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	0.043**	(0.0041)	17.4%	24.7%
Midsize	0.018**	(0.0028)	20.3%	8.9%
Sporty Cars	-0.000014	(0.0026)	4.0 %	-0.04%
Luxury	0.0046**	(0.0015)	9.4 %	4.9%
SUVs	-0.04**	(0.0034)	28.0%	-14.3%
Pickups	-0.018**	(0.0032)	14.3%	-12.6%
Vans	-0.0081**	(0.0017)	6.7 %	-12.1%

These results show an outflow of consumers from SUVs, pickups, and vans (which are the lowest fuel-efficiency segments; see Table 9). These segments lose 4, 1.8, and 1 percentage points of market share, respectively, which corresponds to 14.3%, 12.6%, and 12.1% reductions of the respective market shares. The largest segment market share change is the gain of 4.3 percentage points, a 24.7% increase, for compact cars, the most fuel-efficient segment. Midsize cars also increase their market share by 1.8 percentage points, a 8.9% gain. The market share of luxury cars also increases. While this might seem surprising, buyers may opt for a luxury sedan instead of a luxury SUV if gasoline prices increase. We find no statistically significant effect for sporty cars. This may reflect that this category is not homogeneous in terms of fuel efficiency. It contains many small 2-door coupes, some with fuel efficiency close to that of compact cars, as well as high-performance sports cars, which are generally fuel inefficient.

Summary

Overall, we find both statistically and economically significant effects of gasoline prices on new car market shares measured as either quartiles or segments. This is particularly true for the "extremes", measured as the most fuel-efficient and least fuel-efficient quartiles or the compact and SUV/pickup segments, where market share shifts by more than 22% in response to a $1 increase in gasoline prices. We note that within our sample we observe gasoline price increase in excess of \$3.

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

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

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.[18] Conceptually, we our price variable should 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

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[18] 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.

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 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).

We estimate 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 fuel economy quartile car j fall within; the quartiles are redefined each model year.[19]

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:

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[19] We obtain similar results if we estimate four separate regressions, thus relaxing the constraint that the parameters associated with the other covariates are equal across fuel economy quartiles.

Variable	Coefficient/SE
GasolinePrice*MPG Quart 1	-246** (75)
GasolinePrice*MPG Quart 2	-81* (40)
GasolinePrice*MPG Quart 3	5.2 (30)
GasolinePrice*MPG Quart 4	136** (43)

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 \$246) but a higher price of cars in the most fuel-efficient quartile by (\$136). 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 follows. 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 \$382 (\$136 + \$246) . 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 (an 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 *1.2 years* 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 new car results are reported in Table A-4. 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.[20]

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[20] For compact cars, prices increase in the most fuel-efficient segment of compact cars by \$239 when gasoline prices go up by \$1, and fall or have no statistically significant effect for other quartiles. The prices of luxury cars,

Summary

Overall, we find that prices for fuel-efficient new cars 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 $400. This difference 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 consider the effect on used car prices. We 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 look at the market share effects of gasoline prices first by MPG quartiles and then by segments.

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)	-0.017*	(.0072)	24.1%	-7.1%
MPG Quartile 2	-0.02**	(.0061)	21.0%	-9.5%
MPG Quartile 3	0.026*	(.012)	25.9%	10.0%
MPG Quartile 4 (most fuel-efficient)	0.011	(.009)	28.9%	3.8%

The first thing to note is that the results at the extremes of the fuel-efficiency distribution 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 most fuel-efficient quartile showing the largest increase (7.5 percentage points)

SUVs, and pickups all fall for vehicles in the bottom half of the fuel efficiency distribution for their respective segments, by as much as $815 per $1 increase in gasoline prices (Quartile 1 luxury cars). The most fuel-efficient luxury cars and SUVs see their prices rise by $407 and $292, 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 $160 when gasoline prices increase by $1, and fall by $508 and $211 in the two above-median fuel efficiency quartiles for sporty cars. The results for the midsize segment may due to the fact that this segment sees both inflows and outflows when gasoline prices rise, gaining from SUVs and pickups when gasoline prices rise, and losing to compact cars. This would make the net effects in the different quartiles of the segment hard 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 $403 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 $228, albeit not significant at a 10% level). This may be due to increased usage of carpooling vans in response to increased gasoline prices.

and the least fuel-efficient quartile showing the largest decrease (5.3 percentage points) in conjunction with gasoline price increases. For used cars, the most fuel-efficient quartile shows no statistically significant effect of gasoline price changes while the least fuel-efficient quartile shows a much smaller (1.7 percentage point) decline than for new cars. In a second departure from what we found for new cars, the market share effects of the middle fuel efficiency quartiles exceeds that of the most and least fuel efficient cars.

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	0.0031	(0.0048)	13.98%	2.2%
Midsize Car	0.035**	(0.0096)	25.59%	13.7%
Luxury Car	-0.007+	(0.0037)	10.31%	-6.8%
Sporty Car	-0.0037*	(0.0015)	4.71 %	-7.9%
Sport Utility Vehicle (SUV)	-0.014+	(0.0075)	24.53%	-5.7%
Pickup	-0.016**	(0.0042)	14.07%	-11.4%
Van	0.0021	(0.0047)	6.81 %	3.1%

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 3.5 percentage points in response to an increase in gasoline price of $1, a 13.7% increase in market share. This is substantially larger than the effect estimated for *new* midsize cars. Sporty cars are estimated to lose 0.37 percentage points of market share, a 7.9% 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 1.6 percentage points, or 11.4% of their market share, when gasoline prices rise by $1. This is the only segment whose new and used results are quite close.

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 much smaller 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, ising 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-7. The gasoline price coefficients are as follows:

GasolinePrice*MPG Quart 1	-1096** (38)
GasolinePrice*MPG Quart 2	-936** (57)
GasolinePrice*MPG Quart 3	76 (71)
GasolinePrice*MPG Quart 4	1627** (56)

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 $1096. This is 4.5 times the size of the $246 effect estimated for new cars. Prices in the next least fuel-efficient segment are estimated to fall by nearly as much, namely $936. 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 $1627 for each $1 increase in gasoline prices, an effect that is twelve times the size of the effect estimated for new cars ($136).

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 \$2723 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 nearly 9 years.[21]

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-8. 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.[22]

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[21] This calculation suggests an over-reaction by consumers with respect to changes in gasoline prices, especially once you consider that it ignores discounting. An over-reaction is consistent with recent work by Gicheva, Hastings, and Villas-Boas (2007) which finds consumers over-react relative to the predictions of a permanent income hypothesis model to changes in gasoline prices. At a real interest rate of 3 percent, it takes nearly 11 years of fuel savings to recuperate the increase in upfront costs. Increasing the number of miles driven to 15,000 per year implied an "undiscounted" time frame of over 7 years and a 8 years if we discount.

[22] 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 \$3577 and rise by \$1002 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 \$1850, prices in the third quartile rising by \$832, and prices in the most fuel-efficient quartile rising by \$1519 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 twelve times as large, depending on which results are compared.

5 Robustness

In this section we explore the robustness of our results. First, we analyze the robustness of our results to the variation in the data that is used to estimate the effect of gasoline prices. Second, we allow the response to gasoline price to differ by the level and prior direction of gasoline prices to see whether we are ignoring important response heterogeneity in our estimates. Third, we analyze the robustness of our findings to the aggregation of gasoline prices. Fourth we analyze whether we should treat gasoline prices as being endogenous. Fifth, we examine whether our results depend on our use of a linear probability model to estimate market share changes in response to gasoline prices.

5.1 Source of variation

We now re-estimate the original specifications in this paper with a series of different fixed effects. Recall that all specifications so far control for region by year and region by month-of-year fixed effects. This means that the estimated gasoline price effects are identified only based on within-year region-specific market-share or price changes which deviate from region-specific seasonal effects.

