The Influence of Gasoline Prices and Consideration Sets on the Fuel Economy of New Vehicle Sales

by

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Abstract:

Understanding the factors that influence consumer investment in fuel economy when purchasing a new vehicle is critical for stakeholders including environmental policy makers, automotive manufacturers and oil companies. The energy economics literature shows that consumers are relatively rational in how much fuel economy they purchase in response to changes in gas price. Yet the marketing literature suggests that consumers only consider a small number of vehicle makes/models - as few as 2-6 - when making their purchase decision. Given this, we consider the extent to which consumer's rational response to gas price changes is achieved by including different vehicles in their consideration set, versus choosing differently from within their consideration set. We analyze data from 210,885 responses to a new vehicle customer satisfaction survey collected over 9 years in which respondents state the vehicles they considered purchasing in addition to the vehicle they ultimately purchased. Our findings show that as gasoline prices rise, their purchased vehicle fuel economy increases more than their consideration set average fuel economy does, with both increasing. This is the result of considering more fuel-efficient vehicles and also purchasing higher within their consideration set fuel economy range. The degree to which the consumer adjusts is shown to correspond to the importance they place on the environment during their shopping process. Increased consideration and adoption of alternative fuel vehicles are found to be one mechanism the consumer uses to make these adjustments. Finally, we highlight how changing gasoline prices result in differing consideration set behavior for buyers of low and high fuel economy vehicles.

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1. Introduction

How gasoline prices affect gasoline consumption is a question of interest to stakeholders across the energy economy. Vehicle manufacturers, oil and gas companies, environmentalists, and policy makers all make decisions based in part on how they expect consumers to behave in response to the price of gasoline. While this is a well-studied problem, it is difficult to resolve because multiple players can make dynamic adjustments to variables that affect supply and demand. For example, car manufacturers can change the supply and price of high fuel economy vehicles, oil and gas companies can affect the supply and price of gasoline, environmental groups can influence public sentiment to affect gasoline demand, and governments can introduce policies that alter incentives for consumers.

Numerous papers dating back to the 1970s have studied how gasoline prices affect the various elements of this question such as car choices, car prices, vehicle miles driven and elasticities of demand for gasoline. Of particular interest is a subset of these papers that have focused on evaluating the extent to which consumers correctly value future fuel costs when purchasing a vehicle. The first of these papers, (Kahn 1986), assessed if used car prices adjusted fully to the discounted value of future fuel costs as a result of gasoline price shocks in the 1970s, finding that used car prices only captured about 30-50% of the change in total cost of ownership resulting from changes in gasoline price. A similar study by Kilian and Sims (2006) found that used vehicle prices adjusted asymmetrically, with large increases in gasoline prices being nearly fully accounted for but decreases in gasoline price having little affect. In a unique approach, Sallee et al. (2009) examine differences in used car prices of like models, odometer readings and current gasoline prices to determine how consumers are valuing future fuel costs. They find that a $1 change in future discounted fuel costs, corresponds to a $0.79 to $1.24 change in vehicle purchase price when using discount rates of 5% to 15%. Allcott and Wozny (2011) exploit variation in used car prices for vehicles of the same make, model, and characteristics, finding that a $1 change in future discounted fuel costs corresponds to a $0.76 change in vehicle purchase price assuming a 15% discount rate. Finally, Busse, Knittel, and Zettelmeyer (2013) examine how prices change in response to gasoline prices, within fuel economy quartiles, for both new and used cars. Using prior estimates of demand elasticities, and the differences in prices between quartiles, they compare the implied discount rates to the real interest rates at the time of purchase, ultimately concluding that consumers appear to adjust for future fuel costs rationally.

Given that consumers appear to purchase approximately the right amount of fuel economy, it is interesting to consider how they do this given that the marketing literature on consideration sets suggests that consumers only shop a small number of the numerous vehicles available in the market. With over 350+ vehicle make-model combinations to choose from (Hauser 2014), it impossible for consumers to evaluate all alternatives recognizing that cognitive limits and non-zero search costs exist. The common understanding, first developed by Payne (1976), is that consumers use a ‘consider-then-choose’ process, where the consumer selects a manageable subset of their known possible options, based on some quick filtering and heuristic criteria, for additional evaluation (Hauser 2014). This group of purchase options is referred to as a ‘consideration set’, although similar yet different, terms and definitions have also been used such as knowledge set, retrieval set, relevant set and evoked set (Alba and Chattopadhyay 1985). Since the consumer incurs an incremental cost and benefit for each additional product they evaluate, the consideration set has an optimal number that provides the maximum search cost to benefit ratio (Hauser and Wernerfelt 1990). For automobiles, this consideration set size is typically 2-6, with vehicles being added or removed during the search process before one is eventually selected (Desarbo and Jedidi 1995).

While this concept has been prevalent in the marketing field, academic literature that uses it to understand how consumers respond to gasoline price changes is limited. Palazzolo and Feinberg (2015) develop a consideration set formation model specific to automobiles. However, the focus of their paper is how marketing events influence the substitution of alternatives within the consideration set. While they show that a model which accounts for consideration set substitution to be more accurate than one that doesn’t, they don’t speak to the question of how consumers choose fuel economy. Leard (2020) uses consideration sets to estimate market-price elasticity for demand of new vehicles, ultimately determining that tighter fuel economy regulations will reduce new vehicle sales. However, this paper is concerned with the macro picture of a policy's effect on vehicle sales and doesn't speak to the dynamics of how a consumer determines the correct amount of fuel economy to purchase. Allcott and Knittel (2018) use consideration sets in their analysis of how well consumers are informed about fuel economy. By eliciting the consumer's consideration set, informing them about the fuel economy and costs of each vehicle, and then following up later to see what vehicle was purchased, they conclude that providing additional information to the consumer on the fuel costs of their vehicles doesn't have a significant effect on the average fuel economy purchased. However, this paper too stops short of analyzing the how consideration set fuel economy is affected by gasoline prices and how both influence the final purchased vehicle economy.

In this paper, we seek to understand how consideration sets and consumer behavior interact to shape the amount of fuel economy the consumer purchases when the price of gasoline changes. When the price of gasoline increases, to what extent do consumers include more fuel-efficient vehicles in their consideration set, versus purchase a relatively more fuel-efficient vehicle from within their consideration set? To answer this question, we analyze responses from a new vehicle customer satisfaction survey collected between 2009 and 2017, in which the vehicle the respondent ultimately purchased is known, and where the respondent is asked to state up to 3 other vehicles they considered buying during their purchase process. We find that a $1 increase in gas prices is associated with an increase in the average fuel economy of the consideration set by 0.092 gallons-per-mile (GPM), and an increase in the fuel economy of the purchased vehicle by 0.105 GPM. This shows that as gas prices increase, consumers include more fuel-efficient vehicles in their consideration set, but they also choose a relatively more fuel-efficient vehicle from within that consideration set. This behavior also holds true when we segment by the importance a consumer places on a vehicle's environmental friendliness and purchase price. The one exception is for people who list the environmental friendliness of their vehicle as not at all important in their purchase reasons. For this group, gasoline price does not have a significant effect on their purchased or considered fuel economy. Finally, we find that the odds of purchasing a gasoline vehicle decrease by 32.7%, while the odds of purchasing an alternate fuel vehicle increase by 49.7%, for a $1 change in gasoline price. Similar to our previous findings we see that the odds of purchasing an alternative fuel vehicle increases more than then the odds of considering one, but both of them increase. However, in our robustness section, we find that consumers who purchase the most fuel-efficient vehicles grow their consideration set fuel economy more relative to their purchased vehicle fuel economy, the opposite of our results to this point. This is the outcome of them considering more fuel-efficient vehicles throughout the set but selecting from the top their fuel economy range. While, low fuel economy buyers see their purchased vehicle fuel economy increase more relative to their consideration set because they are selecting slightly higher in their range while not altering their consideration set significantly.

Our results support previous literature in showing that the consumer does adjust their purchased fuel economy in response to changes in future fuel cost. In general, they do this by purchasing higher in their consideration set fuel economy range and increasing the fuel economy of their least and most fuel-efficient vehicles, with a slightly larger increase in the most fuel-efficient. We show that this is being driven, to some degree, by considering and purchasing more alternative fuel vehicles at higher gasoline prices. However, the different behavior by low and high fuel economy buyers suggests different mechanisms for any degree of myopia they may have. Low fuel economy buyers may not be selecting high enough within their consideration set fuel economy range, while high fuel economy buyers may not be expanding the upper fuel economy range of their consideration set enough. Vehicle manufactures and policy makers looking to increase the fuel economy of new vehicle sales need to target these groups in similar yet different ways. For both groups, increasing how much the consumer values the environment is the most effective means to drive purchased vehicle fuel economy improvement in response to gasoline prices. However, with low fuel economy buyers, strategies also need to be aimed at getting them to purchase higher within their existing set. On the other hand, the approach for the high fuel economy segment should target getting even higher fuel-efficient vehicles to break into their consideration set.

2. Data

The primary dataset for our analysis is responses to the New Vehicle Customer Study (NVCS), a study of car buyers' shopping and buying patterns run by MartizCX, a leading customer experience research and management provider serving the automotive industry. The study is conducted annually starting in October through September of the following year, sampling 200,000 people who have purchased or leased a new car in the United States within the last year, with a target of 750 returns per vehicle ("Automotive Syndicated Studies" n.d.). The 9-page survey is sent out monthly by mail and can be returned online or by mail, with respondents entered into a sweepstakes in which they could win one of eight prizes worth up to $10,000. For each response, Maritz has the VIN number of the purchased or leased car, from which they are able to accurately report its year, make, and model. Respondents then answer survey questions to provide information on a range of topics including demographics, planned vehicle use, purchase & finance information, personal viewpoints, satisfaction, other vehicles considered, and reasons for purchase. In total, the survey information we utilized contains 1,497,873 observations collected between October 2009 and January 2017.

To estimate the fuel economy of each purchased and considered vehicle in the Maritz data, we merge the Maritz data with sticker fuel economy numbers from the US federal government website fueleconomy.gov ("Download Fuel Economy Data" 2017), matching on the basis of year, make, model, number of cylinders, drive type and fuel type. In instances where multiple different fuel economy numbers match these criteria, we take the lowest available (least efficient). We were able to successfully match fuel economy numbers for 92% of vehicles in the survey data. For electric vehicles, the miles per gallon reported is a miles per gallon of gasoline-equivalent (MPGe), which represents the number of miles the vehicle can travel using an amount of electricity with an energy content equal to a gallon of gasoline. The miles per gallon used for a plug-in hybrid, which can operate both entirely on electricity or entirely on gasoline, is the combination of its regular gas MPG and its electrical MPGe, where the two are averaged together using a utilization factor provided by the fueleconomy.gov website specific to each plug-in vehicle. For all vehicles, we convert its MPG value to GPM by inverting it and multiplying by 100. We use GPM instead of MPG because GPM has a linear relationship with fuel savings, whereas MPG is curvilinear (Larrick and Soll 2008). This means selecting a vehicle that gets has 1 MPG more fuel economy will result in very different fuel savings costs depending on what the reference MPG was. For example, going from a 10 MPG to 11 MPG vehicle results in a much larger relative fuel savings, than going from a 30 MPG to a 31 MPG. Using the average miles driven, 12,598, and mean gasoline price, $2.99, from our dataset, going from 10 MPG to 11 MPG saves the consumer $342 a year, while going from 30 MPG to 31 MPG only saves $41. Meanwhile a 1GPM reduction will save the consumer the same amount regardless of whether they are going from 10 GPM to 9 GPM or 2 GPM to 1 GPM. Since our paper is concerned with how consumers adjust their fuel economy to account for future fuel costs, we need to make sure the change we are predicting is resulting in the same cost savings regardless of the starting point. We also chose to scale GPM by 100 miles as that is how the EPA reports it on new cars and it allows for more readable coefficients in our regressions.

Because the Maritz survey is completed by respondents approximately 2 months after the date of vehicle purchase, it does not contain data on what the price of gasoline was on the day that each respondent purchased their vehicle. To estimate the corresponding gasoline price, we merge the Maritz data with weekly regular, all formulations, gasoline prices from the US Energy Information Administration (EIA) website ("Retail Prices for Regular Gasoline" 2019), using state-specific prices when available, or otherwise the price for the corresponding PADD region. Each observation in the dataset then has a gasoline price corresponding with the state, month and year in which the vehicle was purchased.

At this point, we remove all observations that did not have at least one considered vehicle with estimated fuel economy in addition to the purchased vehicle, or which were missing information for variables used in our regression models. This leaves us with 210,885 observations, for which the summary statistics are shown in Table 1. Further description of our data cleaning process is provided in appendix section A4. Since we use only the official fuel economies, as reported to the EPA according to CAFÉ standards, any vehicle which is exempt from these reporting requirements is removed from our dataset. Notably, vehicles that weigh more than 8,500lbs are not subject to CAFÉ standards. This means that some large trucks, often those with three-quarter ton rating and higher, such as the Ford F-250 or the Chevrolet Silverado 2500 were dropped from our data.

To understand the representativeness of our sample, we compare summary statistics to corresponding values from the Federal Highway Administration's 2017 National Household Travel Survey (NHTS) (U.S Department of Transportation, Federal Highway Administration, 2019) (Table 1), also breaking down by fuel type (Table 2). Overall, we see that our data is fairly representative as is, with the biggest difference being that we have a significantly higher percentage of male respondents, 71% compared to 49%. Our dataset has a slightly higher level of education, with 63% earning at least a bachelor's degree compared to 53% in the NHTS data. And looking at the breakdown of purchased vehicles by fuel type, we see our dataset is comparable to the NHTS with a slightly lower number of gasoline vehicles, and slightly more hybrids. In the results section, we OLS run our models both as standard regressions and also with a weighting vector to adjust for these differences.

