Gasoline Prices and Consumer Behavior in the Secondary Automobile Market

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1 Abstract

This paper uses the recent drop in United States gasoline prices to gauge how consumer preferences have shifted towards various types of vehicles in the secondary automobile market. I find that consumer preferences for fuel efficient vehicles are largely affected by the price of gasoline while consumer preferences for fuel inefficient vehicles are affected less so by changing gasoline prices. This paper also analyzes asymmetries related to responses to rising and falling gasoline prices.

2 Introduction

Energy policy has been hugely influential worldwide as of late. The United States employs government intervention in the types of vehicles consumers prefer through various subsidies and fuel economy standards imposed on suppliers. However, one of the biggest determinants of the types of vehicles people prefer is the price of gasoline. Gasoline prices have huge effects on the demand for vehicles of various fuel efficiencies and could impact market forces that would incentivize various research and development in areas that would lead to greater fuel efficiency and a smaller carbon footprint. A greater understanding of how exactly the price of gasoline affects consumer preferences could lead to better shaping of policy around this.

According to Kahn (1986) gasoline prices, and more specifically consumer expectations of gasoline prices, have had large effects on consumer preferences for various types of vehicles. In 1986, Kahn studied the shock to gasoline prices caused by the OPEC oil embargo in the 1970s and how that affected used automobile markets. In these past few years, we have seen a shock in the opposite direction caused by various factors in the market. OPEC has lost market power due to dramatic increases in oil production in both the United States and Russia. Specifically, in the United States we have seen less dependence on foreign oil and a dramatic drop in gasoline prices. The following figure spans from January 2014 to October 2016 and shows the weekly average US gasoline price leading up to the first day of each month. All prices are in October 2016 dollars.

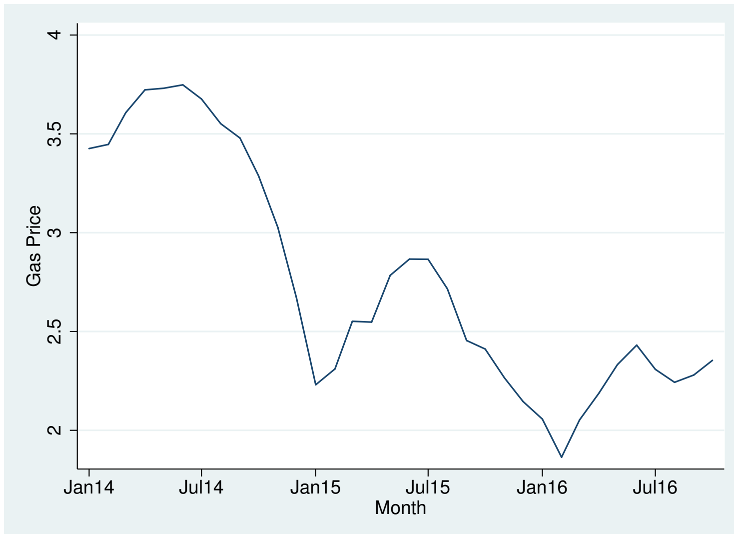

Figure 1: Monthly Gasoline Prices

Gasoline prices experienced a huge drop in October 2014 due to a supply shock. Since then, the price of gasoline has fluctuated significantly but has not come back up to its pre-shock level. This signals that consumer expectations related to gasoline prices have been shifting accordingly to match a new norm of gasoline prices. This is affecting the demand for different types of cars in different ways. In this paper, I will study how these shifting expectations are affecting consumer preferences for vehicles of various fuel economies and whether or not the response is different in times of rising gasoline prices and falling gasoline prices.

I have found that the price of gasoline is negatively correlated with the price of low fuel economy vehicles of advertised miles per gallon (MPG) 17 or less. However the magnitude of this correlation is relatively small. Conversely, the correlation between the price of gasoline and the price of high fuel economy vehicles with advertised MPG 30 or higher is positive with large magnitude. Additionally, these vehicle price differences are relatively similar across vehicle types in times of rising and falling gasoline prices. However, gas guzzler vehicles experience a much larger price shock in times of rising gas prices than in times of falling gas prices, significant at the 5% level.

Understanding the effects of gasoline price expectations on consumer car preferences may have implications in energy and climate change policy. Energy policy manipulating the price of gasoline requires an understanding of how gasoline prices affect consumer preferences to predict its impact on domestic car markets, dependence on foreign oil, and levels of pollution. A carbon tax, which would raise the price of gasoline, is a policy solution that United States lawmakers have begun to discuss and Canada has even enacted.