First, we estimate a specification without any year or month-of-year (seasonal) fixed effects. In our original specification (Equation 2) we captured regional effects by the fact that seasonal dummies were region-specific. To continue allowing for regional variation we include region fixed effects (recall, there are 29 regions). Next, we estimate a specification with region-specific seasonal effects but without year fixed effects. The results from these two more parsimonious specifications show whether we are missing an important source of variation due to the extensive set of fixed effects used in our base specification. Finally, we estimate a specification with *more* detailed time fixed effects, by replacing the year by region fixed effects with quarter by region fixed effects. These results allow us to gain confidence that our effects are not driven by the generally upward-trending gasoline prices in our sample period.

Table 1 shows the results of these three specification for new and used cars. For comparison, the table repeats the estimates of the original specification in Equation 2.

Table 1: Effect of time and seasonal fixed effects in market share specification[†]

Specification	Time FE	Seasonal FE	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
New Cars						
Base (original)	Year × Region	Month-of-year × Region	-.053** (.0049)	-.016** (.004)	-.0061* (.0029)	.075** (.005)
Most Parsimonious	–	–	-.047** (.0043)	-.0028 (.0046)	-.0082** (.003)	.058** (.006)
More Parsimonious	–	Month-of-year × Region	-.046** (.0042)	-.0018 (.0042)	-.0061* (.0028)	.054** (.0056)
Richer	Quarter × Region	Month-of-year × Region	-.066** (.0067)	-.024** (.0063)	.0094* (.0042)	.081** (.0066)
Used Cars						
Base (original)	Year × Region	Month-of-year × Region	-.017* (.0072)	-.02** (.0061)	.026* (.012)	.011 (.009)
Most Parsimonious	–	–	-.02** (.0058)	-.0089+ (.0045)	.014* (.0066)	.014* (.0058)
More Parsimonious	–	Month-of-year × Region	-.019** (.0048)	-.0076* (.0038)	.012* (.0053)	.015** (.0047)
Richer	Quarter × Region	Month-of-year × Region	-.021* (.0095)	-.021* (.01)	.034 (.024)	.0075 (.024)

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

The coefficients on the gasoline price variable are remarkably robust to the included fixed effects. Consider first the new car estimates. In our original specification we found that a $1 increase in gasoline prices decreased the market share of the least fuel efficient cars (MPG Quartile 1) by 5.3 percentage points. Omitting time and/or seasonal fixed effects changes this estimate by only little, to 4.7 percentage points. Similarly, we originally found that a $1 increase in gasoline prices increased the market share of the most fuel efficient cars (MPG Quartile 4) by 7.5 percentage points. Omitting time and/or seasonal fixed effects decreases our estimate to no lower than 5.8 percentage points. Including more granular time fixed effects (region-specific quarter fixed effects) than in our original specification also has a modest effect; we find a market share decrease of 6.6 percentage points for the least fuel efficient cars and a market share increase of 8.1 percentage points for the most fuel efficient cars. Since the market share estimates for used cars also change relatively little, our conclusions from our original specification seem robust to the time and seasonal variation in the data that is used to identify the effect of gasoline prices on the market shares of cars of different fuel efficiency. In

Table 2: Effect of time and seasonal fixed effects in price specification†

Specification	Time FE	Seasonal FE	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4	Price change Quartile 1 to 4
New Cars							
Base (original)	Year × Region	Month-of-year × Region	-246** (75)	-81* (40)	5.2 (30)	136** (43)	$382
Most Parsimonious	–	–	-994** (82)	-863** (44)	-777** (37)	-608** (37)	$386
More Parsimonious	–	Month-of-year × Region	-1184** (76)	-1049** (51)	-966** (53)	-796** (50)	$388
Richer	Quarter × Region	Month-of-year × Region	-133+ (80)	23 (55)	108* (46)	226** (58)	$359
Used Cars							
Base (original)	Year × Region	Month-of-year × Region	-1096** (38)	-936** (57)	76 (71)	1627** (56)	$2723
Most Parsimonious	–	–	-6563** (82)	-6328** (95)	-5306** (90)	-3584** (51)	$2979
More Parsimonious	–	Month-of-year × Region	-6972** (88)	-6755** (104)	-5754** (1.0e+02)	-4053** (66)	$2919
Richer	Quarter × Region	Month-of-year × Region	-1190** (63)	-1035** (76)	-40 (83)	1545** (71)	$2735

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

all reported fixed effect specifications, we find that the market shares of new cars react more gasoline price changes than the market shares of used cars.

We also estimate the equivalent price specifications. First, we eliminate all time and seasonal fixed effects from our original price specification (Equation 4), while retaining regional fixed effects. Next, we include region-specific seasonal effects but no year fixed effects. Finally, we include region-specific quarter effects in addition to region-specific seasonal effects.

The estimation results are reported in Table 2.

At first glance our results seem not to be robust to the fixed effect specification in the price regressions. For example, in our original specification we found that a $1 increase in gasoline prices decreased the prices of the least fuel efficient cars (MPG Quartile 1) by $246 and $1096 for new and used cars, respectively. If we do not control for year fixed effects, these estimates change to $1184 and $6972 for new and used cars, respectively. To understand the dramatic change in estimates, one needs to consider the effect of year fixed effects on the price regressions: As we explained in on page 18, the definition of car type fixed effects (δ_j) includes the model year of a car. On average, one model year of a specific car is sold for about 18-24 months in our data (i.e. two model years of the same car are sold at the same time for a significant amount of time). Hence, our price specification uses only price variation that occurs within a 18-24 month period, even if we do not control for year fixed effects. The reason why omitting the year fixed effect leads to such large decreases in coefficients is that the coefficients of gasoline prices (which are generally increasing in our sample) pick up that car prices decline over the model year. Year fixed effects effectively assign cars which are sold early during the model year (August to December 2007 for a 2008 model year, for example) to a different year than cars that sell during the middle of the model year (January to December 2008 in this example) or which sell during the last month that the car sells (January to April 2009 in this example). This shows that it is important to include time fixed effects in the price specification. However, our basic conclusion that used car price adjust much more to changes in gasoline prices than new car prices holds irrespective of the fixed effects we include in the specification. To see this, consider the price change that develops between a very fuel inefficient and very fuel efficient car when gasoline prices increase. As the last column of Table 2 shows, for new cars, a $1 increase in gasoline price increases the price of the most fuel efficient cars (Quartile 4) relative to the most fuel inefficient cars (Quartile 1) by $359 to $388 across all specifications. For used cars, the equivalent numbers are $2723 to $2979 across all specifications. Hence, used cars experience much larger price adjustments than new cars when gasoline prices change.

In summary, these estimates show that our findings are robust to the variation in the data that is used to estimate the effect of gasoline prices.

5.2 Heterogeneity in gasoline price response

So far we have used the gasoline price for the month of the transaction in the buyer's DMA as our measure of *GasolinePrice*. In doing so we are ignoring potential heterogeneity in the gasoline price response. We investigate two potential sources of heterogeneity. First, whether the response to gasoline prices differs by the absolute price of gasoline. For example, does a $1 increase in gasoline prices have a different effect on market shares and car prices at a current level of $1.50 than at a current level of $3.50? Second, whether the response to gasoline price differs by whether gasoline prices have been consistently rising or falling in prior periods. For example, is the effect of a $1 gasoline price increase larger if gasoline prices have already been increasing in the prior 3 months than if they have been flat or declining?

To answer the first question we repeat 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, as is often suggested by news reports about certain gasoline price "threshold" above which consumers start to really change their behavior. 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-15 and A-16 for a summary of these results; full results are available from the authors.

To answer the second question we also repeat 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-17 and A-18 for a summary of these results; full results are available from the authors.