Table 1: Summary Statistics

Variable	2017 NHTS	Maritz Dataset					
	Mean	Mean	N	Median	SD	Min	Max
Location - Pct. Metro		0.16	210,885	--	--	0	1
Location - Pct. Suburb		0.51	210,885	--	--	0	1
Location - Pct. Town		0.29	210,885	--	--	0	1
Location - Pct. Farm		0.04	210,885	--	--	0	1
Pct. Male	0.49	0.71	210,885	--	--	0	1
Pct. Married		0.73	210,885	--	--	0	1
Pct. Principle Vehicle		0.82	210,885	--	--	0	1
Pct. Purchased		0.82	210,885	--	--	0	1
Pct. White	0.81	0.83	210,885	--	--	0	1
Pct. Bachelor or Higher Edu	0.53	0.63	210,885	--	--	0	1
Age	49.6	48.9	210,885	50	14.2	15	99
Car Age (Months since start of Model Year)		3.4	210,885	3	5.1	-11	21
Car Purchase Month		6.8	210,885	7	3.4	1	12
Car Purchase Price		$35,244	210,885	$32,500	$14,091	$7,000	$205,000

Car Purchase Year		2013	210,885	2013	2.2	2009	2017
Family Size	2.8	2.6	210,885	2	1.2	1	6
Fuel Econ. Purchased GPM		4.55	210,885	4.55	1.14	0.81	8.33
Fuel Econ. Purchased MPG		24.1	210,885	22	10.9	12	124
Avg. Fuel Econ. of CS GPM		4.56	210,885	4.55	1.09	0.82	8.33
Avg. Fuel Econ. of CS MPG		23.9	210,885	22	10.0	12	121.5
Consideration Set Size		2.4	210,885	2	0.7	2	4
Gas Price		$2.99	210,885	$3.01	$0.64	$1.55	$4.41
Income	$102,639	$134,949	210,885	$112,500	$95,570	$7,500	$500,000
Miles Driven per Year	12,750	12,598	210,885	12,000	6,757	1	99,995

Table 2: Purchased Vehicle Fuel Economy Summary Statistics

Fuel Type	2017 NHTS	Maritz Dataset – Purchased Vehicle						
		Observations		Fuel Economy (Gallons per 100 Miles)				
	%	%	N	Mean	Median	SD	Min	Max
Gas	94.3%	91.4%	192,778	4.74	4.76	0.96	2.70	8.33
Hybrid	2.2%	5.1%	10,674	2.68	2.5	0.49	1.92	5.00
Diesel	2.0%	1.5%	3,250	3.57	3.13	0.66	2.78	5.00
Plug-In Hybrid	0.7%	1.2%	2,480	1.45	1.59	0.23	1.04	3.23
Electric	0.6%	0.8%	1,683	0.93	0.89	0.11	0.81	1.32

3. Estimation and Results

In this paper we seek to understand how the price of gasoline affects the average fuel economy of a consumer's vehicle consideration set, the fuel economy of the purchased vehicle and then from that what we can learn about how consumers arrive at a rational value of fuel economy for a given gasoline price. To that end, we begin our analysis by regressing first the purchased vehicle fuel economy on the price of gasoline, and second the average fuel economy of the consideration set on the price of gasoline, including various control variables in both models. Our consideration set is a minimum of two vehicles (including the purchased vehicle) and a maximum of four. Following this we look to understand how these relationships change with the consumers purchase motives. We select two types of purchase reasons from our survey data: the importance of having an environmentally friendly vehicle and the importance of vehicle price. These two motives were selected to capture groups which should value fuel economy differently and show different sensitivity to gas prices. Finally, we perform a series of logit regressions to understand how the likelihood of purchasing and considering an alternative fuel vehicle changes with gas prices.

A. Purchased Vehicle and Consideration Set Average Fuel Economy Model Specification and Results

We start by constructing a reduced form regression model to estimate the effect of gasoline price on purchased vehicle fuel economy. In generic terms this model is expressed as:

(1) $$FE_{PV} = \alpha_0 + \alpha_1 GP + \alpha_2 X_C + \varepsilon$$

Here FE_{PV} is the fuel economy in gallons per 100 miles (GPM) of our purchased vehicle, as described in section 2. Our primary variable of interest is GP, gasoline price in gallons per US dollar, while the variable X_c represents a number of demographic and timing control variables that we will describe in further detail below. As previously described, gas price is the average monthly gas price for the state or region the vehicle was purchased in. For a complete breakdown of the states and regions used please consult the appendix section A5. Finally, let ε represent the error term and the α's the regression coefficients that estimate the effect of each covariate on the purchased vehicle fuel economy.

Expanding our X_c term, our model can be more precisely specified as:

(2) $$FE_{PV_{ist}} = \beta_0 + \beta_1 GP_{st} + \beta_2 Demog_i + \beta_3 VehCont_{it} + \delta_i + \tau_{it} + \mu_{it} + \varepsilon_{it}$$

The fuel economy and gasoline price variables remain as described above, defined for each observation *i,* occurring in state *s,* at time *t*. We use a range of demographic control variables ($Demog_i$) specific to each observation *i* using data provided by the purchaser in the Maritz survey. These include gender, income, education, race, marital status, age, household size, and the type of location they live (metro, suburb, small town, or farm land). In addition to demographic controls related to the individual, we also include various controls related to the vehicle purchase itself ($VehCont_{it}$). These include if it is the purchaser's primary or secondary vehicle, if the vehicle will be leased or purchased, the purchase price, the estimated number of miles they expect to drive per year, and finally the age of the vehicle, which attempts to control for if the purchased vehicle is a new or late model year vehicle by counting the purchase months from the start of the car's model year. For example, a car purchased in June 2011 that was a model year 2010 would receive a value of 18, 12 months from the previous year plus the 6 months into the current year at time of purchase. Finally, the terms $\delta_i, \tau_{it}, \mu_{it}$ represent timing and location fixed effects for each purchase, where δ represents the state of purchase, τ the year, and μ the month. The δ term will capture differences in policy settings (e.g. state gasoline taxes) and vehicle preferences at the state level. The τ term will capture changes in national policy settings and macroeconomic climate over time. And the μ term season will capture seasonal effects.

To estimate the average fuel economy of the consideration set, we maintain the same equation (2) but replace the dependent variable $FE_{PV_{ist}}$ with $FE_{CS_{ist}}$ representing the average fuel economy of the consideration set. The new equation is shown below:

(3) $$FE_{CS_{ist}} = \beta_0 + \beta_1 GP_{st} + \beta_2 Demog_i + \beta_3 VehCont_{it} + \delta_i + \tau_{it} + \mu_{it} + \varepsilon_{it}$$

Using equations (2) and (3) we now estimate the gasoline price coefficient β_1 in each model, which represents the effect of gasoline prices on the fuel economy of the purchased vehicle (2) and the average fuel economy of the consideration set (3). The coefficients and standard errors for the purchased vehicle and consideration set average fuel economy are shown in Table 3 and Table 4 respectively. In each of these tables we also present three variants alongside our baseline model shown in column (1). Column (2) shows the results when performing a weighted regression to adjust our demographics to better match the 2017 NHTS, as was compared in Table 1 and Table 2 of section 2. The weight vector used was calculated using the anesrake package in R, given a target vector corresponding to the NHTS mean values for sex, race, education and fuel type of the purchase vehicle. Further details on the weighting method used are discussed in appendix section A7. Column (3) and (4) are the same regressions as columns (1) and (2), with the addition that we interact the state and time fixed effects, accounting for state-level year and seasonal effects. It is possible that this model is over specified since our data set gets sparse for small states when looking at a year only basis. On average we have 450 samples per state year but for smaller states the yearly averages can be between 50 and 100. In addition, since policy changes are not frequent occurrences we would not suspect large changes in year-to-year state affects. However, we have included the results for reference. In our subsequent analysis we will refer to our simplest model, (1), unless otherwise stated, since the trends we see are often the same for all four models.

Table 3: Gasoline Price Coefficients for Purchased Vehicle Fuel Economy

	(1)	(2)	(3)	(4)
Gasoline Price	-0.105***	-0.082***	-0.081***	-0.058***
	(0.012)	(0.011)	(0.013)	(0.012)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.270	0.302	0.275	0.308
Adjusted R2	0.269	0.302	0.271	0.304

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE’s in parenthesis

Table 4: Gasoline Price Coefficients for Consideration Set Average Fuel Economy

	(1)	(2)	(3)	(4)
Gasoline Price	-0.092***	-0.069***	-0.071***	-0.050***
	(0.011)	(0.010)	(0.013)	(0.012)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.280	0.310	0.285	0.315
Adjusted R2	0.279	0.309	0.281	0.311

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

From Table 3 and Table 4, we see that for a $1 increase in gasoline prices, the average fuel economy of the consumer's consideration set increases by 0.092 GPM, while the fuel economy of the vehicle they purchase increases by 0.105 GPM. Compared to the values of our mean purchased and considered fuel economies of 4.55 GPM and 4.56 GPM respectively, these represent reductions in GPM of ~2%. For reference, a decrease of 0.105GPM at the dataset's mean MPG (24.1) is equal to a 0.63 MPG increase. Later in section 4, we show the same models when predicting on MPG result in a 0.416 to 1.52 MPG increase for a $1 increase in gasoline. Both the GPM and MPG models therefore seem to be roughly aligned with previous work by Klier and Linn (2010) that showed a 0.84 to 1.2 MPG increase for a $1 rise in gasoline price. Our coefficients are of a slightly smaller magnitude when we perform the weighted regression in model 2 or the unweighted interacted fixed effects regression in model 3. Adding both the weighting and interacted fixed effects in model 4 captures yet more variation and reduces the magnitude of gas price coefficients for both the purchased vehicle and consideration set. Across all four models, we see that both the consumer's consideration set and purchased vehicle fuel economy increases when gasoline prices increase. While both of them increase, the models show purchased fuel economy increases 14-19% more than the consideration set average fuel economy. To confirm this difference is statistically significant, we calculate confidence intervals by running model 1 regressions on 1000 bootstrapped datasets. From this we find with 95% confidence that purchased vehicle fuel economy increases 3% to 27% more than the consideration set fuel economy increases for a $1 increase in gasoline prices.

Purchased vehicle fuel economy increasing more than the consideration set implies the consumer is either purchasing higher in their consideration set's fuel economy range or they are adding disproportionally more fuel economy to the area of the consideration set range they typically purchase from. To evaluate this, we re-run the four regressions of the same form as equation (2), changing the dependent variable to be first the minimum GPM considered, then the maximum GPM considered, and finally the percentage of where the purchased vehicle falls within the consideration set range. We calculate the percentage of range such that 100% indicates the most fuel-efficient (lowest GPM) vehicle was purchased and 0% the least fuel-efficient (highest GPM). Observations are dropped when the consideration set only has vehicles of the same fuel economy, such that the range is zero. This results in in 10.2% reduction in our dataset, from 210,885 observations to 189,739. The results are shown in Table 5.

Table 5: Gasoline Price Impact on Consideration Set Minimum & Maximum GPMs and the Purchased Vehicle Percentage of Consideration Set Range

	(1)	(2)	(3)	(4)
CS Min. GPM	-0.098***	-0.073***	-0.084***	-0.060***
	(0.012)	(0.011)	(0.014)	(0.013)
CS Max. GPM	-0.076***	-0.051***	-0.051***	-0.030**
	(0.013)	(0.012)	(0.014)	(0.013)
FE_{PV} as % of CS Range	0.015**	0.020***	0.011*	0.014**
	(0.006)	(0.006)	(0.007)	(0.007)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

From these results it appears that in response to a $1 increase in gasoline prices, consumers are increasing the fuel economy considered at both the minimum and maximum values of their consideration set, with slightly more fuel economy being added to the lowest GPM end. They also appear to purchase between 1% to 2% lower in their consideration set GPM range. However, from our dataset we find that 47% of people purchase the least fuel economy vehicle in their set, 44% the most and only 9% select in the middle. As a result of so many observations on the extremes, a linear regression is likely not the best method to predict the movement of consumers within their consideration set range. However, we include in appendix section A9 a logistic regression model which supports these findings also. It indicates that a $1 increase in gasoline price reduces the odds of someone purchasing the vehicle with the least fuel economy in their set by 6% and increases the odds of purchasing the vehicle in their set with the most fuel economy by 6.5%.

In the introduction, we showed that existing literature supports the idea that vehicle buyers are fairly good at valuing future fuel costs in response to changes in gasoline prices with a slight bias towards undervaluing them. The results from this section illuminate how they achieve this and provide potential explanations for where undervaluing may happen. We show that the consumer is adjusting their purchased vehicle fuel economy in response to gasoline price changes by constructing a consideration set with higher fuel economy on both ends and then selecting slightly higher within that range to achieve a vehicle of higher fuel economy in response to changes in gasoline prices. Since a large percentage of the observed population purchases at the extremes of their consideration set, any undervaluing of fuel economy could occur in two ways. Buyers who purchase at the top of their range may not be increasing their fuel-efficient options enough indicating an undervaluing of fuel economy during their consideration set construction process. However, since the buyers who purchase at the bottom of their range do have more fuel-efficient options in their set, any undervaluing they may do is occurring during the purchasing phase.

B. Purchase Reasons Model Specification and Results

To see if this relationship holds true for different types of consumers, we repeat the analysis above taking two different purchase reason responses into account. Each consumer was asked to rate the importance of the following attributes on their purchase decision; price or deal offered and environmentally-friendly vehicle. The attributes were rated on a 1 to 5 scale where: 1 = Not at All

Important, 2 = Not Very Important, 3 = Somewhat Important, 4 = Very Important, and 5 = Extremely Important. For each of these purchase reasons, we run two regressions of form's similar to equations (2) and (3). However, we replace the GP variable with five dummy variables corresponding to each of the five responses. The variable corresponding to the response of that observation will be equal to the gas price, while the other four dummy variables will be zero. The new equations (4) and (5) are show below where PR represents the five dummy variables corresponding to purchase reason.

(4) $$PV\_FE_{ist} = \beta_0 + \beta_1 GP_{st} * PR + \beta_2 Demog_i + \beta_3 VehCont_{it} + \delta_i + \tau_{it} + \mu_{it} + \varepsilon_{it}$$

(5) $$CS_{AV_{FE}ist} = \beta_0 + \beta_1 GP_{st} * PR + \beta_2 Demog_i + \beta_3 VehCont_{it} + \delta_i + \tau_{it} + \mu_{it} + \varepsilon_{it}$$

The dataset, demographic controls, vehicle controls and fixed effects are all the same in (4) & (5) as in (2) and (3). However, instead of estimating one gasoline price coefficient per model, we estimate five. Each coefficient represents how gas price affects fuel economy for a consumer with that purchase response.

Results for equations 4 and 5 are shown in Table 6 through **Error! Reference source not found.**, with a summary of observations per response given in Table 10. As before, we have repeated the results using the baseline, weighted regression, interacted fixed effects and weighted regression with interacted fixed effects.