Currently, the largest policy in the United States in place to address energy concerns with vehicle fossil fuel emissions is Corporate Average Fuel Economy (CAFE) standards. Knittel (2012) articulates that CAFE standards are not entirely effective in forcing manufacturers to actually improve the fuel economy of vehicles. This is because these standards affect manufacturers as a whole and lead to price manipulation of newly produced vehicles to maximize manufacturer profits. Additionally, consumers are provided no incentive to drive less since the standards only affect types of cars purchased.

In this paper I will be analyzing secondary automobile markets, avoiding any skew caused by CAFE standards on new automobile markets. I argue that price manipulation is potentially more effective than regulatory intervention. Specifically, higher gasoline prices woule lead to the purchase of more fuel efficient vehicles. These incentives could potentially create market forces that push forward research and development in clean energy vehicles.

3 Related Literature

Many papers have studied how shocks in gasoline prices affect consumer behavior in terms of miles driven and demand for different types of vehicles. Kahn (1986) demonstrated that the OPEC oil embargo shock to gasoline prices in the 1970s not only drastically changed consumer expectations of gasoline prices but in turn greatly affected supply and demand in the secondary automobile market. He demonstrated this using a hedonic valuation method to control for various supply shocks in the features of different models of various automobiles in the secondary market.

Most interestingly, Kahn finds that the prices of automobiles in the secondary market adjust about halfway to what they would need to in order to offset the increased cost of gasoline and thus finds that consumers are partially myopic.

However, Busse, Knittel, and Zettelmeyer (2012) argue that consumers are indeed not very myopic after comparing price differences in the used car market to differences in expected future costs of gasoline and interest payments for buyers who borrow to purchase a vehicle. Sallee, West, and Wei (2015) use an approach that looks at different mileage vehicles of the same model in the secondary market and find that the lifetime cost of these various vehicles matches almost exactly with fluctuations in gasoline prices. They thus agree with Busse, Knittel, and Zettelmeyer in that consumers are fully valuing gasoline price shocks as evidenced by varying prices of vehicles with different fuel economies in the used automobile market.

Taking into account all of these previous works on the subject, my paper looks into various groupings of vehicles with different fuel efficiencies and measures how much consumers are changing their valuation of these vehicles in response to fluctuations in the price of gasoline. Unlike these past works, which mostly focus on times of rising gasoline prices, my paper is focused on the most recent drop in gasoline prices which may entail different effects on consumer preferences.

4 Data

The data used in this paper was procured from many sources. Past literature, including nearly all related works mentioned in this paper, have generally used market valuations from various sources such as the National Automobile Dealer's Association (NADA), Kelley Blue Book, or Manheim to obtain a true market value for automobiles in the secondary market. However, obtaining these market valuations would have required funding far beyond the budget of this paper. Instead, I work around this issue by procuring data from many different sources, mainly the website, CarGurus, and the price trends graphs reported on the website.

CarGurus reports the daily average listing price of specific models of used cars as values on associated price trends that span time. The price is calculated by tracking used car listings that go through their website. Through these price trends graphs, monthly price data was collected over 34 months from January 2014 to October 2016 for 69 different models of used cars.

A potential issue with the data collected is that for all models of used cars (e.g. Subaru Outback), the average listing price reported includes all years worth of those models of cars (e.g. Subaru Outback 2010, Subaru Outback 2011, etc.) and does not distinguish between year-specific models. Thus, there is no way to know how many of each year-specific model is accounted for in each average listing price at any given day. There is also no way to control for the mileage on the cars and any other conditions that may affect the value of a used car that is specific to each individual used car. Since these conditions fluctuate on each given day the listing prices are reported, I argue that these differences are aggregated away by the sheer volume of car listings on the website.

In order to set up the fixed effects model, this paper extracted hedonic characteristics of each individual model of car sold from various sources. This was to gain insight into how cars have changed over time and how various supply shocks could have also affected the price. The first of these sources was the Environmental Protection Agency (EPA) which reports on various fuel economy measures of each car. From the EPA I collected data on the inner workings of the cars such as what type of transmission, what type of air circulation, and what type of fuel is recommended for the specific model of car, to name a few. The full list can be found in the Appendix. The most important thing, however, collected from the EPA was the Combined Fuel Economy (City and Highway) that is reported on each car when it is sold new and is the advertised fuel economy of each of these cars. This number was preferred to any other potentially adjusted measure of fuel economy because it is most likely the number that consumers would be looking at to form future expectations about the real cost of owning the car, given gas price expectations.