5.3 Gasoline price aggregation

Next, we investigate the robustness of our findings to the aggregation of gasoline prices. Recall that, although we know the ZIP-code of each buyer, we chose to aggregate gasoline prices at the level of local markets (define by DMAs). The disadvantage of using more disaggregate gasoline prices is potential measurement error (we only observe a small number of stations per ZIP-code), and that consumers are likely to react not only to the gasoline prices in their local ZIP-code but also to gasoline prices in their local area. But one can also argue that we should consider more disaggregate gasoline prices because this would allow us to capture more cross-sectional variation.

One can also make the argument that we should consider gasoline prices which are aggregated to more than the level of local markets. This is because consumers may be more likely to notice gasoline price changes once the gasoline price changes have affected a large area and are thus reported in the media; alternatively, local price variation may contain more transitory price shocks that do not enter into the long run forecasts of gasoline prices over the life of the car.

To investigate whether our conclusions depend of the aggregation of gasoline prices, we re-restimate our original MPG quartile specifications (Equations 2 and 4) using one more disaggregate and one more aggregate measure of gasoline prices. We use 4-digit ZIP codes as our more disaggregate measure instead of 5-digit ZIP codes in order to increase the number of stations going into the calculation of each average and thus reduce measurent error.[23] For

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[23] In our data, the median 4-digit ZIP code reports data from 11.5 stations on average over the months of the

our more aggregate measure, we average the prices for basic grade over all stations in each "Petroleum Administration for Defense District" (PADD). PADDs are the standard geographical classification by the Energy Information Administration and reflect that supply is designed to be homogenous within PADD. There are five PADDs: East Coast, Midwest, Gulf Coast, Rockies, and West Coast. There remains substantial variation in gasoline prices across PADDs. Not only are prices in some PADDs higher than in other PADDs, there is also variation in the magnitude of the difference (not reported).

The full results are reported in Tables A-9 and A-10. We find that the coefficients on gasoline prices in the 4-digit ZIP code aggregation are similar to those in our (original) DMA aggregation but somewhat smaller in magnitude. This is consistent with some measurement error in the 4-digit ZIP code aggregation. If we aggregate gasoline prices at the PADD level, most coefficient estimates increase in magnitude. This suggests that consumers may be more likely to respond to large-area gasoline price changes than just changes in their local market.

Overall, we would reach the exact same conclusion about the difference between the reaction of new and used markets to gasoline price changes if we averaged gasoline prices within 4-digit ZIP code or within PADD instead of within local markets.

5.4 Endogeneity

So far we have assumed that gasoline prices are uncorrelated with the error term in the market share and price specifications. It seems unlikely that such a correlation would arise due to reverse causality; this is because US gasoline prices depend on world oil prices and refinery margins and these are unlikely to be influenced by the yearly sales of cars in the US, given that gasoline demand depends on the stock, not the flow of cars within a short horizon. However, there are other potential sources of endogeneity which may taint our coefficient estimates. First, there could be local variations in economic conditions that are correlated with local variations in gasoline prices. If the changes in economic conditions change what cars people buy or how much they are willing to spend on them, then we are measuring (in part) the cyclical effects on car sales and prices. Second, gasoline tax changes might be endogenous to economic conditions, which also affect car sales and prices. Third, changes in gasoline prices could cause income shocks in local areas (say, areas with refineries or with car plants) and these income shocks may drive car sales and prices.

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year, up from 3 for 5-digit ZIP codes.

We propose two ways to address the potential endogeneity of gasoline prices. First, we can re-estimate our main specifications using gasoline prices which are aggregated at the PADD level. By increasing the level of aggregation we make it less likely that local shocks leads to correlation between gasoline prices and the error term in the market share and price specifications. We have already estimated this specification in the previous section.

Second, we use world oil price as an instrument for gasoline prices at the PADD level. Clearly, world oil prices are correlated with regional fuel prices. At the same time, it seems highly unlikely that local or regional variation in economic conditions, gasoline tax changes, or income shocks would have a meaningful effect on world oil prices. To allow for some variation by PADD, we use as instruments world oil prices interacted with PADD dummies.

The results of these two approaches, i.e. the OLS and IV regressions with PADD-level gasoline prices are reported in Tables 3 and 4. For easier comparison we also report our original DMA-level specification (which uses OLS).

Table 3: OLS and IV results in market share specification†

	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
New Cars				
DMA-level gas prices OLS (original)	-.053** (.0049)	-.016** (.004)	-.0061* (.0029)	.075** (.005)
PADD-level gas prices OLS	-.054** (.0048)	-.016** (.0048)	-.0074* (.0032)	.077** (.005)
PADD-level gas prices IV	-.057** (.0062)	.00075 (.0088)	-.012* (.0048)	.068** (.0097)
Used Cars				
DMA-level gas prices OLS (original)	-.017* (.0072)	-.02** (.0061)	.026* (.012)	.011 (.009)
PADD-level gas prices OLS	-.018* (.0076)	-.022** (.0063)	.03* (.013)	.011 (.0093)
PADD-level gas prices IV	-.011 (.014)	-.028** (.01)	.056** (.02)	-.017 (.014)

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

We have already concluded that the OLS regression with PADD-level gasoline prices yields similar but somewhat larger magnitude estimates compared to the original regression with DMA-level gasoline prices. The IV estimates of the effect of gasoline prices are similar to the PADD-level OLS estimates.

We find, however, that the estimates of the effect of gasoline prices on prices are generally larger in the IV specification than in the OLS specification. This can be seen in Table 4.

Overall, a potential endogeneity between gasoline prices and the error terms of the market

Table 4: OLS and IV results in price specification†

	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
New Cars				
DMA-level gas prices OLS (original specif.)	-246** (75)	-81* (40)	5.2 (30)	136** (43)
PADD-level gas prices OLS	-363** (75)	-78* (37)	43 (30)	173** (34)
PADD-level gas prices OLS	-478** (24)	-58* (23)	59** (23)	265** (20)
Used Cars				
DMA-level gas prices OLS (original specif.)	-1096** (38)	-936** (57)	76 (71)	1627** (56)
PADD-level gas prices OLS	-1137** (39)	-976** (57)	78 (68)	1684** (53)
PADD-level gas prices IV	-1437** (24)	-1227** (24)	-50* (23)	1737** (23)

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

share are price regressions does not change our basic finding that new and used markets react very differently to changes in gasoline prices. Controlling for endogeneity does suggest, however, that our original specification may have underestimated the magnitude of the gasoline price effect on prices. The effect of gasoline prices on market shares is largely unaffected by our two approaches to control for endogeneity.

5.5 Market share specification

As our last robustness check we address potential limitations of the linear probability model (LPM) we have used to estimate the effect of gasoline prices on markets shares. We are particularly concerned that the LPM does not constrain the estimates in the market share regressions to add up to 1. To address this we reestimate our basic MPG quartile specification (Equation 2) with a multinomial logit ("mlogit" in Stata) which estimates the probability that, conditional on purchase, a car falls into MPG Quartile 1, 2, 3, or 4 (all variables and controls remain unchanged). Given the findings from previous sections, we aggregate gasoline prices at the PADD level. In Table 5 we compare the gasoline price coefficients of the LPM with the marginal effects in probability associated with a \$1 increase in gasoline prices. Full estimation results are reported in Table A-11.

The table shows that the estimated marginal effects are nearly identical to those achieved in the linear probability model. We conclude that our quartile results do not depend on our use of the linear probability model.

Table 5: mlogit marginal effects in market share specification†

	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
New Cars				
LPM	-.054** (.0048)	-.016** (.0048)	-.0074* (.0032)	.077** (.005)
mlogit	-.057** (.0045)	-.014** (.0045)	-.0048 (.003)	.076** .0048
Used Cars				
LPM	-.018* (.0076)	-.022** (.0063)	.03* (.013)	.011 (.0093)
mlogit	-0.019* (0.008)	-0.022** (0.006)	0.029* (0.012)	0.012 (0.009)

* significant at 5%; ** significant at 1%; + significant at 10% level. SEs in parentheses. The SEs in the LPM are robust and clustered at the DMA level. The SE of the marginal effects in mlogit are derived using the Delta-method in Stata's "margins" command.