Table 6: Environmentally Friendly Gasoline Price Coefficients for Purchased Vehicle Fuel Economy

	Variable	(1)	(2)	(3)	(4)
Extremely Important	PR_ENVIR_5	-0.233***	-0.171***	-0.212***	-0.150***
		(0.012)	(0.011)	(0.013)	(0.012)
Very Important	PR_ENVIR_4	-0.122***	-0.097***	-0.101***	-0.076***
		(0.012)	(0.011)	(0.013)	(0.012)
Somewhat Important	PR_ENVIR_3	-0.054***	-0.047***	-0.033**	-0.026**
		(0.012)	(0.011)	(0.013)	(0.012)
Not Very Important	PR_ENVIR_2	-0.019	-0.019 *	0.002	0.002
		(0.012)	(0.010)	(0.013)	(0.012)
Not at All Important	PR_ENVIR_1	-0.013	-0.013	0.008	0.008
		(0.012)	(0.011)	(0.013)	(0.012)
Fixed Effects		State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted		No	Yes	No	Yes
R2		0.308	0.326	0.313	0.330
Adjusted R2		0.308	0.325	0.310	0.327

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 7: Environmentally Friendly Gasoline Price Coefficients for Consideration Set Average Fuel Economy

	Variable	(1)	(2)	(3)	(4)
Extremely Important	PR_ENVIR_5	-0.210*** (0.011)	-0.152*** (0.010)	-0.191*** (0.012)	-0.136*** (0.011)
Very Important	PR_ENVIR_4	-0.107*** (0.011)	-0.083*** (0.010)	-0.089*** (0.012)	-0.067*** (0.011)
Somewhat Important	PR_ENVIR_3	-0.044*** (0.011)	-0.037*** (0.010)	-0.027** (0.012)	-0.021* (0.011)
Not Very Important	PR_ENVIR_2	-0.015 (0.011)	-0.014 (0.010)	0.002 (0.013)	0.002 (0.012)
Not at All Important	PR_ENVIR_1	-0.002 (0.011)	-0.001 (0.010)	0.015 (0.013)	0.015 (0.012)
Fixed Effects		State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted		No	Yes	No	Yes
R2		0.316	0.331	0.320	0.336
Adjusted R2		0.315	0.331	0.317	0.333

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 8: Price or Deal Offered - Gasoline Price Coefficients for Purchased Vehicle Fuel Economy

	Variable	(1)	(2)	(3)	(4)
Extremely Important	PR_PRICE_5	-0.094*** (0.012)	-0.073*** (0.011)	-0.071*** (0.013)	-0.050*** (0.012)
Very Important	PR_PRICE_4	-0.107*** (0.012)	-0.083*** (0.011)	-0.083*** (0.013)	-0.060*** (0.012)
Somewhat Important	PR_PRICE_3	-0.137*** (0.012)	-0.107*** (0.011)	-0.113*** (0.014)	-0.083*** (0.012)
Not Very Important	PR_PRICE_2	-0.195*** (0.014)	-0.155*** (0.012)	-0.171*** (0.015)	-0.131*** (0.014)
Not at All Important	PR_PRICE_1	-0.178*** (0.016)	-0.134*** (0.014)	-0.154*** (0.017)	-0.110*** (0.015)
Fixed Effects		State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted		No	Yes	No	Yes
R2		0.272	0.304	0.277	0.309
Adjusted R2		0.271	0.303	0.273	0.305

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 9: Price or Deal Offered - Gasoline Price Coefficients for Consideration Set Average Fuel Economy

	Variable	(1)	(2)	(3)	(4)
Extremely Important	PR_PRICE_5	-0.081*** (0.011)	-0.060*** (0.010)	-0.060*** (0.013)	-0.042*** (0.012)
Very Important	PR_PRICE_4	-0.094*** (0.011)	-0.071*** (0.010)	-0.073*** (0.013)	-0.053*** (0.012)
Somewhat Important	PR_PRICE_3	-0.122*** (0.012)	-0.094*** (0.011)	-0.101*** (0.013)	-0.075*** (0.012)
Not Very Important	PR_PRICE_2	-0.177*** (0.013)	-0.139*** (0.012)	-0.156*** (0.014)	-0.120*** (0.013)

Not at All Important	PR_PRICE_1	-0.157*** (0.015)	-0.114*** (0.014)	-0.137*** (0.016)	-0.095*** (0.015)
Fixed Effects		State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted		No	Yes	No	Yes
R2		0.282	0.311	0.287	0.316
Adjusted R2		0.281	0.311	0.283	0.313

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 10: Summary of Purchase Response Observations

Response	PR_ENVIR	PR_PRICE
Extremely Important	41,230 19.6%	109,599 52.0%
Very Important	57,914 27.5%	75,190 35.7%
Somewhat Important	66,407 31.5%	22,658 10.7%
Not Very Important	27,300 12.9%	2,500 1.2%
Not at All Important	18,034 8.6%	938 0.4%
Total	210,885	210,885

For both purchase reasons, across all models, we see, with only a few exceptions, that our gasoline price purchase reason coefficient, β_1, decreases more for the purchased vehicle than for the consideration set. This is consistent with our findings from our base models given in Table 3 & Table 4. We also perform linear and logistic regressions as we did in the previous section to see how the different purchase groups are adjusting their consideration set to have their purchased fuel economy increase more than their consideration set. We have included these tables in appendix sections A9 and A10. In general, they highlight the same behavior for each purchase reason as for the whole population, that consumers increase the fuel economy of their minimum and maximum GPM vehicle considered, while also selecting slightly more fuel economy relative to the consideration set range. Looking closer at differences across purchase reasons, we see that all responses show significance except PR1 & PR2 for environmentally friendly. Intuitively, it would not be surprising if those who place little to no value on how environmentally friendly their vehicle is also place little value on fuel economy. If this is true, we might expect gasoline price to have an insignificant effect on their fuel economy as our regressions show. This is also seen in our consideration set regressions, where these two PR groups show the least change in odds of purchasing from the top of their fuel economy range, 1% to 4%, and small movement of the consideration set minimum and maximum fuel economies. On the other hand, those who report that the car being environmentally friendly was extremely important to their purchase decision, have a β_1 coefficients, in both the purchased and considered regressions, that are twice as large as those who found it very important and more than four times as large as those who responded that it was somewhat important. These results could be somewhat counterintuitive. One might expect that wanting an environmentally friendly vehicle, corresponds to a personal value that would be independent of gasoline costs. To explore this further, we've included a model in the appendix section A6 where dummy variables for each of the five purchase reason responses have been included in addition to the interaction between purchase reason and gas price. We find that on their own the purchase reasons are statistically insignificant and of small magnitude. All of this indicates, that people for whom buying environmentally friendly is important, will buy more fuel economy than those who it isn't for all levels of gas price. However, as gas prices increase, the difference in fuel economy purchased by people who value the environment will increase greatly relative to those that don't. This indicates a strong link between how important one sees the environment and the degree to which they value future fuel costs in the vehicle purchasing process. This is also shown in the logistic regressions in appendix section A10, where the most environmentally friendly group sees the odds of them purchasing the most fuel-efficient vehicle in their set increase by 11% and the odds of purchasing the least decrease by 9%. Meanwhile, the three groups who consider the environment the least, do not show significance in the change of likelihood of purchasing at the top or bottom of their consideration set in response to gasoline prices. To summarize this, we find that at higher gas prices people who value the environment highly will significantly increase the fuel economy they consider and show greater likelihood to buy the most fuel-efficient car in their set, with an end result that they increase their fuel economy purchased more than any other segment we studied. On the other hand, rising gas prices have a very small, and potentially insignificant, effect on the fuel economy considered and purchased for people who do not value the environmental friendliness of their vehicle in their purchase process.

Finally, looking at the price of the car as the purchase reason, we see that while all response types purchase more fuel economy at higher gas prices, those who said price was not very important or not at all important decrease their purchased vehicle GPM by 0.195 GPM and 0.178 GPM per $1 increase in gasoline price, respectively, than those that for who price is extremely important. This too is counterintuitive, as we'd expect consumers who are more sensitive to car price to also be more sensitive to gas price. However, this could reflect that as gas prices increase everyone purchases more fuel economy but those with higher means, who wouldn't consider car price as a purchase reason, are able to buy more fuel economy than those who find car price to be very important. Similar to our other models, we also see that consumer's purchased vehicle fuel economy increases more than their consideration set fuel economy, while both rise. However, while the environmental group has a wide range between how much their purchased vehicle fuel economy changes relative to the consideration set change, -11% to -550%, the change is consistent within the price groupings -10% to -16%. This would indicate that the groupings who value pricing differently may actually value fuel economy similarly. However, price leads them to build different consideration sets, where those who are indifferent to price are capable of building consideration sets with more fuel economy than those that are price constrained. Once it is time to select however, all groups select similarly higher within the choices they have. Across all price segments, we see the same behavior as the general population also, where the minimum GPM vehicle considered decreases more than the maximum, with both decreasing, and the odds of purchasing the most fuel-efficient vehicle in the set increase.

C. Alternative Fuel Vehicle Purchase and Consideration Likelihood Model Specification and Results

Having looked at how consumers consideration set and purchased vehicle fuel economy varies with gasoline prices, both generally and also across different purchase reasons, lastly, we attempt to quantify the effect of gasoline prices on the likelihood that a consumer considers and then purchases an alternative fuel vehicle (AFV). To do this we start with our basic equation (2) but change our dependent variable to a new binary dummy variable, PV_ALT, which is a one if the purchased vehicle is an alternative fuel vehicle and a zero if it is conventional. In addition, since we are now interested in likelihood, we write our equation as a logistic regression function. This new model is shown in equation (6), where all variables besides PV_ALT, and their descriptions, remain unchanged from equation (2).

$$PV\_ALT_{ist} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 GP_{st} + \beta_2 Demog_i + \beta_3 VehCont_{it} + \delta_i + \tau_{it} + \mu_{it} + \varepsilon_{it})}} \tag{6}$$

We define conventional fuel vehicles to be gasoline or diesel and alternative fuel vehicles as hybrid, plug-in hybrid or electric. To model how the likelihood that an AFV is added to the consideration set changes with gasoline prices, we repeat equation (6) but change our dummy dependent variable, PV_ALT, to CS_ALT which is a one if the consideration set, which includes the purchase vehicle, contains an AFV and a zero otherwise. This is shown in equation (7)

$$CS\_ALT_{ist} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 GP_{st} + \beta_2 Demog_i + \beta_3 VehCont_{it} + \delta_i + \tau_{it} + \mu_{it} + \varepsilon_{it})}} \tag{7}$$

Results for equations 6 and 7 are shown in Table 11 and Table 12 below. As in section A & B, we have repeated the results using the baseline and a weighted regression. However, we have not included the interacted fixed effects models due to instances where too few alternate fuel vehicles were purchased in a given state year or state month.

Table 11: Purchase Vehicle Alternative Fuel Type vs Gasoline Price Logistic Regression Coefficients & % Odds Change

	(1)	(2)
Gasoline Price	0.403***	0.434***
	(0.046)	(0.0562)
% Odds Change	49.7 %	54.4%
Fixed Effects	State, Month, Year	State, Month, Year
Weighted	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 12: Consideration Set Alternative Fuel Type vs. Gasoline Price Logistic Regression Coefficients & % Odds Change

	(1)	(2)

Gasoline Price	0.341***	0.297***
	(0.038)	(0.044)
% Odds Change	40.6%	34.5%
Fixed Effects	State, Month, Year	State, Month, Year
Weighted	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

The results from Table 11 and Table 12 indicate that for a $1 increase in gasoline price the odds of having an alternative fuel vehicle in the consumer's consideration set increases by 40.6%, while the odds that they purchase one increases by 49.7%. Convention fuel vehicles in our dataset have an average fuel economy of 4.73 GPM, while alternate fuel vehicles average 2.27 GPM. Therefore, this follows the similar pattern we've seen in sections A and B, where the effect of gasoline prices is positive on both the consideration set and the purchased vehicle fuel economy but stronger on the purchased vehicle. In this case, people consider more AFVs at higher gasoline prices and the conversion rate, that is how many people purchased an AFV divided by how many considered one, also increases. This can be seen by looking at our sample data. Of our observations, 11% of people included an AFV in their consideration set and 7% of the overall population actually purchased one, for a conversion rate of 64.2%. For a $1 increase in gas price, the percent change in odds for our dataset would mean 14.8% of people now consider an AFV, with 10.2% actually purchasing one, for a conversation rate of 68.9%. This indicates that higher gas prices not only cause consumers to consider more AFVs but a higher percentage end up purchasing one after considering too.

To dig deeper into this, we've repeated the regressions given from equations 6 & 7, but this time our dependent variable represents the specific fuel type of the vehicle. We re-run the regressions five times, one for each fuel type in our dataset, and report the results, in Table 13 & Table 14. To see how this impacts our dataset, we include Table 15 with the actual purchase and considerations by fuel type and show how those numbers would change for a 1$ increase in gas prices based on the probabilities given in our regressions.

Table 13: Purchased Vehicle Fuel Type vs Gasoline Price Logistic Regression Coefficients & % Odds Change

	Fixed Effects	Weighted	Gasoline	Diesel	Hybrid	Plug-in Hybrid	Electric
(1)	State,	No	-0.396***	0.225**	0.286***	0.448***	0.354**
	Month,		(0.042)	(0.101)	(0.054)	(0.105)	(0.128)
	Year		-32.7%	25.3 %	33.1%	56.5%	42.5%
(2)	State,	Yes	-0.445***	0.348***	0.248***	0.414***	0.457***
	Month,		(0.052)	(0.090)	(0.080)	(0.135)	(0.146)
	Year		-35.9%	41.6%	28.1 %	51.3%	57.9%

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 14: Consideration Set Vehicle Fuel Type vs Gasoline Price Logistic Regression Coefficients & % Odds Change

	Fixed Effects	Weighted	Gasoline	Diesel	Hybrid	Plug-in Hybrid	Electric
(1)	State,	No	-0.440 ***	0.206***	0.268***	0.444***	0.363***
	Month,		(0.060)	(0.071)	(0.042)	(0.083)	(0.093)
	Year		-35.6%	22.9%	30.7%	55.9%	43.7%
(2)	State,	Yes	-0.468***	0.293***	0.181***	0.451***	0.460***
	Month,		(0.076)	(0.070)	(0.049)	(0.102)	(0.107)
	Year		-37.4%	34.06%	19.8%	57.0 %	58.3%

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 15: Conversion and Probabilities of Purchase and Consideration by Fuel Type

	Gasoline	Diesel	Hybrid	Plug-in Hybrid	Electric
Purchased	192,778	3,250	10,674	2,480	1,683
Considered	202,633	6,373	19,292	4,048	3,178
% Purchased	91.4%	1.5%	5.1%	1.2%	0.8%
% Considered	96.1%	3.0%	9.1%	1.9%	1.5%
New Purchased	185,061	4,055	13,972	3,855	2,390
New Considered	198,340	7,777	24,527	6,423	4,537
% New Purchase	87.8%	1.9%	6.6%	1.8%	1.1%
% New Considered	94.1%	3.7%	11.6 %	3.0%	2.2%
Conversion Rate	95.1%	51.0%	55.3%	61.3%	53.0%
New Conversion	93.3%	52.1%	57.0%	61.7%	52.7%

Conversion rate is the percent that purchase after considering. New purchase, new considered and new conversion rates are from applying the change in probability for a $1 increase in gas prices, found in Tables 14 & 15, to our dataset.