To add to the characteristics of each car model collected from the EPA, this paper also presents data collected through the Edmunds Developer API. Edmunds is another used car listings website that contains much more information regarding each specific model of car. Procuring this information through GET requests, we supplement the original car characteristics gathered from the EPA by also taking into account engine characteristics such as torque, horsepower, the compression ratio, number of engine valves, and the number of cylinders present in the engine. This is significant because, as Busse, Knittel and Zettelmeyer (2009) found, fuel economy has grown relatively slowly due to dramatic increases in horsepower of newer vehicles. It is thus important to control for.

Beyond car prices and car characteristics, it was also necessary to track the price of gasoline. It is important to take into account that this measure must be a proxy for consumer expectation of gasoline prices. I assumed that consumers formed expectations based on the past week's worth of gasoline prices. As a result, I collected data on the average weekly gasoline price associated with the first day in each month to capture what consumers believed the gas price would be in the future on each day the prices of vehicles were collected. All of the data on gasoline prices was taken from United States Energy Information Administration (EIA).

All values are Consumer Price Index (CPI) adjusted using a daily CPI calculator (given the daily nature of our price listings) that was extrapolated from the Bureau of Labor Statistics (BLS) yearly CPI reports and comes from the finance research tool, Don't Quit Your Day Job.

5 Specification and Results

The model presented in this section was somewhat constrained by available data. Specifically, the data consisted of price information of 69 different models of cars over 34 months, lending itself nicely to a fixed effects model. Essentially, we want to find how gasoline prices affect the price of different types of cars in the secondary car market. Thus I propose using a time and car model fixed effects regression to control for consumer valuation that arises due to the brand of car and the time of listing.

However, the value of many of these cars is also dependent on various features such as engine power and transmission type. I exploit the fact that changes occur in car features over time. Because there is no data on what year-specific models of cars are available on the used car markets, I analyze how these hedonic features changed in new cars 3 years prior to the year the price data was collected in the secondary market to match up how the features of cars for sale on the secondary market change over time. A large assumption I have to make is that the variation in cars by model year is uniform across all models of cars. After looking through the CarGurus website and what types of cars are listed for sale, I concluded that a 3 year lag is appropriate to encapsulate what type of year-specific models are present in the secondary market. Thus for each year of the data, I conclude that the cars on the market match up pretty well with new cars from 3 years prior. Thus I collect hedonic valuation data from new vehicles 3 years before the price data collected in the secondary market to also control for supply shocks in these vehicles. These shocks could be a variety of things such as improved horsepower, or automatic transmission and could therefore explain additional variation in prices.

Summary statistics are available for all the hedonic characteristics along with a description of each in the Appendix. For the sake of simplicity, I will refer to them simply as the hedonic characteristics.

Picking which vehicles to analyze required an analysis as to which vehicles had robust data associated with them. In general, the vehicles selected were those that are very popular amongst consumers and generally have a new model come out every year. This is so price trends in these vehicles is not too affected by devaluation of older models. Additionally, the vehicles selected encapsulate a wide range of fuel economies and thus capture a large amount of this variation present in the entire market.

One of the biggest manipulations to the dataset is creating Fuel Economy Quintiles. Busse, Knittel, and Zettelmeyer create Fuel Economy Quartiles to estimate the effects of gasoline prices on groups of used vehicles with different fuel efficiencies. Since my dataset is smaller than the one used in Busse, Knittel, and Zettelmeyer, the reasoning behind using quintiles is because it is where fuel economy cutoffs landed the most nicely. The following are the quintiles used and the fuel efficiencies associated with them in the dataset.

Table 1: Fuel Economy Quintiles

Quintile	**Range of Fuel Economy (MPG)**
1	14-17
2	18-21
3	22-24
4	25-29
5	30-50

The plot of average price of these fuel economies is below. These prices are all in October 2016 dollars:

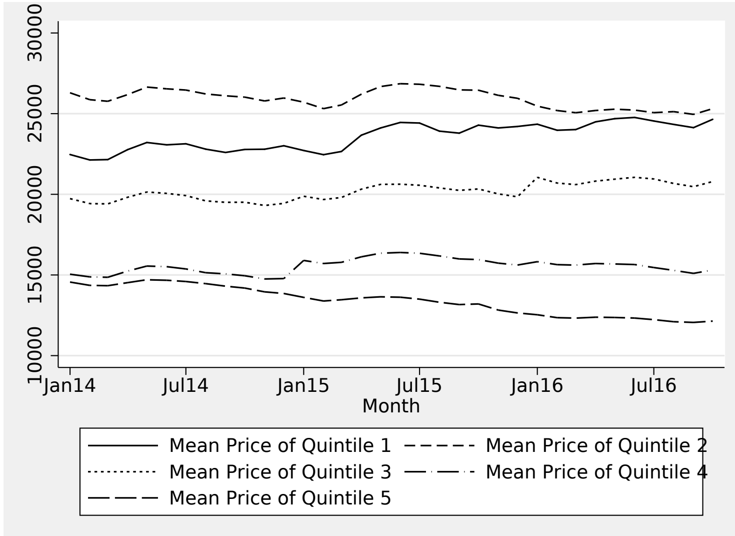

Figure 2: Monthly Average Market Price by Fuel Economy Quintile

From Figure 2, it is evident that cars of higher fuel economy are in general much less expensive than those with lower fuel economy. This effect is most likely due to the larger size and higher horsepower of gas guzzling vehicles.

There are also very stark differences in how the prices of the best fuel economy vehicles and the prices of the worst fuel economy vehicles respond to gasoline price shocks. Recall from the introduction that we have witnessed a sharp decline in gasoline prices over the past few years. As consumer expectations of these gasoline prices have adjusted recently, we can now witness how these gasoline prices have affected automobile prices. The following plot is the average market price of just the worst fuel economy vehicles:

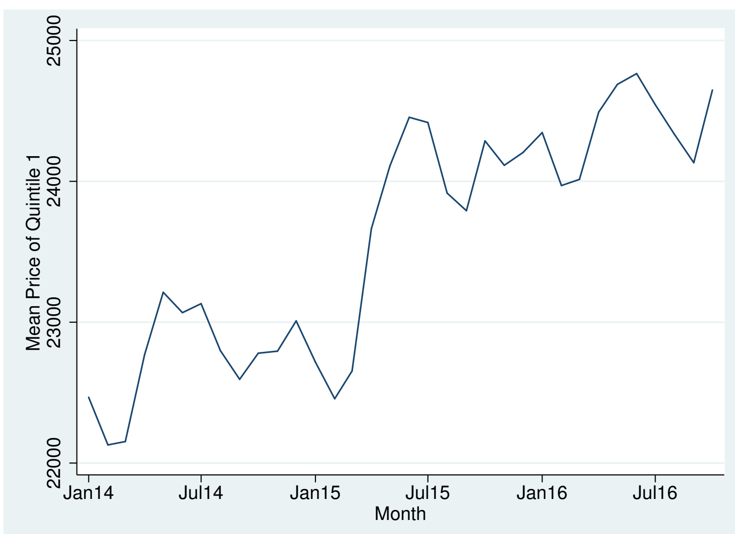

Figure 3: Monthly Average Market Price, Quintile 1 - Worst Fuel Economy

As we can see, the price of these vehicles is dramatically increasing over time. We are witnessing nearly a 10% increase in price over the course of nearly 3 years with price being adjusted to October 2016 dollars. Alternately, we see nearly the exact opposite effect occurring in our top quintile of best fuel economy vehicles present in the secondary car market.

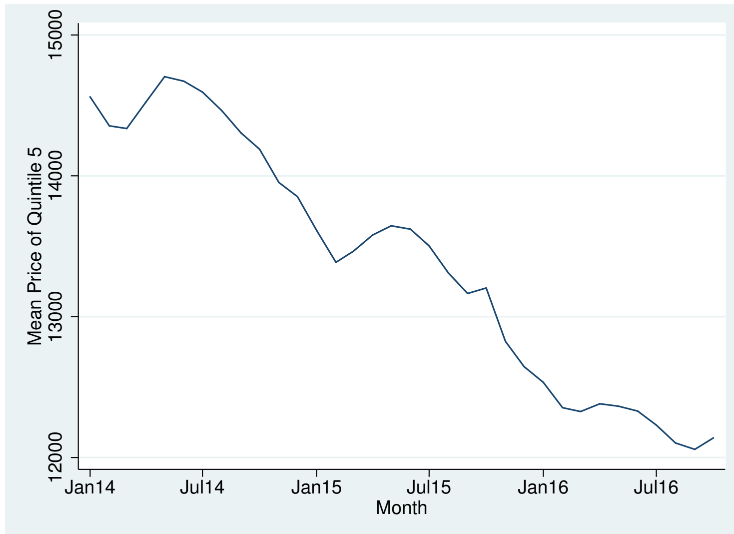

Figure 4: Monthly Average Market Price, Quintile 5 - Best Fuel Economy

Figure 4 demonstrates an entirely opposite effect found on the other end of the fuel economy spectrum. Although the average price difference measured in these types of cars is nearly identical, with the most fuel efficient vehicles, we are seeing nearly a 16% decrease in the price since they are much less expensive to begin with as compared to a 10% increase in the price of gas guzzlers.