6 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 the propensity of new versus used car transactions, dealer inventories, and trade-ins.

6.1 New versus used transaction

Our previous results, estimated separately for new and used cars, have certain implications for the propensity of new versus used car transactions. Because we find the relative price of new fuel efficient cars falls as gasoline prices increase, we would expect to see an increase in the probability a fuel efficient car transaction is a new car. Conversely, we find that the relative price of new fuel *in*efficient vehicles increases as gasoline prices increase, suggesting an increase in the probability an inefficient car transaction is a used variety.

To determine whether these implications exist in the data, we estimate the probability a transaction is a new vehicle as a function of gasoline prices. We do this across all transactions and separately for each segment.

6.1.1 Specification and variables

Our empirical approach is similar to the segment linear probability models previously estimated. Specifically, we estimate:

$$I_{irjkt}(new) = \gamma_0 + \gamma_1 \text{GasolinePrice}_{it} + \gamma_2 \text{Demog}_{it} + \gamma_3 \text{PurchaseTiming}_{it} + \tau_{rt} + \mu_{rt} + \epsilon_{ijkt} \quad (5)$$

$I_{irjkt}(new)$ is an indicator that equals 1 if transaction i in region r on date t for car type j for class k was for a new car. We begin by estimating this across all segments, but focus on the results within specific segments. We estimate the model with the same control variables and fixed effects as in our base specifications (equation 2), as well as a richer model that include manufacturer/model fixed effects. Thus, in this second specification, we estimate how gasoline prices affect the probability a transaction for a particular model (across vintages), e.g., a Honda Accord, is a new or used vehicle. Both specifications yield results that are nearly identical, so we report those that include the make-model fixed effects.

6.1.2 New versus used transaction results

The full results from estimating the specification in Equation 5 are presented in Table A-12. The coefficients of interest are as follows:

Segment	Coefficient	SE	Mean New Share	% Change in Share
All Transactions	-0.007	(0.0055)	59.6%	1.2%
Compacts	0.035**	(0.0044)	64.7%	5.4%
Midsize	-0.01	(0.0081)	53.9%	-1.9%
Sporty Cars	0.026**	(0.0092)	55.3%	4.7%
Luxury	0.0098**	(0.005)	57.3%	1.7%
SUVs	-0.021*	(0.007)	62.8%	-3.3%
Pickups	0.0099	(0.0083)	60.0%	1.7%
Vans	-0.027**	(0.0095)	59.4%	-4.5%

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. Previously, we found a large increase in the market share of new compact cars, relative to new cars in general, and no statistically significant increase in the market share of used compact cars, relative to used cars in general. Because we find that across all transactions, gasoline prices does not affect the propensity of new transactions, the market share results, along with the price results, would imply that we would expect to see a greater share of new compact cars being sold. Indeed, we do. A $1 increase in gasoline prices increases the share of compact transactions that are new by over 5 percent. Similarly, we see an increase in the share of transactions that are new for Sporty and Luxury cars; these increase by 4.7 and 1.7 percent, respectively, for a \$1 increase in gasoline prices. On the other extreme, we see fewer new SUVs and vans when gasoline prices increase. A \$1 increase in gasoline prices reduces the proportion of new SUV sales by over 3 percent and reduces the proportion of new van sales by 4.5 percent.

6.2 Inventories

We next 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.

6.2.1 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:

$$\begin{aligned} DTT_{irdjt} = \omega_0 + \omega_1(\text{GasolinePrice}_{it} \cdot \text{MPG Quartile}_j) + \omega_2\text{Demog}_{it} + \\ \omega_3\text{PurchaseTiming}_{jt} + \delta_{dj} + \tau_{rt} + \mu_{rt} + \nu_{ijt} \end{aligned} \tag{6}$$

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}).

6.2.2 Inventory results

The full results from estimating the specification in Equation 6 are presented in Table A-13. The coefficients of interest are as follows:

	New Cars			Used Cars		
Variable	Coefficient (SE)	DTT sample mean	% Change in DTT	Coefficient (SE)	DTT sample mean	% Change in DTT
GasolinePrice * Quart. 1 (least fuel-efficient)	12** (2.5)	68.3	17.6 %	.83 (.79)	47.8	1.7%
GasolinePrice * Quart. 2	3.1** (.97)	61.4	5.0 %	1.7* (.71)	47.3	3.6%
GasolinePrice * Quart. 3	.087 (.88)	57.2	0.2 %	.041 (.77)	49.1	0.1%
GasolinePrice * Quart. 4 (most fuel-efficient)	-6.7** (.93)	50.2	-13.3%	-1.2+ (.72)	45.4	-2.6%

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 12 days longer on the lot, a 17.6% 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 13.3% 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 1.7 days, or 3.6%.

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.

6.3 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.[24] 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.

6.3.1 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:

$$\mathrm{MPG}_{irjt} = \beta_0 + \beta_1 \mathrm{GasolinePrice}_{it} + \beta_2 \mathrm{Demog}_{it} + \beta_3 \mathrm{PurchaseTiming}_{jt} + \delta_k + \tau_{rt} + \mu_{rt} + \xi_{ijkt} \quad (7)$$

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 DMA 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

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[24] 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 7 separately for new and used cars.

6.3.2 Purchased cars vs. trade-in results

The full results for new and used cars are reported in Table A-14 (columns 1 and 2). The gasoline price coefficients are as follows:

	New Car MPG	Used Car MPG
GasolinePrice	.94** (.052)	.48** (.051)

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 0.94 miles per gallon.[25] 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 14% of the interquartile range.

The second column reports the same results for the used car transactions. In this sample we find that a $1 gasoline price increase increase the fuel efficiency of the newly purchased used car relative to the trade-in by 0.48 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.[26]

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

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[25] 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.

[26] This presumes that the sample of cars with trade-ins are comparable to the overall sample. In unreported specifications, we have separately estimated our models for those transactions with and without trade-ins. The results are qualitatively similar and often no statistically significantly different. When they are different, market shares are slightly more responsive to gasoline prices when the consumer is trading in a vehicle.

for fuel-efficient cars and lower prices for fuel-inefficient cars when gasoline prices increased. These results suggest 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.

6.4 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.

6.4.1 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:

$$\begin{aligned}\mathrm{ACV}_{ikrt} = {} & \beta_0 + \beta_1 \mathrm{GasolinePrice}_{it} \cdot \mathrm{MPG\ Quartile}_k + \beta_2 \mathrm{Odometer}_{ikt} + \beta_3 \mathrm{Demog}_{it} + \\ & \beta_4 \mathrm{PurchaseTiming}_{jt} + \delta_k + \tau_{rt} + \mu_{rt} + \xi_{ikrt}\end{aligned} \tag{8}$$

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 region × year and region × month-of-year fixed effects.

6.4.2 Results

The full results of estimating Equation 8 are reported in Table A-14 (columns 3 and 4). We estimate Equation 8 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	Used Car Transaction Prices
GasolinePrice*MPG Quart 1	-1173** (56)	-1003** (27)	-1096** (38)
GasolinePrice*MPG Quart 2	-883** (39)	-595** (46)	-936 (57)
GasolinePrice*MPG Quart 3	178** (46)	201** (43)	76 (71)
GasolinePrice*MPG Quart 4	1281** (37)	775** (39)	1627** (56)

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 $1173 when gasoline prices rise by $1, and by $883 in the next least fuel-efficient quartiles. Prices rise for trade-in cars that are above median fuel efficiency when gasoline prices rise; by $178 per $1 gasoline price increase in the third quartile, and by $1281 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 $1003 in the least fuel-efficient quartile and by $595 in the next quartile, and rise by $201 in the third quartile and by $775 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 22. The first three quartiles of the actual cash value results are in almost all cases within \$100-200 of the used car price results.[27] This result is consistent 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.