From Table 13 & Table 14, we see that at higher gasoline prices the odds of considering and purchasing a gasoline vehicle decrease, while the odds for all other fuel types increase. The largest change in likelihood of purchase occurs with plug-in hybrid vehicles at a 56.5% increase in odds. Diesel, hybrid and electric vehicles show similar changes of 25.3 %, 33.1% and 42.5% respectively. A caveat to this is that hybrid vehicles are the most considered, as well as purchased, fuel type in our dataset after gasoline. So, while this shows that plug-in hybrid vehicles would have the largest change in odds of consider and purchase percentages, the overall increase in number of hybrids considered and purchased is actually higher than that of diesel, plug-in hybrid and electric combined. It is also interesting to note that while diesel, hybrid and plug-in hybrid all have their odds of purchase increase more than their odds of consideration, electric vehicles have a higher change in odds to consider, 43.7%, than of actual purchase, 42.5% increase in odds.

In Table 15 we see how applying these changes in odds affects conversion rates of different vehicle fuel types. Overall, we see a decrease in the conversion rate for gasoline cars of 95.1% to 93.5%, indicating that fewer people who consider a gasoline car end up buying one at higher gas prices. We see that hybrid vehicles are the biggest beneficiary of increasing gasoline prices. Their changes in purchased and considered, 5.1% to 6.6% and 9.1% to 11.6% respectively, as well as the jump in conversion rate, from 55.3% to 57.0%, are all the largest in the group. While smaller in number purchased and considered, plug-in hybrids have the largest conversion rate of all vehicles besides gasoline. Relative to other AFV types, plug-ins seem to hold up best to further scrutiny once added to a set. On the flip side, we see the conversion rate fall slightly for electric vehicles. This indicates that while more people purchase and consider electric vehicles as gasoline prices rise, the increase in likelihood of purchase is driven mostly by additional consideration. It would appear then that dramatically increasing electric vehicle sales is not simply a matter of getting more consideration. Since their new overall conversion rate is lower than all other non-conventional fuel types, it suggests that electric vehicles have a number of factors, potentially cost or range anxiety, that cause consumers to ultimately go elsewhere after they have l closer at them.

Overall, the results in this section support the finding that consumers purchase vehicle fuel economy increases greater than the average fuel economy they consider but increase both in response to gasoline price increases. In addition, we show that consumers switching from conventional to alternative fuel vehicles is a likely driver in the increase in fuel economy, both for the considered and purchased vehicles. Hybrids play the biggest role in this transition with the largest increase in purchased and considered vehicles as a result of gasoline price. However, it appears that when consumers add an AFV to their consideration set, and can evaluate it further, plug-in hybrids are the most favorable and electric the least.

4. Robustness

The main finding from our results is that the average fuel economy of a consumer's vehicle consideration set increases with gasoline prices but that the fuel economy of their purchased vehicle increases more. We've also shown that this is accomplished by increasing the fuel economy of the most fuel-efficient vehicle they consider slightly more than the least and also purchasing slightly higher in their fuel economy consideration set range. In this section, we probe how robust these findings are by first examining how the model behaves under different transformations of our dependent variable. We will also explore the confidence intervals, briefly discussed at the start of section three in more detail. We then look to see if consumer behavior is different in different environments or by segments. We explore low and high gasoline price environments by looking at the impact of gasoline price on fuel economy when the price is above our dataset mean and when it is below it. Lastly, we see if these results are consistent when we segment by car and truck purchases and by low and high fuel economy purchases.

For the models described in Section 3 we chose to use fuel economy in GPM, as opposed to the more familiar MPG, for our dependent variable. In addition, to the benefits of linearity already discussed, we looked at models with log-log, log-linear and no transformations from MPG but found GPM best fit our data. However, since MPG is commonly used in the US and familiar to many, we include it here by taking our basic four models previously described, but now predicting on purchased vehicle fuel economy in MPG instead of GPM. We show the results in Table 16 and Table 17 where we have repeated what we did in Table 3 and Table 4.

Table 16: Gasoline Price Coefficients for Purchased Vehicle Fuel Economy (MPG)

	(1)	(2)	(3)	(4)
Gasoline Price	1.520*** (0.127)	1.203*** (0.108)	0.580*** (0.141)	0.416*** (0.121)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.124	0.130	0.134	0.139
Adjusted R2	0.124	0.129	0.130	0.135

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 17: Gasoline Price Coefficients for Consideration Set Average Fuel Economy (MPG)

	(1)	(2)	(3)	(4)
Gasoline Price	1.368 ***	1.048***	0.539***	0.356***
	(0.115)	(0.099)	(0.128)	(0.110)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.139	0.146	0.149	0.156
Adjusted R2	0.139	0.146	0.145	0.152

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

The results shown in Table 16 and Table 17 support the relationship demonstrated previously; for higher gasoline prices consumers increase their purchased fuel economy more than they increase their consideration set average fuel economy. The difference between consideration set and purchased is slightly smaller, 8%-17% than the 14%-19% difference in our GPM models. In addition, the R2 values range from 0.124 to 0.156 compared to 0.27 to 0.315 in our GPM model, showing the difference in fit. The smaller gap in difference for MPG, given its non-linear relationship with fuel savings, could indicate slightly different behavior when extreme fuel economies are considered. Overall, though the relationship appears to still hold, we will explore this further when we segment the data by car and truck, and low and high fuel economies.

In Table 18, we show confidence intervals to confirm that the difference we see between the purchased vehicle and consideration set gasoline price coefficients are statistically significant. To calculate these, we bootstrap with replacement 1000 replicate datasets from our observations. For each bootstrapped dataset we run our basic regressions from equations (2) and (3), where fuel economy of the purchased and consideration sets in GPM are the dependent variables, and we record the gasoline coefficient from each regression. For each of the 1000 bootstrap pairs, we then take the difference between the purchased vehicle gasoline coefficient and the consideration set gasoline coefficient. If this difference is negative it signifies that, for that observation, purchased vehicle fuel economy increased more than the consideration set fuel economy for a given increase in gasoline price. With 1000 observations of this difference we then calculate the 95% confidence intervals. The raw difference values and a histogram are shown in the appendix section A3. Table 18 shows three difference methods, Normal, Basic and Percentile, as calculated using the R package "boot". The normal method assumes our differences follow a normal distribution, which we confirm visually and by using a Shapiro-Wilk normality test that gives a p-value of 0.498, where a p-value less than 0.05 is required to reject the hypothesis that our data is normal. In addition, a skewness value of 0.06 with excess kurtosis of 0.22 support a mostly normal distribution. Assuming normality, we calculate the intervals as shown in equation 6 using the standard 95% confidence interval formula for a normal distribution, where r is the mean of bootstrap original sample estimates for the difference between the purchase and consider gasoline price coefficients, equal to -0.01358. The bias of -0.00023, is the delta between this original sample and the mean of all our bootstrap difference estimates -0.01381. We find the standard error, SE_r, to be the standard deviation of our bootstrap coefficient differences distribution, 0.0055.

$$95\%\ CI = r - bias \ \pm 1.96\ x\ SE_r \quad (6)$$

In the basic method, we find the intervals by subtracting the 2.5% and 97.5% quartile values of our bootstraps from twice our original sample difference, while in the percentile method we use the 97.5% and 2.5% quartile values without any correction.

Table 18: Confidence Intervals for Purchased Vehicle and Consideration Set Gasoline Coefficient Differences

Normal	Basic	Percentile
(-0.0241, -0.0026)	(-0.0243, - 0.0031)	(-0.0240, -0.0029)

We see relatively similar values for all three methods of calculation. Given that we will speak in reference to the normal calculation method for simplicity. The intervals give us 95% confidence that for a $1 increase in gasoline prices the consumer will increase the fuel economy they purchase more than they will increase the average fuel economy of their consideration set. Using the original consideration set gasoline price coefficient value of -0.092 as a reference and the normal confidence intervals in Table 18, we approximate that the purchased vehicle fuel economy increases by 3% to 26% more than the consideration set fuel economy does for a $1 change in gasoline prices.

In Table 19 and Table 20**Error! Reference source not found.** we repeat the approach above and show confidence intervals for the difference between purchased vehicle and consideration set gasoline coefficients for environmental and purchase price purchase reason groups. In these tables we only include the normal method, as the basic and percentile deliver similar confidence interval values. We also add the percentage change from the original consideration set gasoline price coefficient that these confidence intervals imply. In addition, we do not calculate the confidence intervals for coefficients that did not show significance in our original regression, which are the PR1 & PR2 environmentally friendly groups, as they would not be meaningful. There are a couple of findings from this to highlight. First, in general most groups are confirmed to follow a similar pattern of the purchased vehicle fuel economy increasing by 0-30% compared to the consideration set average fuel economy. We see the tightest spread in the PR5 environmental group, those who identify with having an environmentally friendly vehicle as being extremely important in their purchase reasons. Amongst this group, we have the second highest low-end confidence, 6%, and lowest high-end confidence, 16%, of any group. This would indicate that people who find having an environmentally friendly vehicle extremely important are most consistent in increasing their purchased fuel economy more than their consideration set average as a function of gasoline price. Within the price group, we see all sub groups show positive lower and upper confidence intervals, with similar range between the low and high intervals. This seems consistent with our previous findings that when grouping by the price purchase reason everyone increases their purchased vehicle fuel economy similarly relative to their consideration set. Overall, these results support the general finding that in most cases consumers purchased fuel economy increases more than their consideration set average fuel economy as gasoline prices increase.

Table 19: Confidence Intervals for Purchased Vehicle and Consideration Set Gasoline Coefficient Differences by Environmental Purchase Reason Group

	Normality Test p-value	Normal CI	CI as % of CS Coefficient

PR5 ENVIR	0.781	(-0.035, -0.012)	(5.7%, 16.7%)
PR4 ENVIR	0.976	(-0.026, -0.004)	(3.7%, 24.3%)
PR3 ENVIR	0.869	(-0.021, 0.002)	(-4.5%, 47.7%)

Table 20: Confidence Intervals for Purchased Vehicle and Consideration Set Gasoline Coefficient Differences by Price Purchase Reason Group

	Normality Test p-value	Normal CI	CI as % of CS Coefficient
PR5 PRICE	0.080	(-0.024, -0.002)	(2.6%, 30.0%)
PR4 PRICE	0.136	(-0.024, -0.001)	(1.5%, 25.2%)
PR3 PRICE	0.182	(-0.026, -0.003)	(2.6%, 21.3%)
PR2 PRICE	0.248	(-0.032, -0.006)	(3.1%, 17.9%)
PR1 PRICE	0.628	(-0.034, -0.005)	(2.9%, 21.8%)

With various current factors such as a trend toward AFVs, increasing environmental policies and an oversupply of crude oil suggesting future sustained downward pressure on gasoline prices we thought it prudent to see if the behaviors we've observed are the same in both high and low gas price environments. To do this we take the average of the annual EIA gasoline price over this time period, $2.98, and create two dummy variables to add to our original equations (2) and (3) in place of our regular gasoline price variable, where one dummy is the gasoline price for that state and time if the price is greater than or equal to $2.98 and zero if it is less, while the other dummy is the gasoline price for that state and time when it is below $2.98 and zero when it is above it. This allows us to see the effect of gasoline price on fuel economy in low and high price environments. We took the national average instead of the average at the state level because we care about how consumers respond at different absolute pricing levels. Even though $3.25 per gallon may be cheap to a California resident, because they are accustomed to it, this still represents a higher future fuel costs which they have to account for in their purchase analysis. The results for the purchased vehicle and the consideration set are given in Table 21 and Table 22 using the same four models as previously discussed. Our data is fairly equally split with 103,964 observations occurring in high price environments and 102,428 in low price environments.

Table 21: Purchased Vehicle Fuel Economy Gasoline Co-efficient in High and Low-Price Environments

	(1)	(2)	(3)	(4)
High-Price Env.	-0.116 ***	-0.090 ***	-0.072 ***	-0.048 ***

	(0.012)	(0.011)	(0.014)	(0.013)
Low-Price Env.	-0.132 ***	-0.102 ***	-0.059 ***	-0.034 **
	(0.014)	(0.012)	(0.016)	(0.014)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.270	0.302	0.275	0.308
Adjusted R2	0.269	0.302	0.271	0.304

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 22: Consideration Set Gasoline Co-efficient in High and Low-Price Environments

	(1)	(2)	(3)	(4)
High-Price Env.	-0.102 ***	-0.077 ***	-0.064 ***	-0.043 ***
	(0.012)	(0.011)	(0.013)	(0.012)
Low-Price Env.	-0.117 ***	-0.090 ***	-0.054 ***	-0.033 ***
	(0.013)	(0.012)	(0.015)	(0.014)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.280	0.310	0.285	0.315
Adjusted R2	0.279	0.309	0.281	0.311

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Regardless of whether we are in a high or low gasoline price environment, the results in Table 21 and Table 22 show the same behavior we have seen through the paper. The purchased vehicle coefficient, across all models and gas price environments, is between 3% to 17% greater in magnitude than the consideration set coefficient. We show the changes in consideration minimum and maximum GPMs, as well as the change in purchase vehicle fuel economy as a percentage of the consideration set range in Table 23 and Table 24. From this we see the consideration set minimum GPM decrease more than the maximum GPM in both low and high price environments, with the buyer purchasing slightly higher within their consideration set range fuel economy. This is consistent with our previous results and indicates the consumer's decision process is influenced by gasoline prices similarly regardless of it being a high or low-price environment.