The parameters of interest for modeling exactly how the changing gasoline prices are affecting each type of vehicle in the secondary market are the prices of the vehicles over time, the price of gasoline over time, and the prices of the vehicles of different fuel economy quintiles over time and how those trends differ from one another. The following is a fixed effects model that encapsulates these parameters of interest, in addition to the hedonic characteristics.

$$Price_{i,t} = \alpha_i + \alpha_t + \beta_1 FEQuintile_i * GasPrice_t$$
$$+\gamma HedonicCharacteristics_{i,t} + \epsilon_{i,t}$$

Where α_i encapsulates the car model fixed effects and α_t encapsulates time fixed effects. The main independent variable is an interaction term between the fuel economy type of the vehicle (which quintile it lies in) and the real price of gasoline. We can then tell how the gasoline price affects the price of these different types of vehicles. The hedonic characteristics here are used to do simply control for supply shocks to different models of vehicles.

The following are summary statistics from these parameters of interest. It is important to note that the fuel economy quintiles are not very evenly spaced as quintiles. This was due to a large amount of clustering at certain fuel economies that I also tried to capture with the quintiles. They may not be perfect quintiles but I did not want to split up different cars with the same advertised fuel economy. However, it is important to see that the worst and best quintile for fuel economy are roughly the same size and those are the most important two in this specification. It is also of significance to note that there are huge differences in the actual prices of cars of different fuel economies, most likely relating to size and horsepower. The fixed effects model with hedonic valuation characteristics should help correct for this. Summary statistics representing the hedonic characteristics can again be found in the Appendix of the paper.

Table 2: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**N**	**Min**	**Max**
CPI Adjusted Gasoline Price	2.762	0.592	2346	1.86	3.75
CPI Adjusted Vehicle Price	19722.193	7221.81	2346	7277.724	44426.88
Fuel Economy	23.772	7.396	2322	14	50
Quintile 1 Mean Price	23621.469	838.364	500	22128.85	24794.82
Quintile 2 Mean Price	25969.122	713.113	476	24953.88	28326.17
Quintile 3 Mean Price	20148.817	544.833	392	19308.39	21235.75
Quintile 4 Mean Price	15616.761	438.168	492	14752.05	16394.25
Quintile 5 Mean Price	13404.209	939.553	486	12058.02	15443.54

Finally, we can apply the model presented above and the fuel economy quintiles to find how consumers react to gasoline prices when it comes to both the best fuel economy vehicles and the worst fuel economy vehicles.

Table 3: Fixed Effects with and without Hedonic Characteristics

Variable	**Fixed Effects**	**Fixed Effects w/ Hedonic**
Constant	17154.68***	16188.37***
	(358.2432)	(2201.33)
Quintile 1 (Worst FE)	-240.96*	-443.46***
	(128.46)	(121.31)
Quintile 2	981.71***	1000.80***
	(125.02)	(116.25)
Quintile 3	959.50***	783.15***
	(123.85)	(116.18)
Quintile 4	1148.08***	1007.89***
	(126.78)	(117.70)
Quintile 5 (Best FE)	1376.24***	1467.61***
	(127.01)	(123.25)
Horsepower		-3.238***
		(.749)
Torque		-0.957
		(1.084)
Total Valves		35.47***
		(11.05)
Compression Ratio		11.03
		26.88
Engine Displacement		-51.05
		56.85
Cylinders		124.52***
		(28.51)
Gears		-181.71
		(311.80)
Transmission Lockup		1489.84**
		(454.39)
R^2	0.4369	0.4816
N	2346	2254

*, **, *** Statistically significant at the 10%, 5%, and 1% level

The effect of gasoline prices on the prices of both the best fuel economy vehicles and the worst fuel economy vehicles is statistically significant in each case at the 1% level but in the opposite direction. This correlates to the relationship between automobile prices and gasoline prices as observed in earlier graphs. It also makes sense that when the price of gasoline rises, the demand for fuel efficient vehicles subsequently rises, thus increasing the prices of fuel efficient vehicles. This is evidenced by the positive coefficient of the interaction term between gasoline prices and the best quintile in terms of fuel efficiency. Conversely, when the price of gasoline decreases, like it has in recent years, the demand for fuel inefficient vehicles rises and thus increases the price of these gas guzzlers. This is evidenced by the negative coefficient on the interaction term that denotes how gasoline prices affect the worst fuel economy quintile.