7 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 21.9% when gasoline prices increase by \$1, and the market share of the most fuel-efficient quartile to increase by 25.4%. Furthermore, we estimate market shares of very fuel-efficient or very fuel inefficient segments to adjust by 10-24% when gasoline prices increase by \$1. 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

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[27] 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 on actual cash values are \$350 (in the new car column) to \$850 (in the used car column) below the estimated effects on used car transaction prices. One story that would explain this would be that when gasoline 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 \$1600, a difference of more than \$2700. 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 takes 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 6: 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 7: 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 8: New car fuel economy quartile cutoffs

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

Table 9: 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
FuelPrice	-.053**	-.016**	-.0061*	.075**
	(.0049)	(.004)	(.0029)	(.005)
PctLessHighSchool	.033*	.025*	-.023+	-.034*
	(.015)	(.01)	(.012)	(.017)
PctCollege	-.057**	.017	.017	.022
	(.012)	(.011)	(.011)	(.017)
Income	1.0e-08	3.4e-07**	2.4e-07*	-5.9e-07**
	(9.0e-08)	(9.5e-08)	(1.0e-07)	(1.1e-07)
MedianHHSize	.016**	.0063*	-.0061	-.016**
	(.0032)	(.0026)	(.0047)	(.0061)
MedianHouseValue	7.0e-08*	3.0e-08+	1.2e-08	-1.1e-07**
	(3.0e-08)	(1.7e-08)	(9.2e-09)	(4.1e-08)
VehiclePerHH	.049**	.0036	-.029**	-.024
	(.014)	(.0037)	(.0057)	(.018)
TravelTime	-.000026	-.00028**	-.00028*	.00058*
	(.0002)	(.000099)	(.00013)	(.00025)
Weekend	-.019**	-.0034*	-.0013	.023**
	(.0019)	(.0015)	(.0016)	(.0021)
EndOfMonth	.0035**	.0028*	.0039**	-.01**
	(.00097)	(.0011)	(.001)	(.0013)
EndOfYear	-.0038	-.0055*	-.0015	.011**
	(.0026)	(.0022)	(.0027)	(.0037)
Constant	.54**	.22**	.15**	.083
	(.074)	(.054)	(.034)	(.082)
Observations	1866008	1866008	1866008	1866008
R-squared	0.030	0.009	0.009	0.035

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

Not reported: Region × year and 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
FuelPrice	.043**	.018**	-.000014	.0046**	-.04**	-.018**	-.0081**
	(.0041)	(.0028)	(.0026)	(.0015)	(.0034)	(.0032)	(.0017)
PctLessHighSchool	-.028	-.025	.064**	-.019**	-.016	.04**	-.015**
	(.022)	(.017)	(.01)	(.0045)	(.013)	(.015)	(.0057)
PctCollege	.011	-.033*	.055**	-.0045	.07**	-.11**	.0082
	(.017)	(.014)	(.0099)	(.0037)	(.017)	(.017)	(.0054)
Income	-3.0e-07**	-3.7e-07**	8.8e-07**	7.0e-08*	2.9e-07**	-4.6e-07**	-1.2e-07**
	(1.0e-07)	(8.6e-08)	(1.2e-07)	(2.8e-08)	(9.8e-08)	(1.2e-07)	(2.6e-08)
MedianHHSize	-.0086+	-.0046	-.033**	-.00045	.013**	.013**	.02**
	(.0047)	(.0041)	(.0024)	(.0012)	(.0035)	(.0035)	(.0036)
MedianHouseValue	-5.5e-08+	-1.1e-07**	2.0e-07**	-7.3e-09	4.4e-08	-5.4e-08**	-2.1e-08**
	(2.9e-08)	(1.3e-08)	(2.1e-08)	(4.9e-09)	(3.1e-08)	(1.2e-08)	(6.4e-09)
VehiclePerHH	-.0061	-.024**	-.022**	.0055**	.0061	.047**	-.0062+
	(.012)	(.0069)	(.0052)	(.0015)	(.0082)	(.0066)	(.0034)
TravelTime	.00036	.0003	-.00081**	.000014	.00013	.00012	-.00011
	(.00023)	(.0002)	(.00016)	(.000092)	(.00018)	(.00017)	(.000065)
Weekend	.012**	.011**	-.013**	-.002*	.0041**	-.01**	-.002**
	(.0015)	(.002)	(.0019)	(.00082)	(.0013)	(.002)	(.0006)
EndOfMonth	-.013**	.00088	.0098**	-.0026	.0041*	-.0013	.0017**
	(.0014)	(.0018)	(.0014)	(.0016)	(.0019)	(.00091)	(.00063)
EndOfYear	.0042+	.012**	-.013**	-.0056**	.0015	.00076	-.00015
	(.0025)	(.0031)	(.0023)	(.0019)	(.0032)	(.0023)	(.0015)
Constant	.099	.15*	.092**	.053*	.012	.62**	-.025
	(.062)	(.062)	(.034)	(.023)	(.05)	(.067)	(.023)
Observations	1866008	1866008	1866008	1866008	1866008	1866008	1866008
R-squared	0.025	0.016	0.051	0.006	0.018	0.057	0.009

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

Not reported: Region × year and 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
FuelPrice*MGP Quart 1	-246** (75)
FuelPrice*MGP Quart 2	-81* (40)
FuelPrice*MGP Quart 3	5.2 (30)
FuelPrice*MGP Quart 4	136** (43)
PctLessHighSchool	193* (75)
PctCollege	45 (53)
Income	.0011** (.00035)
MedianHHSize	25* (11)
MedianHouseValue	.00017* (.000078)
VehiclePerHH	-122** (37)
TravelTime	-.24 (.91)
Weekend	-11+ (5.9)
EndOfMonth	-135** (4.4)
EndOfYear	-83** (17)
Constant	33223** (345)
Observations	1866008
R-squared	0.053

[*] significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses. Not reported: Region × year, 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
FuelPrice*MGP Quart 1	-7.8	34	-815**	211	-255**	-381**	228
	(69)	(84)	(244)	(144)	(74)	(96)	(182)
FuelPrice*MGP Quart 2	80+	69+	-157	209+	-344**	-237**	-403**
	(42)	(38)	(109)	(124)	(50)	(71)	(126)
FuelPrice*MGP Quart 3	-62*	49	83	-508**	61	81	-93
	(30)	(35)	(89)	(117)	(59)	(66)	(73)
FuelPrice*MGP Quart 4	239**	-160**	407**	-211**	292**	-63	-13
	(45)	(41)	(85)	(75)	(44)	(89)	(68)
PctLessHighSchool	330**	92	-198	-58	97	385**	22
	(96)	(97)	(200)	(280)	(130)	(120)	(165)
PctCollege	-175**	-6.9	-26	-402*	232*	-38	-129
	(46)	(57)	(162)	(158)	(90)	(134)	(122)
Income	.00066	-.00083*	.0011	.0019	.0016**	.0019**	.00098
	(.00042)	(.00039)	(.00094)	(.0017)	(.0005)	(.00073)	(.0011)
MedianHHSize	-8.8	67**	-69+	-63	41+	61**	41+
	(11)	(16)	(36)	(48)	(23)	(20)	(23)
MedianHouseValue	.00017	-.000079	.00029*	.00057**	.00016	-.00013	.0003
	(.0001)	(.0001)	(.00013)	(.00017)	(.00013)	(.00013)	(.0002)
VehiclePerHH	-1.0e+02**	-136**	17	-40	-163**	-171**	-96+
	(23)	(45)	(83)	(62)	(56)	(36)	(50)
TravelTime	.18	.033	-3.7*	.28	.9	2.6*	2.5
	(.66)	(1)	(1.9)	(2)	(1.1)	(1.3)	(1.8)
Weekend	-17*	12	-15	-13	-23**	6.2	-32*
	(8.1)	(8.8)	(18)	(23)	(7.8)	(15)	(16)
EndOfMonth	-86**	-113**	-221**	-124**	-138**	-152**	-158**
	(7.9)	(8.7)	(16)	(36)	(9.5)	(11)	(14)
EndOfYear	-54*	-93**	-46	-40	-123**	-59	-52
	(24)	(24)	(49)	(83)	(38)	(47)	(51)
Constant	20253**	28242**	55754**	35904**	38002**	30662**	32370**
	(462)	(462)	(1209)	(839)	(370)	(433)	(657)
Observations	324017	377978	174572	73681	522717	267296	125747
R-squared	0.044	0.060	0.087	0.067	0.066	0.061	0.085