Table 23: Gasoline Price Coefficients for Consideration Set Minimum, Maximum and Purchased Vehicle Fuel Economy as Percentage of CS Range - High Gasoline Price Environments

	(1)	(2)	(3)	(4)
CS Min. GPM	-0.109***	-0.081***	-0.076***	-0.052***
	(0.013)	(0.011)	(0.014)	(0.013)
CS Max. GPM	-0.085***	-0.058***	-0.045***	-0.023*
	(0.013)	(0.012)	(0.015)	(0.014)
FE_{PV} as % of CS	0.018***	0.023***	0.012	0.015**
Range	(0.006)	(0.006)	(0.007)	(0.007)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 24: Gasoline Price Coefficients for Consideration Set Minimum, Maximum and Purchased Vehicle Fuel Economy as Percentage of CS Range - Low Gasoline Price Environments

	(1)	(2)	(3)	(4)
CS Min. GPM	-0.123***	-0.094***	-0.064***	-0.041***
	(0.013)	(0.013)	(0.016)	(0.015)
CS Max. GPM	-0.099***	-0.068***	-0.035**	-0.013
	(0.014)	(0.013)	(0.017)	(0.015)
FE_{PV} as % of CS	0.021***	0.026***	0.012	0.016*
Range	(0.007)	(0.007)	(0.008)	(0.008)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

We perform a similar analysis in Table 25 and Table 26 to evaluate if the likelihood of considering and purchasing a vehicle by fuel type as a result of a $1 gasoline price change is different in low or high price fuel environments. The original equations, (6) and (7), are modified by replacing the gas price variable with two dummies for low and high price environments as described previously. Again, we confirm that regardless of the gas price environment, a change in gasoline price results in more consideration and purchase of alternative fuel vehicles and a decrease in consideration and purchase of gasoline vehicles. We also observe that the likelihood of purchasing an AFV increases more than the likelihood of purchase in both low and high price environments, as seen previously. It is interesting to note that a gasoline price change in a low-price environment, changes the likelihood of purchasing an electric vehicle much more than it does in a high price environment. This might reflect that electric vehicles, having the lowest GPM of the group, are more sensitive to gasoline prices than the other AFVs. As a result, in a low-price environment a $1 gas price change has a relatively larger effect on changing the odds that a consumer will consider and purchase an electric vehicle.

Table 25: Purchased Vehicle Gasoline Price Coefficients by Fuel Type for High and Low Gasoline Price Environments and Percent Change in Odds

	Fixed Effects	Weighted	Gasoline	Alt. Fuel	Diesel	Hybrid	Plug-in Hybrid	Electric
High-Price Env.	State, Month, Year	No	-0.442***	0.441***	0.244**	0.272***	0.436***	0.444***
			(0.044)	(0.048)	(0.107)	(0.056)	(0.115)	(0.146)
			-35.7%	55.4%	27.6%	31.3%	54.6%	55.9%
Low-Price Env.	State, Month, Year	No	-0.489***	0.480***	0.260**	0.256***	0.426***	0.498***
			(0.050)	(0.054)	(0.121)	(0.063)	(0.134)	(0.171)
			-38.7%	61.5%	29.7%	29.2%	53.1%	64.6%

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table 26: Consideration Set Gasoline Price Coefficients by Fuel Type for High and Low Gasoline Price Environments and Percent Change in Odds

	Fixed Effects	Weighted	Gasoline	Alt. Fuel	Diesel	Hybrid	Plug-in Hybrid	Electric
High-Price Env.	State, Month, Year	No	-0.497***	0.357***	0.207***	0.261***	0.471***	0.405***
			(0.063)	(0.040)	(0.075)	(0.043)	(0.091)	(0.104)
			-39.2%	42.9%	23.0%	29.8%	60.1%	50.0%
Low-Price Env.	State, Month, Year	No	-0.549***	0.376***	0.209**	0.252***	0.492***	0.434***
			(0.071)	(0.044)	(0.083)	(0.048)	(0.105)	(0.121)
			-42.2%	45.7%%	23.2%	28.7%	63.6%	54.3%

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Next, we split our data into two subsets. One includes only the observations where a car was purchased and the other only observations of truck purchases. In the Maritz data a classification has already been provided as truck or car based on the purchased vehicle and we use this to split our data. Our data turns out to be evenly represented with 105,194 truck observations and 105,691 car observations. The results are shown in Table 27 through Table 28.

Table 27: Gasoline Price Coefficients for Purchased Vehicle Fuel Economy - Car Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.129*** (0.015)	-0.110*** (0.013)	-0.061*** (0.016)	-0.048*** (0.015)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes

R2	0.244	0.260	0.255	0.272
Adjusted R2	0.244	0.260	0.247	0.264

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

Table 28: Gasoline Price Coefficients for Consideration Set Fuel Economy - Car Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.124***	-0.099***	-0.055***	-0.039***
	(0.014)	(0.013)	(0.016)	(0.014)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.254	0.264	0.263	0.275
Adjusted R2	0.253	0.264	0.256	0.267

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

Table 29: Gasoline Price Coefficients for Purchased Vehicle Fuel Economy - Truck Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.058***	-0.043***	-0.090***	-0.059***
	(0.015)	(0.014)	(0.016)	(0.014)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.282	0.319	0.291	0.328
Adjusted R2	0.281	0.319	0.284	0.321

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

Table 30: Gasoline Price Coefficients for Consideration Set Fuel Economy - Truck Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.043***	-0.034***	-0.074***	-0.051***
	(0.014)	(0.013)	(0.015)	(0.014)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.294	0.330	0.303	0.338
Adjusted R2	0.293	0.329	0.296	0.332

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

We see that across all models, for both car and truck data, the consumer's purchased vehicle fuel economy improves more than their consideration set for a $1 change in gasoline price, with both increasing. The gap between purchased vehicle and consideration set coefficients is greater for trucks, 16% to 35%, compared to cars at 4% to 23%. In addition, we see that the magnitudes are in most cases larger for cars than trucks, in both the purchased and considered regression. Since trucks and cars are generally low and high fuel economy vehicles respectively, this could be pointing out something different that is occurring in the decision-making process for high and low fuel economy buyers.

To test this, we run one final robustness check. Since we think that whatever difference in behavior we are subtly picking up is occurring at the tails of our data, we split our data by the 60% and 40% quartiles of our purchased GPM. This split occurs at 4.166 GPM, or 24 MPG, very close to the mean MPG of our dataset 24.1. The result is a low fuel economy group with 139,864 observations and a high fuel economy group with 71,021. The findings for the purchased vehicle and consideration set fuel economy changes in response to gasoline prices are presented in Table 31 through Table 34.

Table 31: Gasoline Price Coefficients for Purchased Vehicle Fuel Economy – High Fuel Economy Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.095 ***	-0.062 ***	-0.067 ***	-0.038 ***
	(0.014)	(0.012)	(0.016)	(0.014)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.120	0.091	0.134	0.106
Adjusted R2	0.119	0.090	0.121	0.093

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

Table 32: Gasoline Price Coefficients for Consideration Set Fuel Economy – High Fuel Economy Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.102 ***	-0.062***	-0.075 ***	-0.040 ***
	(0.015)	(0.014)	(0.016)	(0.016)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.110	0.094	0.123	0.109
Adjusted R2	0.108	0.093	0.110	0.096

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

Table 33: Gasoline Price Coefficients for Purchased Vehicle Fuel Economy – Low Fuel Economy Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.026 **	-0.020 *	-0.038 ***	0.013
	(0.011)	(0.011)	(0.012)	(0.008)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.189	0.209	0.196	0.017

Adjusted R2	0.189	0.208	0.190	0.010

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

Table 34: Gasoline Price Coefficients for Consideration Set Fuel Economy –Low Fuel Economy Purchases Only

	(1)	(2)	(3)	(4)
Gasoline Price	-0.014	-0.012	-0.027 **	-0.025**
	(0.011)	(0.011)	(0.012)	(0.012)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes
R2	0.204	0.227	0.211	0.235
Adjusted R2	0.204	0.227	0.205	0.229

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

When we split the data this way we see all groups and all models still purchase and consider more fuel economy at higher gasoline prices. However, the high fuel economy group actually has the opposite behavior of our results to this point. This group increases the fuel economy of their consideration set more than they increase the fuel economy of their purchased vehicle. Meanwhile, models (1) and (2) for the low fuel economy group, do not show gasoline price to be significant in determining the fuel economy of their consideration set. However, when we add the interacted fixed effects, models (3) and (4) do show gasoline price as significant in determining the low fuel economy group's consideration set fuel economy. Comparing across groups in model (3), we see the high fuel economy group increasing the fuel economy of their consideration set by more than twice as much as the low fuel economy group does for a $1 change in gasoline price. To show the difference between the two groups we have taken our model (3) regression, the only model where purchased and considered showed significance for both groups, and simulated the results over the course of our data time period. We simulate from two large states with low and high state average fuel economies, California and Texas. The respective graphs are shown in Figure 1 and Figure 2. We choose demographics equal to the average values in Table 1 and select the actual gas price for the state at that time to create these figures.

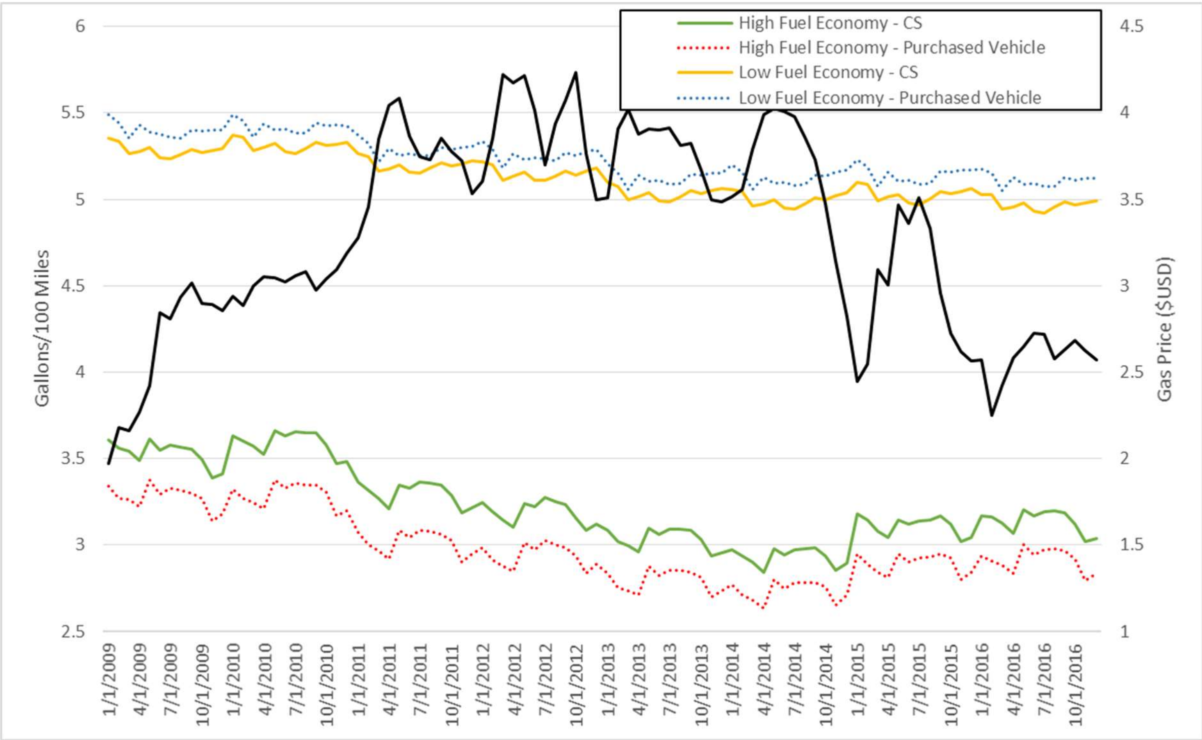

Figure 1: Model 4 Regression Simulation for California - Purchased and Consideration Set Fuel Economy vs. Gasoline Price

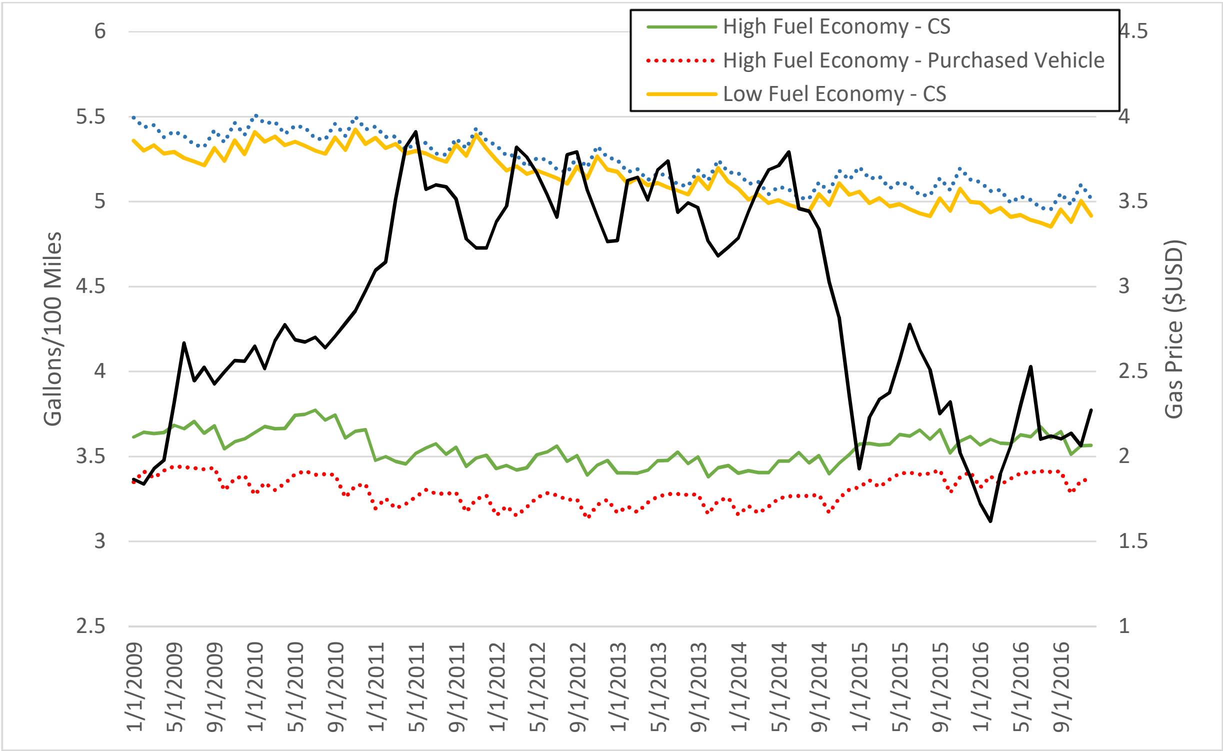

Figure 2: Model 4 Regression Simulation for Texas - Purchased and Consideration Set Fuel Economy vs. Gasoline Price

From this we can see that high fuel economy buyers typically select below their consideration set average, while low economy buyers choose above theirs. The gap between the low and high GPM groups purchased and considered fuel economy is also evident. Since there are other factors accounting for the fuel economy movement than gasoline, as seen by the consistent downtrend of the low fuel economy buyers in Texas, the insights that can be gleaned towards our problem from these visualizations are small. What the graphs do highlight is the differential between low and high fuel economy buyers and how the groups purchase relative to their consideration set. To illustrate this further we can look at where the purchased vehicle fuel economy for both groups, and then our dataset as whole, lies within the consideration set. We provide the mean and median values of the purchased vehicle fuel economy as a percentage of the consideration set range in Table 35.