It appears that there exist differences between how gas guzzlers and gas sippers are affected by shocks to gasoline prices. The price of gasoline increasing by a dollar affects gas sipper vehicles significantly more than it does gas guzzling vehicles. Take the best fuel economy quintile, for example. Recall that this quintile contains all vehicles in the dataset with fuel economy 30 MPG or higher. According to Edmunds, Americans average around 12,000 miles per year on their vehicles. To just compare the highest and lowest fuel economy quintiles. In the best fuel economy quintile, the average fuel economy is 35.5 MPG. Thus, if the price of gasoline goes up by a dollar, your vehicle would then spend about $12,000/35.5 = \$338.02$ a year. Alternatively, the lowest fuel economy quintile has an average fuel economy of 15.4 MPG and the owner of a gas guzzling vehicle would then spend an extra $12,000/15.4 = \$779.22$ on gasoline in a year. These disparities thus shift consumer demand toward more fuel efficient vehicles in times of rising gasoline prices. In times of falling prices, we then see an opposite effect as consumers more highly value gas guzzling vehicles.

Exploring Price Asymmetries

Now I'll exploit variation in price data to parse what actually happens in times of rising and falling gasoline prices and see if there are any asymmetries that arise from responses found in the prices of various vehicles. The following are two different specifications, one run on the dataset only where the price of gasoline is rising and the other where the price of gasoline is falling.

Table 4: Consumer Reactions to Falling Prices

Variable	**Fixed Effects w/ Hedonic**
Constant	14919.06***
	(2842.05)
Quintile 1 (Worst FE)	-194.48*
	(102.47)
Quintile 2	1100.81***
	(90.31)
Quintile 3	827.28***
	(90.31)
Quintile 4	1079.38***
	(92.71)
Quintile 5 (Best FE)	1534.64***
	(104.57)
R^2	0.4365
N	1194

*, **, *** Statistically significant at the 10%, 5%, and 1% level

Table 5: Consumer Reactions to Rising Prices

Variable	**Fixed Effects w/ Hedonic**
Constant	17784.49***
	(3319.36)
Quintile 1 (Worst FE)	-579.16***
	(136.18)
Quintile 2	984.84***
	(126.28)
Quintile 3	825.36***
	(126.02)
Quintile 4	1002.02***
	(129.04)
Quintile 5 (Best FE)	1439.70***
	(140.49)
R^2	0.5543
N	1060

*, **, *** Statistically significant at the 10%, 5%, and 1% level

Every quintile in the different specifications have responses to the gasoline price that are not statistically significant from one another except for the first quintile. In the worst fuel economy quintile, consumers react much more to rising prices in gasoline over falling prices as evidenced by a magnitude of nearly $384.68 more with rising prices of gasoline. The standard error for this difference is 170.43 making it statistically significant at the 5% level. This asymmetry arises due to consumers of gas guzzling vehicles either over adjusting their valuation of vehicles when gasoline prices are rising or not paying much attention when gasoline prices are falling. This finding is complementary to previous work on price asymmetries in various other settings such as Muller and Ray (2007) discovered in Chicago grocery stores.

Vehicles and their Hybrid Counterparts

Another interesting variation in car models I exploit is modeling the impact of being a hybrid vehicle on the effects of gasoline prices on vehicle prices. The data collected contain 3 vehicles that have hybrid counterparts. N=6 is not large enough for statistical significance but just looking at the following trends in these 3 vehicles, the Hyundai Sonata, the Kia Optima, and the Toyota Highlander and their hybrid counterparts, we can see large variation in hybrid versus their regular vehicles across the time domain we are interested in.