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

Not reported: Region × year, 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
FuelPrice	-.017* (.0072)	-.02** (.0061)	.026* (.012)	.011 (.009)
PctLessHighSchool	.011 (.015)	.038** (.012)	-.03 (.027)	-.019 (.024)
PctCollege	-.042* (.017)	.0091 (.016)	-.012 (.021)	.045* (.021)
Income	-5.3e-07** (1.3e-07)	3.6e-07** (7.2e-08)	6.0e-07** (1.5e-07)	-4.4e-07** (1.4e-07)
MedianHHSize	.014** (.004)	-.0019 (.0032)	-.0059+ (.0031)	-.0066 (.004)
MedianHouseValue	4.6e-08* (1.9e-08)	9.9e-08** (1.2e-08)	-4.3e-08* (1.7e-08)	-1.0e-07** (2.8e-08)
VehiclePerHH	.049** (.011)	-.0085 (.0054)	-.037** (.0061)	-.0038 (.014)
TravelTime	.00012 (.00025)	-.00031* (.00015)	-.00036+ (.00022)	.00055 (.00033)
Weekend	-.0062** (.0022)	-.0093** (.0025)	.0045 (.0028)	.011** (.0028)
EndOfMonth	.0025 (.0024)	-.0016 (.0013)	.0014 (.0023)	-.0024 (.0022)
EndOfYear	-.013** (.0039)	.0037 (.004)	.0043 (.0042)	.0051 (.0045)
Constant	.37** (.051)	.35** (.087)	.15** (.042)	.14+ (.072)
Observations	1263940	1263940	1263940	1263940
R-squared	0.026	0.011	0.014	0.018

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

Not reported: Region × year and 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
FuelPrice	.0031	.035**	-.007+	-.0037*	-.014+	-.016**	.0021
	(.0048)	(.0096)	(.0037)	(.0015)	(.0075)	(.0042)	(.0047)
PctLessHighSchool	-.02	-.0031	.058**	-.015**	-.018	.023	-.026**
	(.016)	(.017)	(.015)	(.004)	(.017)	(.016)	(.0087)
PctCollege	.022	-.029	.084**	-.0085+	.051**	-.094**	-.025**
	(.013)	(.018)	(.017)	(.0049)	(.015)	(.016)	(.0078)
Income	-2.0e-07	-2.8e-07+	1.1e-06**	1.3e-07**	-2.7e-08	-6.0e-07**	-1.1e-07
	(1.2e-07)	(1.4e-07)	(9.5e-08)	(3.8e-08)	(1.2e-07)	(7.2e-08)	(7.0e-08)
MedianHHSize	-.0021	.00088	-.035**	.0011	.011**	.0073*	.016**
	(.003)	(.0036)	(.0028)	(.001)	(.0029)	(.003)	(.0025)
MedianHouseValue	-8.8e-08**	-1.3e-07**	2.3e-07**	-5.9e-09	7.5e-08**	-5.2e-08**	-2.8e-08**
	(1.9e-08)	(1.6e-08)	(2.0e-08)	(4.3e-09)	(2.2e-08)	(1.2e-08)	(1.1e-08)
VehiclePerHH	.0061	-.021**	-.036**	.005*	.0023	.052**	-.0085
	(.009)	(.0078)	(.0045)	(.0023)	(.0079)	(.0053)	(.0052)
TravelTime	.00056*	-.00023	-.00067**	.000053	.00012	.00019	-.000024
	(.00025)	(.0002)	(.00012)	(.000057)	(.00021)	(.00014)	(.0001)
Weekend	.0051*	.0044	-.012**	.00028	.0029	-.00074	-.00033
	(.0021)	(.0033)	(.0022)	(.00048)	(.002)	(.0025)	(.0016)
EndOfMonth	-.0012	-.0023	.0049**	-.0013**	.0039+	-.0032+	-.00079
	(.0026)	(.0032)	(.0011)	(.00048)	(.002)	(.0017)	(.00076)
EndOfYear	-.0024	.0084+	.00024	-.0042*	.0026	-.0087**	.0041+
	(.0047)	(.0046)	(.0029)	(.0017)	(.0043)	(.0029)	(.0021)
Constant	.093*	.18*	.2**	.015	.013	.49**	.008
	(.041)	(.085)	(.049)	(.014)	(.039)	(.087)	(.027)
Observations	1263940	1263940	1263940	1263940	1263940	1263940	1263940
R-squared	0.014	0.023	0.046	0.005	0.020	0.039	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 × year and 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: Price results, fuel efficiency quartiles†

Variable	Coefficient/SE
FuelPrice*MGP Quart 1	-1096** (38)
FuelPrice*MGP Quart 2	-936** (57)
FuelPrice*MGP Quart 3	76 (71)
FuelPrice*MGP Quart 4	1627** (56)
PctLessHighSchool	150 (96)
PctCollege	102 (75)
Income	.0031** (.00074)
MedianHHSize	-56* (24)
MedianHouseValue	.00067** (.00017)
VehiclePerHH	-159** (30)
TravelTime	-1.4 (1.2)
Weekend	109** (12)
EndOfMonth	-82** (7.6)
EndOfYear	24 (26)
Constant	25999** (425)
Observations	1263857
R-squared	0.588

[*] significant at 5%; ** significant at 1%; + significant at 10% level. SEs (robust and clustered at the DMA level) in parentheses. Not reported: Region × year, 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-8: Used Cars: Price results, fuel efficiency quartiles by segment†

	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
FuelPrice*MGP Quart 1	-972** (67)	-258** (90)	-3577** (248)	-649** (191)	-1850** (76)	-911** (63)	1171** (120)
FuelPrice*MGP Quart 2	253** (38)	28 (35)	59 (122)	104 (95)	95+ (56)	-570** (52)	993** (78)
FuelPrice*MGP Quart 3	238** (36)	146** (32)	376** (117)	624** (93)	832** (66)	26 (50)	-62 (60)
FuelPrice*MGP Quart 4	366** (34)	498** (41)	1002** (130)	643** (91)	1519** (62)	1638** (63)	-153* (63)
PctLessHighSchool	232** (87)	72 (110)	166 (259)	-262 (331)	280* (126)	20 (131)	369+ (197)
PctCollege	51 (76)	52 (83)	-30 (210)	179 (242)	271* (132)	81 (120)	151 (158)
Income	-.0019** (.00072)	-.00061 (.00061)	.0046** (.0011)	.0024 (.002)	.0037** (.00087)	.00038 (.0011)	.0018 (.0014)
MedianHHSize	23 (25)	-6.3 (21)	-258** (38)	-22 (48)	-3.3 (35)	-.21 (44)	38 (48)
MedianHouseValue	.00022 (.00014)	.00012 (.00012)	.00091** (.00017)	.00091** (.00026)	.00016 (.00019)	-.000047 (.00019)	.00022 (.00025)
VehiclePerHH	-126** (30)	-139** (35)	-117+ (71)	-263** (74)	-146** (40)	-87+ (45)	-137* (62)
TravelTime	1.3 (1.2)	2.4* (1)	-8.5** (3)	-1.2 (2.6)	-.9 (1.3)	.6 (1.5)	-1.8 (1.8)
Weekend	77** (10)	93** (14)	151** (33)	63* (30)	127** (19)	129** (19)	87** (25)
EndOfMonth	-51** (8.8)	-66** (12)	-156** (29)	-35 (33)	-116** (17)	-88** (15)	-55* (24)
EndOfYear	-2 (36)	18 (35)	-30 (97)	-32 (117)	68 (45)	83 (55)	-64 (74)
Constant	16029** (430)	20311** (392)	41012** (1186)	24450** (764)	33820** (593)	23997** (510)	24519** (817)
Observations	176614	323461	130296	59577	310026	177855	86028
R-squared	0.575	0.640	0.678	0.523	0.676	0.583	0.698