Table 35: Purchased Vehicle Fuel Economy Relative to Consideration Set Range

	Entire Population	High Fuel Economy	Low Fuel Economy
Mean	0.491	0.675	0.397
Median	0.457	1	0
N	210,885	71,021	139,864

The results in Table 35 match our simulations, with the low fuel economy group buying below their consideration set average and the high fuel economy group buying above it. However, what is most interesting is the median values for both groups. These indicate that the high fuel economy group is buying at the upper limit of their consideration set range most of the time and the lower fuel economy at the bottom. When we add this information to what we've previously demonstrated in this paper we can arrive at some interesting conclusions. First, even if the low fuel economy group makes minimal to no changes to their consideration set, there is opportunity for a change in gasoline price to drive an increase in purchased vehicle fuel economy just by getting this group to purchase higher in their range. Secondly, since the high fuel economy group is purchasing more than their consideration set average fuel economy and consistently near the top of the range, we'd expect it would be difficult for them to increase their purchased vehicle fuel economy more than they change their consideration set average fuel economy. Finally, we see that the behavior of the purchased vehicle fuel economy changing more than our consideration set, that we've seen throughout the paper, is being driven by the low fuel economy group. While the magnitude in change is being driven by our high fuel economy purchasing group. To tease out further how these two subgroups are altering their consideration sets differently in response to gasoline prices, we show how the consideration set minimum GPM, consideration set maximum GPM and purchased vehicle fuel economy as a percentage of the consideration set range respond to gasoline price changes in Table 36 and Table 37.

Table 36: Consideration Set Fuel Economy Min and Max with Purchase FE as % of CS Range for Low Fuel Economy Buyers

	(1)	(2)	(3)	(4)
CS Min. GPM	-0.013	-0.009	-0.032**	-0.029**
	(0.012)	(0.012)	(0.014)	(0.013)
CS Max. GPM	-0.003	-0.003	-0.013	-0.009
	(0.013)	(0.013)	(0.015)	(0.014)
FE_{PV} as % of CS	0.015*	0.017**	0.015*	0.013
Range	(0.008)	(0.008)	(0.009)	(0.009)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

Table 37: Consideration Set Fuel Economy Min and Max with Purchase FE as % of CS Range for High Fuel Economy Buyers

	(1)	(2)	(3)	(4)
CS Min. GPM	-0.116***	-0.075***	-0.094***	-0.060***
	(0.016)	(0.015)	(0.018)	(0.017)
CS Max. GPM	-0.084***	-0.049***	-0.058***	-0.027
	(0.019)	(0.018)	(0.022)	(0.020)
FE_{PV} as % of CS	-0.007	0.005	-0.012	-0.003
Range	(0.009)	(0.009)	(0.010)	(0.010)
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted	No	Yes	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level

These results aren't as consistent model to model as other findings in this paper, however when viewed as a whole we think there are a few conclusions that can be gleaned. For the low fuel economy group, the changes in the consideration set min and max values are small in magnitude and usually don't show significance, reflecting that this group is making minimal, if any changes to their consideration set in response to gasoline prices. If they are making changes it appears they are making it to the top of their fuel economy range, by increasing the minimum GPM considered. Since this group is purchasing above their consideration set average GPM, decreasing the minimum GPM considered more than the maximum GPM considered will result in the consideration set average GPM decreasing more than the purchased vehicle GPM, if the purchase percentage of consideration set range is constant. However, we see that purchase percentage of their consideration set range increases by 1-3% across all four models. This small increase in percentage of range purchased, is enough to overcome the increase in the minimum GPM considered to result in the purchased vehicle fuel economy increasing more than the consideration set. For the high fuel economy group, all four models report, with significance, a decrease in the minimum and maximum GPM considered, with all four showing the minimum decreasing more than the maximum. However, the fuel economy purchased as a percentage of consideration set range for this group is of small magnitude and insignificant. This could reflect that high fuel economy buyers are often already purchasing at the top of their range. That they don't appear to increase their purchase range, while adding fuel economy to both sides of the consideration set, corresponds well with the finding that high fuel economy buyers increase the fuel economy of their consideration set more than the fuel economy of their purchased vehicle in response to gasoline prices.

Throughout the paper we have made the case that consumer's change their purchased fuel economy more than their consideration set in response to a $1 increase in gasoline price and that this is achieved by purchasing higher within their consideration set range while also increasing the fuel economy of the lowest GPM vehicle considered more than the highest GPM vehicle. On the whole, this remains the case. However, this robustness check has shown that the behavior may be different for low and high fuel economy buyers. If we accept the literature introduced at the start of the paper, that consumers are rational in adjusting their fuel economy purchased to changes in gasoline prices, with a slight biasing towards undervaluing future fuel costs, we see that there are two different mechanisms that may account for this. The low fuel economy buyers, who buy at the bottom of their range, don't significantly alter their consideration set fuel economy in response to changing gasoline prices. However, they may choose slightly higher within it. The high fuel economy buyers on the other hand, make larger changes to their consideration set average fuel economy in response to gasoline price, with changes at the top being greater than at the bottom of their range. They still purchase near the top of their range but since they added fuel economy to both sides of their consideration set this results in their purchased fuel economy increasing less than their consideration set average fuel economy.

5. Conclusion

In this paper, we have provided a range of models and results to show how gasoline prices and consideration sets influence the purchased fuel economy of new car buyers. In doing this we believe this paper makes two main contributions to existing literature on how consumers adjust their vehicle purchasing behavior in response to gasoline prices.

First, we provide robust support of previous literature that consumers adjust the fuel economy of the vehicle they purchase to account for future fuel costs. We do this by showing that for a $1 increase in gasoline price the GPM of the consumer's purchased vehicle decreases by 0.102, while the average GPM of their consideration set decreases by 0.092. This relationship holds true, to different magnitudes, across a range of purchase reasons and segments. The only category of consumer where we see evidence of complete myopia is with those do not consider the environmental friendliness of the vehicle to be at all important in their purchase decision. For this group, we were unable to show that gasoline prices were significant in determining the fuel economy they consider or purchase. At the other extreme, we find that people who list the environmental friendliness of a vehicle as extremely important increase the fuel economy purchased the most of any group as a result of gasoline prices. While we don't attempt to quantify how close the consumer's change in fuel economy purchased comes to fully adjusting for new future fuel costs, we do show conclusively that both the consideration set average fuel economy and purchased vehicle fuel economy increase with higher gasoline prices.

Second, having shown the consumer is not myopic to future fuel costs, this paper sheds light on the mechanisms by which a consumer does adjust the fuel economy of their purchased vehicle in response to gasoline prices. We show that for a higher gas prices the consumer, as a whole, increases their purchased vehicle fuel economy more than their consideration set average. This relationship is confirmed using a bootstrap confidence interval, where we find the purchased vehicle fuel economy increases between 2% to 24% more than the consideration set average. The consumer accomplishes this difference in increasing fuel economies in two ways. They first increase the fuel economy throughout their consideration set, with the most fuel-efficient vehicles increasing slightly more than the least. Our four models show that the minimum GPM of the consideration set decreases 20% to 76% more than the maximum GPM vehicle does. In addition, they also select higher within their consideration set fuel economy range. The odds of purchasing the most fuel-efficient vehicle increase by 6%, while the odds of purchasing the least fuel-efficient vehicle decline by 5% for a $1 change in gasoline price. While this is true as a whole, we also highlight that the behavior is subtly different for low and high fuel economy buyers. Low fuel economy buyers purchase below their consideration set average fuel economy and make minimal changes to their consideration set as a result of gasoline price. However, higher gasoline prices do make them purchase slightly higher within their consideration set fuel economy range. This results in their purchased vehicle fuel economy growing more than their consideration set. High fuel economy buyers, however, typically purchase at the top of their range. They increase the fuel economy of their consideration set significantly in response to gas prices and, since they already purchase near the top of their range, their consideration set fuel economy actually increases more than their purchased vehicle fuel economy. Taken as a whole, the high fuel economy buyers drive the magnitude changes we see in purchased and considered fuel economy, while the low fuel economy buyers are largely responsible for the purchased vehicle fuel economy increasing more than the consideration set average. The main takeaway from this is that low and high fuel economy buyers construct and select within their consideration set differently in response to gasoline prices. As a result, if one thinks the consumer is not fully adjusting to future fuel costs, the reasons why are likely different for the two segments. Low fuel economy buyers are not purchasing high enough in their consideration set range, while high fuel economy buyers are not increasing their consideration set fuel economy enough. Lastly, we show that higher gasoline prices result in less gasoline vehicles being considered and purchased but more alternative fuel vehicles being considered and purchased. We propose this as one method by which the consumer is increasing their consideration set and purchased vehicle fuel economy.

The question of how gasoline price affects gasoline consumption is complex, well-studied and has significant importance to policy makers and companies across a range of industries. Many previous papers have shown the degree to which the consumer adjusts their vehicle purchasing behavior to account for future fuel costs. Understanding the magnitude of this adjustment is critical in assessing the potential effectiveness of fuel economy policies and business strategies. However, the final vehicle purchased is an emergent outcome from the consumer's entire decision-making process which we think is best evaluated with a consider then choose framework. Understanding how consumers construct and select from within their consideration set can lead to more targeted and meaningful decisions than simply considering the final outcome in isolation. We think the uniqueness of this paper lies in its ability to explore, through a large dataset, how the general population, and different segments of it, alter and select from within their consideration set to arrive at a vehicle purchase that has accounted for changing future fuel costs. Future work could build on this by studying how different segment's degree of myopia to gasoline prices corresponds to their consideration set behavior. A study that is able to capture the changes consumers make to their consideration set throughout the shopping process, as opposed to our look at the final consideration set before purchase, would also prove interesting.

6. References

Alba, Joseph W., and Amitava Chattopadhyay. 1985. "Effects of Context and Post-Category Cues on Recall of Competing Brands." *Journal of Marketing Research* 22 (August): 340–49.

Allcott, Hunt, and Christopher Knittel. 2018. "Are Consumers Poorly Informed About Fuel Economy? Evidence from Two Experiments." *National Bureau of Economic Research Working Paper Series*, February. http://www.nber.org/papers/w23076.

Allcott, Hunt, and Nathan Wozny. 2011. "Gasoline Prices, Fuel Economy, and the Energy Paradox," 58.

"Alternative Fuels Data Center: E85 (Flex Fuel)." 2020. May 13, 2020. https://afdc.energy.gov/fuels/ethanol_e85.html.

"Automotive Syndicated Studies." n.d. *MaritzCX* (blog). Accessed May 27, 2020. https://www.maritzcx.com/automotive-studies/.

Busse, Meghan R, Christopher R Knittel, and Florian Zettelmeyer. 2013. "Are Consumers Myopic? Evidence from New and Used Car Purchases." *American Economic Review* 103 (1): 220–56. https://doi.org/10.1257/aer.103.1.220.

Daley, R., J. Nangle, G. Boeckman, and M. Miller. 2014. "Refueling Behavior of Flexible Fuel Vehicle Drivers in the Federal Fleet." NREL/TP-5400-61777, 1134133. https://doi.org/10.2172/1134133.

Desarbo, Wayne S., and Kamel Jedidi. 1995. "The Spatial Representation of Heterogeneous Consideration Sets." *Marketing Science* 14 (3): 326–42. https://doi.org/10.1287/mksc.14.3.326.

"Download Fuel Economy Data." 2017. August 17, 2017. https://www.fueleconomy.gov/feg/download.shtml.

Hauser, John R. 2014. "Consideration-Set Heuristics." *Journal of Business Research* 67 (8): 1688–99. https://doi.org/10.1016/j.jbusres.2014.02.015.

Hauser, John R., and Birger Wernerfelt. 1990. "An Evaluation Cost Model of Consideration Sets." *Journal of Consumer Research* 16 (4): 393. https://doi.org/10.1086/209225.

Kahn, James A. 1986. "Gasoline Prices and the Used Automobile Market: A Rational Expectations Asset Price Approach." *The Quarterly Journal of Economics* 101 (2): 323–39. https://doi.org/10.2307/1891118.

Kilian, Lutz, and Eric R Sims. 2006. "The Effects of Real Gasoline Prices on Automobile Demand: A Structural Analysis Using Micro Data." *Unpublished*, 44.

Klier, Thomas, and Joshua Linn. 2010. "The Price of Gasoline and New Vehicle Fuel Economy: Evidence from Monthly Sales Data." *American Economic Journal: Economic Policy* 2 (3): 134–53. https://doi.org/10.1257/pol.2.3.134.

Larrick, R. P., and J. B. Soll. 2008. "ECONOMICS: The MPG Illusion." *Science* 320 (5883): 1593–94. https://doi.org/10.1126/science.1154983.

Leard, Benjamin. 2020. "Estimating Consumer Substitution Between New and Used Passenger Vehicles." *Resources for the Future*, April, 49.

"Number of Gasoline Stations in the U.S." 2020. Statista. March 5, 2020. https://www.statista.com/statistics/525107/number-of-gasoline-stations-in-the-united-states/.

"PADD Regions Enable Regional Analysis of Petroleum Product Supply and Movements - Today in Energy - U.S. Energy Information Administration (EIA)." 2020. June 26, 2020. https://www.eia.gov/todayinenergy/detail.php?id=4890.

Palazzolo, Mike, and Fred Feinberg. 2015. "Modeling Consideration Set Substitution." *Unpublished*, June, 40.

Payne, John W. 1976. "Task Complexity and Contingent Processing in Decision Making: An Information Search and Protocol Analysis." *Organizational Behavior and Human Performance* 16 (2): 366–87. https://doi.org/10.1016/0030-5073(76)90022-2.

"Retail Prices for Regular Gasoline." 2019. November 18, 2019. https://www.eia.gov/dnav/pet/pet_pri_gnd_a_epmr_pte_dpgal_w.htm.