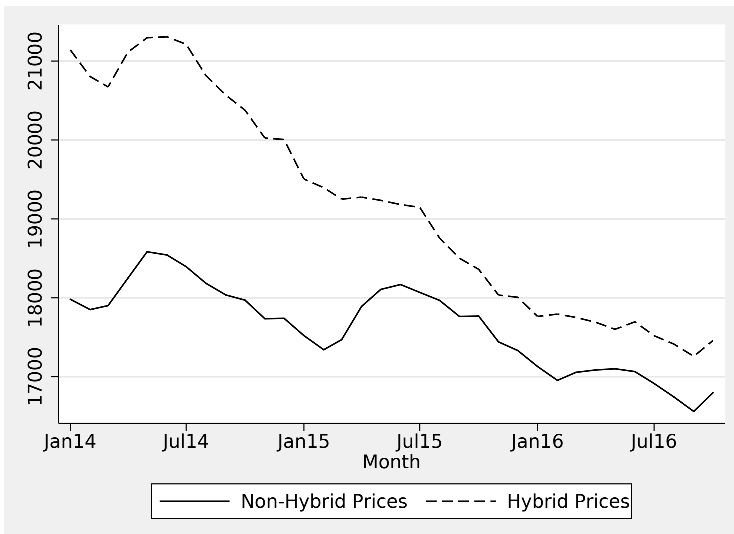

Figure 5: Monthly Average Market Price, Quintile 5 - Best Fuel Economy

We can also model this similarly to the quintile interactions by seeing how the gasoline price affects the prices of hybrid vehicles and non hybrid vehicles. As demonstrated in Table 6, prices of hybrid vehicles are highly correlated with the price of gasoline whereas the specific non hybrid vehicles in the dataset were less correlated with the price of gasoline due to varying fuel economies. Hybrid vehicles on average in this small dataset are 10 MPG more efficient than their non-hybrid counterparts. The difference between the price reactions in the two types of vehicles is over $1140.66 and significant at the 1% level.

Table 6: Hybrid Specification

Variable	Fixed Effects w/ Hedonic
Not Hybrid	1326.613***
	(227.983)
Hybrid	2467.273***
	(271.833)
Difference	1140.66 ***
	(354.78)
Intercept	2036.770
	(3290.474)
R^2	0.8972
N	170

*, **, *** Statistically significant at the 10%, 5%, and 1% level

6 Conclusion

Given the dramatic fall in United States gasoline prices, it is evident that if this trend persists, we will see a disproportionately low demand for high fuel economy cars in the consumer market. Thus the current market for gasoline is naturally disincentivizing the sale of gas sipper vehicles.

The differing magnitudes between the two types of vehicles (gas guzzlers versus gas sippers) can perhaps be explained by those desiring gas guzzling vehicles being more averse to switching to different vehicle types. This could be because the demand for these types of vehicles is more inelastic and consists of people who need large vehicles for off-road purposes or because they have large families and are more hard-pressed to switch to a small, fuel efficient sedan. On the other hand, the large, positive correlation between the price of gasoline and highly fuel efficient vehicles could be related to the fact that demand for these types of vehicles is more elastic and consumers are much less attached to these small, fuel-efficient vehicles for features other than their fuel efficiency. This could explain how these vehicles are much more highly valued in time of high gasoline prices

In this market, we see a dual effect of both supply and demand shocks. Since this is a secondary car market, the prices of these vehicles and subsequent demand for types of vehicles is influenced both by willingness to sell and willingness to buy. If the price of gasoline rises, sellers may be more willing to put used gas guzzlers on the market, which they should value less, and not be as willing to put used gas sippers on the market, which they should value more. On the demand side, consumers would be more willing to buy fuel efficient vehicles in times of high gasoline prices, thus leading to shifting prices. Due to the constraints of the data, I am unable to quantify the number of listings in various times to actually gauge whether or not this correlation between gasoline price and vehicle price is more due to supply shocks (shortages or excesses depending on vehicle type and gasoline price) or demand shocks working in the opposite direction in these same times.

The potential asymmetries that have arisen from different reactions as evidenced by the prices of gas guzzling vehicles in times of rising versus falling prices could be also be due to the potential inelasticity of demand for these types of cars. This could be explained by consumers of these large vehicles paying less attention to falling gas prices when revaluing a vehicle. However, consumers of large vehicles may be more sensitive to rising gasoline prices, given the higher costs of owning such a vehicle being more noticeable, causing the prices of gas guzzling vehicles to be more highly correlated with the price of gasoline during times of rising gasoline prices. This finding could also explain why previous literature, which heavily studied times of rising gasoline prices, found a greater effect in consumer revaluation of gas guzzling vehicles, to the point that they almost entirely correct for any additional spending on fuel.

The results presented in this paper nevertheless show significant market reactions to the falling price of gasoline in the United States. In the secondary automobile market, there are virtually no ways to regulate the externalities of carbon and fossil fuel emissions. There are far-reaching effects of this sort of analysis on how to incentivize firms to develop more fuel efficient vehicles, since consumers are now valuing fuel efficient vehicles at a much lower price. The lower demand for fuel efficient vehicles incentivizes firms to produce vehicles at different quantities or manipulate prices to route around CAFE standards or even pay the fees related to breaking CAFE standards in production in order to make even more of a profit selling gas guzzling vehicles in a market with increasing demand for these types of cars. We may increasingly see the effects of CAFE standards decreasing with consumer expectations adjusting to a lower gasoline price.