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

Not reported: Region × year, 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: Effect of gasoline price aggregation in market share regression[†]

New Cars

Gas Price Aggregation	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
4-digit ZIP	-.041**	-.018**	-.0038	.062**
	(.0082)	(.0039)	(.0035)	(.0086)
DMA (original specification)	-.053**	-.016**	-.0061*	.075**
	(.0049)	(.004)	(.0029)	(.005)
PADD	-.054**	-.016**	-.0074*	.077**
	(.0048)	(.0048)	(.0032)	(.005)

Used Cars

Gas Price Aggregation	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
4-digit ZIP	-.011	-.016*	.024*	.0022
	(.0068)	(.0063)	(.012)	(.008)
DMA (original specification)	-.017*	-.02**	.026*	.011
	(.0072)	(.0061)	(.012)	(.009)
PADD	-.018*	-.022**	.03*	.011
	(.0076)	(.0063)	(.013)	(.0093)

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

Table A-10: Effect of gasoline price aggregation in price regression[†]

New Cars				
Gas Price Aggregation	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
4-digit ZIP	-219** (69)	-71* (33)	5 (30)	137** (43)
DMA (Base Case)	-246** (75)	-81* (40)	5.2 (30)	136** (43)
PADD	-363** (75)	-78* (37)	43 (30)	173** (34)
Used Cars				
Gas Price Aggregation	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
4-digit ZIP	-1080** (39)	-921** (59)	83 (74)	1615** (59)
DMA (Base Case)	-1096** (38)	-936** (57)	76 (71)	1627** (56)
PADD	-1137** (39)	-976** (57)	78 (68)	1684** (53)

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

Table A-11: mlogit estimates (baseline is MPG Quartile 4) [†]

	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3
New Cars			
FuelPrice	-.52**	-.3**	-.25**
	(.034)	(.032)	(.019)
PctLessHighSchool	.25*	.23**	-.037
	(.11)	(.085)	(.077)
PctCollege	-.38**	-.013	-.048
	(.1)	(.1)	(.061)
Income	2.9e-06**	4.1e-06**	3.6e-06**
	(7.9e-07)	(6.6e-07)	(5.4e-07)
MedianHHSize	.13**	.074**	.016
	(.029)	(.025)	(.034)
MedianHouseValue	7.0e-07*	5.0e-07*	4.0e-07*
	(3.1e-07)	(2.1e-07)	(1.7e-07)
VehiclePerHH	.32**	.091	-.052
	(.12)	(.066)	(.069)
TravelTime	-.0027+	-.003**	-.0027**
	(.0016)	(.001)	(.00098)
Weekend	-.17**	-.087**	-.075**
	(.014)	(.012)	(.0095)
EndOfMonth	.049**	.044**	.047**
	(.0076)	(.0082)	(.0062)
EndOfYear	-.053**	-.059**	-.039*
	(.02)	(.02)	(.019)
Constant	1.2*	.25	-.23
	(.56)	(.5)	(.27)
Observations	1866362		
Log pseudolikelihood	-2488466.1		
Used Cars			
	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3
FuelPrice	-.13**	-.15**	.071
	(.043)	(.041)	(.073)
PctLessHighSchool	.11	.26*	-.056
	(.11)	(.11)	(.17)
PctCollege	-.35**	-.12	-.22
	(.12)	(.11)	(.13)
Income	2.4e-08	3.5e-06**	4.3e-06**
	(9.5e-07)	(6.0e-07)	(9.5e-07)
MedianHHSize	.091**	.013	-.0047
	(.023)	(.026)	(.021)
MedianHouseValue	5.5e-07**	7.9e-07**	2.1e-07
	(1.8e-07)	(1.3e-07)	(1.5e-07)
VehiclePerHH	.21*	-.023	-.14*
	(.087)	(.073)	(.058)
TravelTime	-.0019	-.003+	-.0031+
	(.002)	(.0016)	(.0017)
Weekend	-.067**	-.083**	-.021
	(.013)	(.017)	(.018)
EndOfMonth	.018	.0013	.015
	(.015)	(.0098)	(.014)
EndOfYear	-.071*	-.0016	-.0019
	(.028)	(.027)	(.027)
Constant	.59+	.81	-.19
	(.35)	(.54)	(.29)
Observations	1264175		
Log pseudolikelihood	-1712332.3		

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

Table A-12: New versus used transactions†

	All Segm.	Compact	Midsize	Luxury	Sporty	SUV	Pickup	Van
FuelPrice	-.007	.035**	-.01	.0098*	.026**	-.021**	.0099	-.027**
	(.0055)	(.0044)	(.0081)	(.005)	(.0092)	(.007)	(.0083)	(.0095)
PctLessHighSchool	.071**	.041+	.052**	.088**	.0011	.079**	.043*	.045+
	(.017)	(.021)	(.02)	(.019)	(.029)	(.022)	(.02)	(.025)
PctCollege	-.0017	-.019	-.04+	.016	.0059	.0042	-.024	.0027
	(.018)	(.018)	(.022)	(.02)	(.023)	(.022)	(.022)	(.031)
Income	6.9e-07**	4.6e-07**	8.7e-07**	4.5e-07**	6.4e-07**	7.0e-07**	8.6e-07**	8.8e-07**
	(1.2e-07)	(1.5e-07)	(1.8e-07)	(1.1e-07)	(1.6e-07)	(1.2e-07)	(2.2e-07)	(1.9e-07)
MedianHHSize	-.02**	-.02**	-.031**	-.029**	-.023**	-.0099**	-.011*	-.015*
	(.0027)	(.0043)	(.0042)	(.0029)	(.0059)	(.0035)	(.0046)	(.0065)
MedianHouseValue	9.5e-08**	6.8e-08**	8.7e-08**	1.1e-07**	8.0e-08*	7.5e-08**	9.2e-08**	1.2e-07**
	(2.1e-08)	(1.9e-08)	(2.6e-08)	(2.0e-08)	(3.7e-08)	(2.0e-08)	(3.1e-08)	(3.3e-08)
VehiclePerHH	-.016**	-.025**	-.019*	-.000053	-.0096	-.007	-.022**	-.0079
	(.0055)	(.0052)	(.0081)	(.0069)	(.0077)	(.006)	(.0063)	(.0098)
TravelTime	.00041+	.00012	.00089**	-.00036	.00036	.00059*	.00031	.00022
	(.00021)	(.00031)	(.00026)	(.00025)	(.00032)	(.00026)	(.00021)	(.00034)
Weekend	-.0085**	-.00032	-.0039	-.02**	-.011**	-.0067**	-.014**	-.013**
	(.0026)	(.0039)	(.004)	(.0029)	(.0038)	(.0025)	(.0028)	(.0036)
EndOfMonth	.034**	.024**	.037**	.034**	.021**	.035**	.038**	.041**
	(.002)	(.0038)	(.0027)	(.0021)	(.0034)	(.0022)	(.0025)	(.0033)
EndOfYear	.012**	.016+	.014*	-.015*	.0026	.0077	.032**	.0023
	(.0026)	(.0089)	(.0055)	(.0061)	(.013)	(.0047)	(.0054)	(.0082)
Constant	.68**	.81**	.54**	.61**	.86**	.63**	.73**	.47**
	(.073)	(.079)	(.12)	(.079)	(.1)	(.083)	(.075)	(.085)
Observations	3129948	500669	701470	304870	133260	832750	445153	211776
R-squared	0.182	0.157	0.191	0.314	0.186	0.190	0.129	0.218

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

Not reported: Region × year, region × month-of-year fixed effects, and car type × dealer fixed effects.