Sallee, James M, Sarah E West, Macalester College, and Wei Fan. 2009. "CONSUMER VALUATION OF FUEL ECONOMY: A MICRODATA APPROACH." *Proceedings of the National Tax Association's 102nd Annual Conference on Taxation*, 254–59.

A. Appendix

A1. Purchased Vehicle Fuel Economy Results

Table A-1: Purchased Vehicle Fuel Economy Regression Coefficients

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Intercept	4.728*** (0.064)	4.505*** (0.055)	4.293*** (0.315)	4.251*** (0.279)
Gasoline Price	-0.105*** (0.012)	-0.082*** (0.011)	-0.082*** (0.013)	-0.058*** (0.012)
Age	-0.006*** (0.0002)	-0.004*** (0.0002)	-0.006*** (0.0002)	-0.004*** (0.0002)
Bachelor's Degree	-0.214*** (0.005)	-0.163*** (0.004)	-0.214*** (0.005)	-0.164*** (0.004)
White	0.076*** (0.006)	0.064*** (0.005)	0.075*** (0.006)	0.063*** (0.005)
Income >= $400,000	-0.155*** (0.021)	-0.198*** (0.019)	-0.152*** (0.022)	-0.194*** (0.019)
Income: $300,000 - $400,000	-0.025 (0.021)	-0.044** (0.019)	-0.022 (0.022)	-0.041** (0.019)
Income: $200,000 - $300,000	0.054*** (0.019)	0.031*** (0.015)	0.056*** (0.019)	0.033*** (0.015)
Income: $100,000 - $200,000	0.160*** (0.017)	0.153*** (0.013)	0.161*** (0.017)	0.154*** (0.014)
Income: $50,000 - $100,000	0.195*** (0.017)	0.192*** (0.013)	0.195*** (0.017)	0.192*** (0.013)
Income: $25,000 - $50,000	0.136*** (0.018)	0.136*** (0.014)	0.137*** (0.018)	0.137*** (0.014)
Mileage Quantile 2	-0.039*** (0.008)	-0.025*** (0.007)	-0.040*** (0.008)	-0.025*** (0.007)
Mileage Quantile 3	-0.053*** (0.008)	-0.033*** (0.007)	-0.053*** (0.008)	-0.032*** (0.007)
Mileage Quantile 4	-0.108*** (0.011)	-0.072*** (0.009)	-0.107*** (0.010)	-0.071*** (0.009)
Mileage Quantile 5	-0.177*** (0.011)	-0.121*** (0.010)	-0.178*** (0.011)	-0.121*** (0.010)
Car Age	0.016*** (0.0004)	0.018*** (0.0004)	0.016*** (0.0004)	0.018*** (0.0004)
Principle Vehicle	-0.092*** (0.006)	-0.065*** (0.006)	-0.092*** (0.006)	-0.066*** (0.006)
Purchase	0.227*** (0.006)	0.182*** (0.005)	0.228*** (0.006)	0.183*** (0.005)
Purchase Price	0.000036*** (0.0000002)	0.000037*** (0.0000002)	0.000036*** (0.0000002)	0.000037*** (0.0000002)
Family Size = 4	-0.085*** (0.010)	-0.081*** (0.009)	-0.086*** (0.010)	-0.082*** (0.010)
Family Size = 1	-0.123*** (0.012)	-0.129*** (0.011)	-0.124*** (0.012)	-0.131*** (0.011)
Family Size = 6	0.022 (0.016)	0.028* (0.015)	0.022 (0.016)	0.027* (0.015)
Family Size = 3	-0.123*** (0.010)	-0.126*** (0.009)	-0.123*** (0.010)	-0.127*** (0.009)
Family Size = 2	-0.149*** (0.010)	-0.149*** (0.010)	-0.150*** (0.010)	-0.158*** (0.009)
Married	0.006 (0.008)	0.031*** (0.007)	0.006 (0.008)	0.031*** (0.007)
Single, never married	-0.098*** (0.009)	-0.081*** (0.008)	-0.099*** (0.009)	-0.082*** (0.008)
Location = Metropolitan City	-0.364*** (0.012)	-0.313*** (0.010)	-0.364*** (0.012)	-0.314*** (0.010)

Location = Small Town	-0.158*** (0.011)	-0.139*** (0.009)	-0.159*** (0.011)	-0.141*** (0.009)
Location = Suburb of Large City	-0.284** (0.011)	-0.249** (0.009)	-0.285** (0.011)	-0.250** (0.009)
Gender = Male	0.191*** (0.005)	0.192*** (0.004)	0.191*** (0.005)	0.192*** (0.004)
Observations	210,885	210,885	210,885	210,885
R2	0.0270	0.302	0.275	0.308
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State * Year State * Month	State, Month, Year State * Year State * Month
Weighted	No	Yes	No	Yes

***Significant at the 1 percent level, ** Significant at the 5% level, *Significant at the 10% level, SEs in parenthesis

All coefficients shown except for state, month, year and interactions between state and month and state and year.

Mileage quantiles: 1= 0 - 5,000 miles, 2= 5,001 – 10,000 miles, 3 = 10,001 – 15,000, 4= 15,001 – 20,000, 5= >20,000.

Model numbers correspond to the models described in Section 3.

A2. Consideration Set Average Fuel Economy Results

Table A- 2: Consideration Set Average Fuel Economy Regression Coefficients

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Intercept	4.759*** (0.061)	4.570*** (0.053)	4.433*** (0.298)	4.428*** (0.266)
Gasoline Price	-0.092*** (0.011)	-0.069*** (0.010)	-0.071*** (0.013)	-0.050*** (0.012)
Age	-0.006*** (0.0002)	-0.005*** (0.0002)	-0.006*** (0.0002)	-0.005*** (0.0002)
Bachelor's Degree	-0.241*** (0.005)	-0.195*** (0.004)	-0.240*** (0.005)	-0.195*** (0.004)
White	0.064*** (0.006)	0.047*** (0.005)	0.063*** (0.006)	0.047*** (0.005)
Income >= $400,000	-0.150*** (0.020)	-0.188*** (0.018)	-0.148*** (0.020)	-0.184*** (0.018)
Income: $300,000 - $400,000	-0.017 (0.020)	-0.043** (0.018)	-0.014 (0.020)	-0.040** (0.018)
Income: $200,000 - $300,000	0.045** (0.016)	0.021 (0.014)	0.046*** (0.018)	0.023 (0.014)
Income: $100,000 - $200,000	0.140*** (0.016)	0.130*** (0.013)	0.141*** (0.016)	0.132*** (0.013)
Income: $50,000 - $100,000	0.170*** (0.016)	0.162*** (0.012)	0.170*** (0.016)	0.163*** (0.012)
Income: $25,000 - $50,000	0.121*** (0.017)	0.119*** (0.013)	0.122*** (0.017)	0.120*** (0.013)
Mileage Quantile 2	-0.043*** (0.008)	-0.032*** (0.007)	-0.043*** (0.008)	-0.033*** (0.007)
Mileage Quantile 3	-0.049*** (0.008)	-0.032*** (0.007)	-0.048*** (0.008)	-0.032*** (0.007)
Mileage Quantile 4	-0.102*** (0.009)	-0.073*** (0.008)	-0.100*** (0.009)	-0.071*** (0.008)
Mileage Quantile 5	-0.154*** (0.009)	-0.106*** (0.009)	-0.154*** (0.011)	-0.106*** (0.009)
Car Age	0.013*** (0.0004)	0.014*** (0.0004)	0.013*** (0.0004)	0.014*** (0.0004)
Principle Vehicle	-0.103*** (0.006)	-0.077*** (0.005)	-0.103*** (0.006)	-0.077*** (0.005)
Purchase	0.215*** (0.005)	0.170*** (0.005)	0.214*** (0.006)	0.170*** (0.005)
Purchase Price	0.000034*** (0.0000002)	0.000035*** (0.0000002)	0.000034*** (0.0000002)	0.000035*** (0.0000002)
Family Size = 4	-0.086*** (0.010)	-0.089*** (0.009)	-0.086*** (0.010)	-0.091*** (0.009)
Family Size = 1	-0.126*** (0.012)	-0.145*** (0.010)	-0.127*** (0.012)	-0.147*** (0.010)
Family Size = 6	0.028* (0.015)	0.031** (0.014)	0.028* (0.015)	0.030** (0.014)
Family Size = 3	-0.123*** (0.010)	-0.134*** (0.009)	-0.123*** (0.010)	-0.135*** (0.009)
Family Size = 2	-0.148*** (0.009)	-0.165*** (0.008)	-0.149*** (0.009)	-0.167*** (0.008)
Married	-0.005 (0.008)	0.018*** (0.006)	-0.005 (0.008)	0.017*** (0.006)
Single, never married	-0.109*** (0.008)	-0.095*** (0.007)	-0.110*** (0.008)	-0.096*** (0.007)
Location = Metropolitan City	-0.369*** (0.011)	-0.321*** (0.010)	-0.369*** (0.011)	-0.323*** (0.010)

Location = Small Town	-0.156*** (0.010)	-0.138*** (0.009)	-0.157*** (0.010)	-0.140*** (0.009)
Location = Suburb of Large City	-0.287*** (0.010)	-0.255*** (0.009)	-0.287*** (0.010)	-0.257*** (0.009)
Gender = Male	0.212*** (0.005)	0.215*** (0.004)	0.212*** (0.005)	0.215*** (0.004)
Observations	210,885	210,885	210,885	210,885
R2	0.280	0.310	0.285	0.315
Fixed Effects	State, Month, Year	State, Month, Year	State, Month, Year State * Year State * Month	State, Month, Year State * Year State * Month
Weighted	No	Yes	No	Yes

***Significant at the 1 percent level, ** Significant at the 5% level, *Significant at the 10% level, SEs in parenthesis

All coefficients shown except for state, month, year and interactions between state and month and state and year.

Mileage quantiles: 1= 0 - 5,000 miles, 2= 5,001 – 10,000 miles, 3 = 10,001 – 15,000, 4= 15,001 – 20,000, 5= >20,000.

Model numbers correspond to the models described in Section 3

A3. Data from Bootstrap Observations Used to Calculate Differences Between Purchased and Consideration Set Gasoline Coefficients

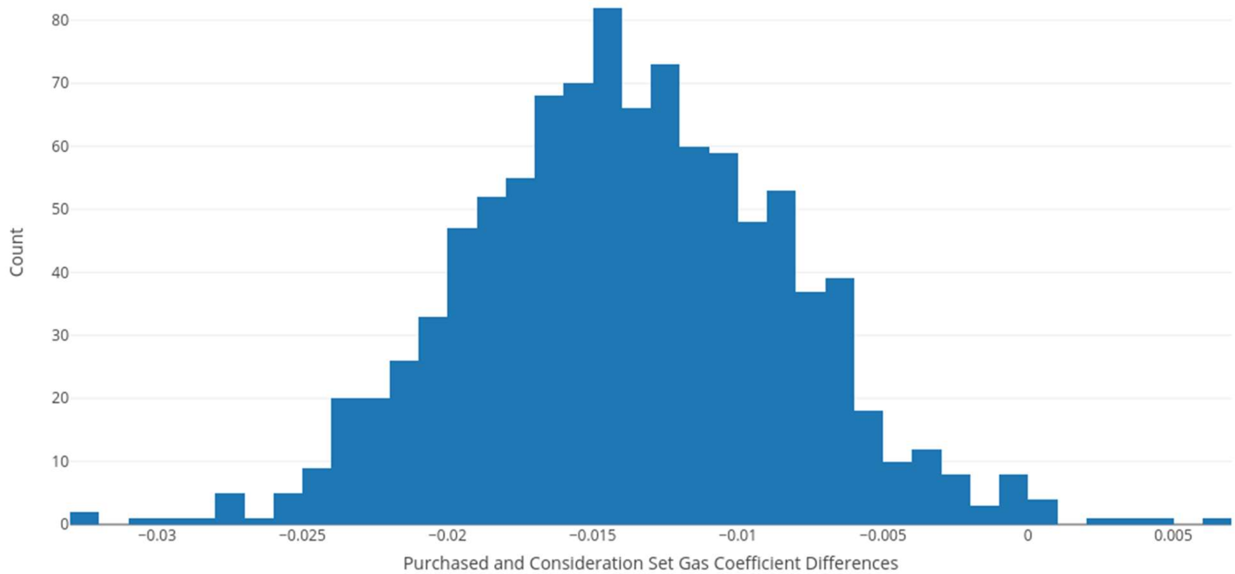

Figure A-1: Histogram of Bootstrap Observations of Differences Between Purchased and Consideration Set Gasoline Coefficients

Table A-3: Raw Data from Bootstrap Observations of Differences Between Purchased and Consideration Set Gasoline Coefficients

Observation	Difference in Coefficients	Purchased Vehicle Gas Price Co-efficient	Consideration Set Gas Price Co-efficient
1	-0.02104	-0.11104	-0.09
2	-0.02223	-0.10774	-0.08551
3	-0.00932	-0.11746	-0.10813
4	-0.011	-0.09977	-0.08878
5	-0.0132	-0.09076	-0.07757
6	-0.01966	-0.1001	-0.08045
7	-0.01451	-0.08384	-0.06933
8	-0.00624	-0.08578	-0.07954
9	-0.01843	-0.08857	-0.07014
10	-0.01315	-0.09855	-0.0854
11	-0.00502	-0.11494	-0.10992
12	-0.01964	-0.09853	-0.07889
13	-0.01841	-0.09816	-0.07974
14	-0.01832	-0.10092	-0.0826
15	-0.01434	-0.10997	-0.09562
16	-0.01061	-0.12462	-0.11401
17	-0.00709	-0.08678	-0.0797
18	-0.02058	-0.10546	-0.08487
19	-0.01124	-0.09858	-0.08734
20	-0.01532	-0.0997	-0.08438
21	-0.0212	-0.1137	-0.09251