Since we have already seen how much of an effect gasoline prices have on consumer demand for different vehicles, and many past works have studied this as well, it could be argued that manipulating the price of gasoline could shift consumer preferences in order to offset the externalities associated with owning gas guzzling vehicles. A carbon tax to increase the price of gasoline would thus be more effective in changing consumer preferences to reflect such externalities as we may increasingly find that CAFE standards are ineffective in addressing such issues. This could be a good thing for consumers who perhaps do not need a large SUV and end up saving a lot of money by driving a small sedan instead. However, it could be argued that using a fuel tax as a means to influence driving patterns would also have negative social consequences. Specifically, fuel taxes disproportionately impact lower income families in which gasoline expenses are a higher percentage of overall out of pocket expenditures and could thus be considered a regressive tax. This could especially affect a family that, say, needs a large minivan with bad fuel efficiency to hold a lot of children.

There are many potential expansions that could be done in this field to better understand consumer preferences that I have not done in my paper. Gathering both price and quantity data on used vehicle listings would be a big step in understanding the effects of supply versus demand shocks in the used automobile markets. This could better extract whether it is more supplier aversion to selling vehicles or increased consumer demand for certain types of vehicles that leads to price fluctuations of different cars in the used automobile markets.

Additionally, creating a model to see how the price of gasoline, along with various supply shocks, affects the true value of vehicles of various fuel economies could also add to the literature on whether or not consumers are optimally revaluing vehicles on the secondary market. Microdata on consumers' changing driving habits (miles driven) for cars of various fuel efficiencies would be needed to cleanly model this sort of valuation.

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7 Appendix

Table 7: Summary Statistics - Hedonic Valuation Controls

Variable	Mean	Std. Dev.	N	Min	Max
Horsepower	245.906	97.18	2324	31	536
Torque	249.838	104.742	2278	68	590
TotalValves	20.63	6.06	2324	8	32
CompressionRatio	10.604	1.26	2324	8.2	16.5
EngDispl	3.04	1.248	2322	1	5.7
Cyl	5.162	1.534	2322	3	8
Gears	4.991	1.945	2322	1	8
auto_A5	0.112	0.315	2346	0	1
auto_A6	0.205	0.403	2346	0	1
auto_AM5	0.014	0.12	2346	0	1
auto_AV	0.14	0.347	2346	0	1
auto_S6	0.184	0.388	2346	0	1
auto_A4	0.083	0.275	2346	0	1
auto_A7	0.029	0.168	2346	0	1
auto_AVS6	0.029	0.168	2346	0	1
auto_S5	0.043	0.204	2346	0	1
auto_S8	0.047	0.211	2346	0	1
man_M5	0.014	0.12	2346	0	1
air_NA	0.853	0.355	2346	0	1
air_SC	0.033	0.179	2346	0	1
air_TC	0.104	0.305	2346	0	1
trans_AM	0.038	0.19	2346	0	1
trans_CVT	0.14	0.347	2346	0	1
trans_SA	0.309	0.462	2346	0	1
trans_A	0.433	0.496	2346	0	1
trans_M	0.014	0.12	2346	0	1
trans_OT	0.015	0.123	2346	0	1
trans_lockup	0.883	0.321	2346	0	1

Table 8: Description of Controls - Hedonic Characteristics

Hedonic Characteristics	**Description**
Horsepower	Power of the Engine
Torque	Turning Power
TotalValves	Total Number of Valves
CompressionRatio	Engine Compression Ratio
EngDispl	Volume of Pistons
Cyl	Number of Cylinders
auto_A6	Automatic Transmission Type A6
auto_A5	Automatic Transmission Type A5
auto_AM5	Automatic Manual Transmission Type AM5
auto_AV	Automatic Variable Transmission
auto_S6	Multiple Speed Transmission Type S6
auto_A4	Automatic Transmission Type A4
auto_A7	Automatic Transmission Type A7
auto_AVS6	Automatic Variable Transmission type AVS6
auto_S5	Multiple Speed Transmission Type S5
auto_S8	Multiple Speed Transmission Type S8
man_M5	Manual Transmission Type M5
man_M6	Manual Transmission Type M6
air_NA	Air Aspiration Method - Naturally Aspirated
air_SC	Air Aspiration Method - Supercharged
air_TC	Air Aspiration Method - Turbocharged
trans_A	Automatic
trans_M	Manual
trans_OT	Other Transmission
trans_AM	Automatic Manual
trans_CVT	Continuously Variable
trans_SA	Semi Automatic
Gears	Number of Gears)
trans_lockup	Transmission Lockup Dummy (Yes or No)