Table A-13: New and Used Cars: Inventory results, fuel efficiency quartiles†

Dependent Variable: Days To Turn	**New Cars**	**Used Cars**
GasolinePrice*MPG Quart 1	12**	.83
	(2.5)	(.79)
GasolinePrice*MPG Quart 2	3.1**	1.7*
	(.97)	(.71)
GasolinePrice*MPG Quart 3	.087	.041
	(.88)	(.77)
GasolinePrice*MPG Quart 4	-6.7**	-1.2+
	(.93)	(.72)
Constant	-359**	68**
	(6.9)	(1.3)
Observations	1852346	1262978
R-squared	0.657	0.575

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

Not reported: Region × year, region × month-of-year fixed effects, and car type × dealer fixed effects.

Table A-14: New and Used Cars: Trade-in results†

	New Cars MPG	**Used Cars** MPG	**New Cars** Trade-in Booked Value	**Used Cars** Trade-in Booked Value
GasolinePrice	.94** (.052)	.48** (.051)		
GasolinePrice*MPG Quart 1			-1173** (56)	-1003** (27)
GasolinePrice*MPG Quart 2			-883** (39)	-595** (46)
GasolinePrice*MPG Quart 3			178** (46)	201** (43)
GasolinePrice*MPG Quart 4			1281** (37)	775** (39)
Trade-in Odometer			-.041** (.0005)	-.03** (.00045)
PctLessHighSchool	-.21 (.19)	.0031 (.17)	34 (97)	226** (82)
PctCollege	.038 (.18)	.3* (.13)	154 (96)	-15 (91)
Income	-1.9e-06* (9.2e-07)	3.4e-06* (1.4e-06)	-.0021* (.00095)	.00013 (.0008)
MedianHHSize	-.32** (.033)	-.28** (.048)	-26 (16)	-19 (21)
MedianHouseValue	-1.8e-07 (2.7e-07)	-6.7e-07** (1.9e-07)	-.00049** (.000088)	-.000055 (.00011)
VehiclePerHH	-.27** (.093)	-.29** (.1)	195** (39)	124** (30)
TravelTime	.0021 (.0016)	.004+ (.0021)	-2.2* (1.1)	-1.1 (.91)
Weekend	.00079 (.017)	-.01 (.019)	-50** (8.6)	-41** (9)
EndOfMonth	-.088** (.014)	-.012 (.016)	-27* (13)	-13 (10)
EndOfYear	.058 (.05)	.16** (.054)	-116** (32)	-107** (37)
Constant	19** (.74)	19** (.57)	15267** (361)	10777** (359)
Observations	743648	498740	591228	351941
R-squared	0.263	0.197	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 × year and 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-15: New and Used Cars: Market share (quartile) results by gasoline price levels[†]

	New Cars			
	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice (<1.5 dollar)	-.049** (.0066)	-.012* (.0057)	-.011* (.0046)	.072** (.006)
GasolinePrice (1.5-2.5 dollars)	-.05** (.0061)	-.0092+ (.0049)	-.009* (.0041)	.068** (.0054)
GasolinePrice (2.5-3.5 dollars)	-.051** (.0054)	-.012** (.0043)	-.0066+ (.0034)	.069** (.0047)
GasolinePrice (>3.5 dollars)	-.052** (.0058)	-.013* (.0058)	-.015** (.0035)	.079** (.0074)

	Used Cars			
	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice (<1.5 dollar)	-.025** (.0089)	-.0076 (.0077)	.015 (.017)	.017 (.015)
GasolinePrice (1.5-2.5 dollars)	-.023** (.0084)	-.0077 (.0069)	.013 (.016)	.018 (.015)
GasolinePrice (2.5-3.5 dollars)	-.022** (.0073)	-.0088 (.0056)	.011 (.014)	.02 (.013)
GasolinePrice (>3.5 dollars)	-.018 (.011)	-.024** (.0088)	.043* (.017)	-.00076 (.012)

[*] 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-16: New and Used Cars: Price results by gasoline price levels[†]

	New Cars, MPG Quartiles	Used Cars, MPG Quartiles
GasolinePrice(< 1.5)*MPG Quart 1	-285**	-1331**
	(91)	(75)
GasolinePrice(1.5-2.5)*MPG Quart 1	-238*	-1181**
	(103)	(59)
GasolinePrice(2.5-3.5)*MPG Quart 1	-239**	-1096**
	(84)	(51)
GasolinePrice(> 3.5)*MPG Quart 1	-395**	-1394**
	(76)	(67)
GasolinePrice(< 1.5)*MPG Quart 2	-144*	-1230**
	(66)	(110)
GasolinePrice(1.5-2.5)*MPG Quart 2	-125+	-1148**
	(64)	(86)
GasolinePrice(2.5-3.5)*MPG Quart 2	-122*	-1012**
	(53)	(79)
GasolinePrice(> 3.5)*MPG Quart 2	-91+	-1007**
	(49)	(85)
GasolinePrice(< 1.5)*MPG Quart 3	-44	479**
	(41)	(108)
GasolinePrice(1.5-2.5)*MPG Quart 3	-59	421**
	(41)	(101)
GasolinePrice(2.5-3.5)*MPG Quart 3	-39	301**
	(34)	(85)
GasolinePrice(> 3.5)*MPG Quart 3	-.49	206
	(33)	(134)
GasolinePrice(< 1.5)*MPG Quart 4	96	2532**
	(64)	(170)
GasolinePrice(1.5-2.5)*MPG Quart 4	40	2336**
	(70)	(161)
GasolinePrice(2.5-3.5)*MPG Quart 4	68	2092**
	(56)	(113)
GasolinePrice(> 3.5)*MPG Quart 4	147**	1783**
	(47)	(98)

[*] 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-17: 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)	-.055**	-.018**	-.0011	.075**
	(.0045)	(.0038)	(.0028)	(.0047)
GasolinePrice (3 months mixed)	-.055**	-.018**	.00084	.072**
	(.0049)	(.0042)	(.003)	(.0049)
GasolinePrice (3 months down)	-.057**	-.022**	.0044	.075**
	(.0053)	(.0046)	(.0033)	(.0054)
Used Cars Results	MPG Quartile 1	MPG Quartile 2	MPG Quartile 3	MPG Quartile 4
GasolinePrice (3 months up)	-.013+	-.017**	.019+	.011
	(.0067)	(.006)	(.011)	(.008)
GasolinePrice (3 months mixed)	-.01+	-.014*	.012	.012+
	(.006)	(.0059)	(.0088)	(.0068)
GasolinePrice (3 months down)	-.0085	-.015*	.012	.012
	(.0066)	(.0064)	(.0092)	(.0075)

[*] 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-18: 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	-300** (81)	-1060** (40)
GasolinePrice(3 mo mixed)*MPG Quart 1	-322** (91)	-1129** (42)
GasolinePrice(3 mo down)*MPG Quart 1	-374** (101)	-1254** (50)
GasolinePrice(3 mo up)*MPG Quart 2	-118* (46)	-902** (59)
GasolinePrice(3 mo mixed)*MPG Quart 2	-144** (51)	-967** (62)
GasolinePrice(3 mo down)*MPG Quart 2	-151** (56)	-1055** (68)
GasolinePrice(3 mo up)*MPG Quart 3	-37 (37)	94 (74)
GasolinePrice(3 mo mixed)*MPG Quart 3	-53 (41)	109 (70)
GasolinePrice(3 mo down)*MPG Quart 3	-81+ (46)	107 (74)
GasolinePrice(3 mo up)*MPG Quart 4	106* (52)	1621** (56)
GasolinePrice(3 mo mixed)*MPG Quart 4	94 (60)	1788** (63)
GasolinePrice(3 mo down)*MPG Quart 4	89 (64)	1919** (67)

[*] 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.