22	-0.00685	-0.11572	-0.10887
23	-0.01679	-0.1238	-0.107
24	-0.01626	-0.10281	-0.08655
25	-0.01487	-0.10772	-0.09285
26	-0.02566	-0.12405	-0.09839
27	-0.01118	-0.10555	-0.09437
28	-0.0142	-0.1181	-0.1039
29	-0.02357	-0.10755	-0.08398
30	-0.01124	-0.10309	-0.09185
31	-0.00656	-0.09935	-0.09279
32	-0.01581	-0.10995	-0.09414
33	-0.01948	-0.12128	-0.1018
34	-0.013	-0.1024	-0.0894
35	-0.0135	-0.08682	-0.07332
36	-0.02195	-0.09839	-0.07644
37	-0.00068	-0.09262	-0.09193
38	-0.00106	-0.10172	-0.10066
39	-0.02751	-0.1083	-0.08079
40	-0.01569	-0.11583	-0.10014
41	-0.0158	-0.09626	-0.08045
42	-0.00758	-0.11593	-0.10834
43	-0.01201	-0.09701	-0.085
44	0.002032	-0.08924	-0.09128
45	-0.00588	-0.11456	-0.10868
46	-0.0169	-0.10321	-0.08631
47	-0.01306	-0.10135	-0.08829
48	-0.01529	-0.11494	-0.09965
49	-0.01853	-0.11863	-0.1001
50	-0.0107	-0.1121	-0.1014
51	-0.00906	-0.11284	-0.10378
52	-0.01713	-0.11335	-0.09623
53	-0.01213	-0.10847	-0.09633
54	-0.01939	-0.12266	-0.10327
55	-0.01295	-0.10679	-0.09383
56	-0.016	-0.08996	-0.07396
57	-0.00752	-0.08515	-0.07762
58	-0.00813	-0.08277	-0.07464
59	-0.01825	-0.12279	-0.10454
60	-0.00879	-0.10647	-0.09768
61	-0.02078	-0.10758	-0.08679
62	-0.01744	-0.11206	-0.09461
63	-0.00816	-0.09319	-0.08503
64	-0.01016	-0.07977	-0.06961
65	-0.0167	-0.09108	-0.07438
66	-0.00674	-0.10596	-0.09922
67	-0.01437	-0.08456	-0.07018
68	-0.00645	-0.10398	-0.09753
69	-0.01259	-0.11056	-0.09798
70	-0.00931	-0.10367	-0.09436
71	-0.02093	-0.10335	-0.08242
72	-0.01476	-0.09674	-0.08198
73	-0.01743	-0.10854	-0.09111
74	-0.01422	-0.10643	-0.09221
75	-0.01469	-0.10098	-0.08629
76	-0.01911	-0.11218	-0.09307
77	-0.01629	-0.11235	-0.09606
78	-0.02136	-0.10814	-0.08677
79	-0.00675	-0.09122	-0.08447
80	-0.00869	-0.09595	-0.08726
81	-0.01415	-0.09022	-0.07607
82	-0.01095	-0.0899	-0.07896
83	-0.01457	-0.07931	-0.06474
84	-0.00782	-0.10263	-0.09481
85	-0.01153	-0.08943	-0.0779
86	-0.01224	-0.10307	-0.09083
87	-0.02124	-0.11549	-0.09425

88	-0.01418	-0.12428	-0.1101
89	-0.00733	-0.09004	-0.08271
90	-0.00672	-0.09798	-0.09126
91	-0.01175	-0.08562	-0.07386
92	-0.01376	-0.12923	-0.11546
93	-0.01532	-0.11377	-0.09845
94	-0.01847	-0.11588	-0.09741
95	-0.01513	-0.1006	-0.08547
96	-0.01933	-0.13486	-0.11553
97	-0.01267	-0.1083	-0.09563
98	-0.02705	-0.14206	-0.11502
99	-0.02704	-0.09481	-0.06777
100	-0.00802	-0.08873	-0.08071
101	-0.01387	-0.11618	-0.10231
102	-0.0159	-0.09543	-0.07954
103	-0.01148	-0.13593	-0.12445
104	-0.01014	-0.10038	-0.09024
105	-0.0166	-0.08957	-0.07297
106	-0.01036	-0.09136	-0.08101
107	-0.01304	-0.1376	-0.12456
108	-0.01543	-0.08923	-0.07379
109	-0.00637	-0.08846	-0.08209
110	-0.01202	-0.12009	-0.10807
111	-0.02371	-0.11935	-0.09564
112	-0.00969	-0.09249	-0.0828
113	-0.01086	-0.08212	-0.07126
114	-0.0192	-0.10325	-0.08405
115	-0.00952	-0.12754	-0.11802
116	-0.01087	-0.1072	-0.09633
117	-0.01745	-0.11192	-0.09446
118	-0.01331	-0.1171	-0.10379
119	-0.01323	-0.1136	-0.10037
120	-0.0147	-0.10516	-0.09046
121	-0.00777	-0.10937	-0.1016
122	-0.01629	-0.10742	-0.09113
123	-0.00802	-0.11861	-0.11059
124	-0.01451	-0.12612	-0.1116
125	-0.02032	-0.11239	-0.09207
126	-0.01406	-0.0916	-0.07754
127	-0.02179	-0.12618	-0.10439
128	-0.015	-0.12519	-0.1102
129	-0.01523	-0.09365	-0.07842
130	-0.00585	-0.09182	-0.08597
131	-0.01455	-0.106	-0.09145
132	-0.01464	-0.10301	-0.08838
133	-0.01501	-0.08333	-0.06832
134	-0.01923	-0.1094	-0.09016
135	-0.00678	-0.09047	-0.08369
136	-0.01648	-0.10629	-0.08981
137	-0.02402	-0.11765	-0.09363
138	-0.01213	-0.10442	-0.09229
139	-0.01558	-0.11285	-0.09727
140	-0.01641	-0.11074	-0.09433
141	-0.01083	-0.09939	-0.08856
142	-0.02204	-0.118	-0.09596
143	-0.01473	-0.11748	-0.10275
144	-0.00957	-0.10381	-0.09424
145	-0.00992	-0.1211	-0.11118
146	-0.01188	-0.09867	-0.08679
147	-0.01132	-0.08623	-0.07491
148	-0.01653	-0.11503	-0.0985
149	-0.02084	-0.10312	-0.08228
150	-0.01626	-0.11343	-0.09717
151	-0.0182	-0.11828	-0.10008
152	-0.01657	-0.09538	-0.07881
153	-0.01601	-0.10358	-0.08757

154	-0.00971	-0.10473	-0.09503
155	-0.02181	-0.10045	-0.07865
156	-0.00698	-0.09596	-0.08899
157	-0.013	-0.11913	-0.10613
158	-0.02006	-0.11435	-0.09428
159	-0.02118	-0.10293	-0.08175
160	-0.01882	-0.09233	-0.07351
161	-0.01696	-0.10728	-0.09032
162	-0.01272	-0.0858	-0.07308
163	-0.01842	-0.09437	-0.07595
164	-0.01828	-0.0973	-0.07902
165	-0.01198	-0.11082	-0.09884
166	-0.01477	-0.12196	-0.10719
167	-0.01465	-0.09662	-0.08197
168	-0.01516	-0.08853	-0.07337
169	-0.01587	-0.10736	-0.09149
170	-0.01483	-0.11341	-0.09858
171	-0.02071	-0.10681	-0.0861
172	-0.00884	-0.14574	-0.13689
173	-0.01763	-0.09837	-0.08073
174	-0.01506	-0.10309	-0.08803
175	-0.01691	-0.12442	-0.10751
176	-0.00916	-0.10884	-0.09968
177	-0.01071	-0.09942	-0.0887
178	-0.00989	-0.10761	-0.09772
179	-0.00967	-0.10237	-0.0927
180	-0.01603	-0.09931	-0.08328
181	-0.01547	-0.108	-0.09254
182	-0.01558	-0.12067	-0.10509
183	-0.01598	-0.10552	-0.08953
184	-0.02113	-0.09463	-0.0735
185	-0.01105	-0.10678	-0.09573
186	-0.01322	-0.13165	-0.11842
187	-0.01735	-0.10586	-0.08851
188	-0.00527	-0.09878	-0.09351
189	-0.02008	-0.13411	-0.11403
190	-0.01147	-0.10188	-0.09041
191	-0.00753	-0.11452	-0.10699
192	-0.01338	-0.09902	-0.08564
193	0.004255	-0.10705	-0.11131
194	-0.00809	-0.10796	-0.09987
195	-0.01566	-0.10045	-0.08479
196	-0.01586	-0.09228	-0.07641
197	-0.01075	-0.09621	-0.08545
198	-0.01513	-0.11536	-0.10023
199	-0.01559	-0.095	-0.07941
200	-0.00901	-0.07951	-0.07051
201	-0.01011	-0.09172	-0.0816
202	-0.01786	-0.10611	-0.08825
203	-0.01074	-0.12303	-0.11229
204	-0.01208	-0.10337	-0.09129
205	-0.01772	-0.08747	-0.06975
206	-0.01224	-0.11286	-0.10062
207	-0.0067	-0.09193	-0.08522
208	-0.01922	-0.10986	-0.09064
209	-0.01388	-0.1091	-0.09522
210	-0.01434	-0.10357	-0.08923
211	-0.00825	-0.0804	-0.07216
212	-0.0124	-0.09978	-0.08738
213	-0.00953	-0.08709	-0.07755
214	-0.01228	-0.11124	-0.09896
215	-0.01263	-0.11532	-0.10268
216	-0.01345	-0.09087	-0.07741
217	-0.00836	-0.09444	-0.08608
218	-0.01792	-0.10875	-0.09082
219	-0.01443	-0.11049	-0.09605

220	-0.01451	-0.10192	-0.08741
221	-0.01731	-0.12108	-0.10376
222	-0.01743	-0.09156	-0.07413
223	-0.00845	-0.09353	-0.08509
224	-0.01438	-0.11961	-0.10524
225	-0.00647	-0.09655	-0.09008
226	-0.0165	-0.10505	-0.08854
227	-0.00959	-0.08531	-0.07572
228	-0.01408	-0.09223	-0.07815
229	-0.01918	-0.10634	-0.08716
230	-0.01706	-0.10114	-0.08407
231	-0.00168	-0.1019	-0.10022
232	-0.01071	-0.10423	-0.09351
233	-0.01218	-0.11368	-0.1015
234	-0.01663	-0.11162	-0.09499
235	-0.01755	-0.09238	-0.07483
236	-0.01749	-0.10162	-0.08413
237	-0.01101	-0.11252	-0.1015
238	-0.01663	-0.09483	-0.0782
239	-0.01495	-0.10203	-0.08708
240	-0.01172	-0.09072	-0.079
241	-0.00805	-0.08252	-0.07447
242	-0.01367	-0.1075	-0.09383
243	-0.02071	-0.1054	-0.08469
244	-0.00626	-0.09065	-0.08438
245	-0.01158	-0.09762	-0.08604
246	-0.01479	-0.106	-0.09121
247	-0.01733	-0.12102	-0.10369
248	-0.00874	-0.08224	-0.07351
249	-0.01397	-0.08449	-0.07051
250	-0.02122	-0.13097	-0.10975
251	-0.01233	-0.1225	-0.11017
252	-0.0222	-0.12786	-0.10566
253	-0.0131	-0.11294	-0.09985
254	-0.01147	-0.12316	-0.11169
255	-0.00866	-0.11063	-0.10198
256	-0.02191	-0.10813	-0.08622
257	-0.02009	-0.10839	-0.08829
258	-0.01622	-0.11251	-0.0963
259	-0.01765	-0.09169	-0.07404
260	-0.02243	-0.11721	-0.09479
261	-0.01269	-0.10602	-0.09332
262	-0.02428	-0.12755	-0.10327
263	-0.01883	-0.1276	-0.10876
264	-0.0212	-0.08576	-0.06457
265	-0.01742	-0.10304	-0.08562
266	-0.01226	-0.12003	-0.10777
267	-0.01257	-0.10564	-0.09307
268	-0.0154	-0.10864	-0.09323
269	-0.01475	-0.1081	-0.09336
270	-0.02331	-0.11851	-0.0952
271	-0.01597	-0.11021	-0.09424
272	-0.0163	-0.09439	-0.07808
273	-0.007	-0.0889	-0.0819
274	-0.01603	-0.11275	-0.09672
275	-0.01427	-0.10744	-0.09317
276	-0.01271	-0.13151	-0.1188
277	-0.02315	-0.11976	-0.09661
278	-0.01273	-0.107	-0.09427
279	-0.0191	-0.12624	-0.10713
280	-0.01025	-0.08449	-0.07424
281	-0.00888	-0.09555	-0.08668
282	-0.02248	-0.1252	-0.10272
283	-0.02227	-0.1173	-0.09503
284	-0.01729	-0.11499	-0.09769
285	-0.00895	-0.10507	-0.09613

286	-0.01747	-0.09972	-0.08226
287	-0.01065	-0.10213	-0.09148
288	-0.0131	-0.08758	-0.07447
289	-0.0125	-0.11387	-0.10137
290	-0.0128	-0.10348	-0.09068
291	-0.00884	-0.08991	-0.08107
292	-0.02314	-0.10561	-0.08247
293	-0.02516	-0.11075	-0.08559
294	-0.00972	-0.10652	-0.0968
295	-0.01559	-0.11231	-0.09671
296	-0.01887	-0.11706	-0.09819
297	-0.01008	-0.11885	-0.10876
298	-0.01857	-0.1088	-0.09024
299	-0.01996	-0.10127	-0.08131
300	-0.01529	-0.12137	-0.10608
301	-0.00861	-0.10517	-0.09656
302	-0.00961	-0.09578	-0.08617
303	-0.01975	-0.11759	-0.09784
304	-0.01108	-0.08311	-0.07203
305	-0.01361	-0.10442	-0.09082
306	-0.01154	-0.10583	-0.09428
307	-0.02039	-0.11682	-0.09643
308	-0.01769	-0.09508	-0.0774
309	-0.00936	-0.09711	-0.08776
310	-0.01794	-0.09822	-0.08028
311	-0.00815	-0.0764	-0.06825
312	-0.01996	-0.10899	-0.08903
313	-0.01984	-0.10042	-0.08058
314	-0.00768	-0.08104	-0.07337
315	-0.02133	-0.1101	-0.08878
316	-0.013	-0.09976	-0.08676
317	-0.01518	-0.09976	-0.08459
318	-0.01478	-0.1121	-0.09732
319	-0.01768	-0.10035	-0.08267
320	-0.01367	-0.1075	-0.09384
321	-0.01642	-0.1003	-0.08387
322	-0.01401	-0.12418	-0.11018
323	-0.01293	-0.09862	-0.08569
324	-0.00843	-0.11025	-0.10183
325	-0.01271	-0.10085	-0.08814
326	-0.02306	-0.13032	-0.10726
327	-0.0032	-0.08216	-0.07896
328	-0.00863	-0.10534	-0.09671
329	-0.01723	-0.11134	-0.09411
330	-0.01516	-0.1037	-0.08854
331	-0.0236	-0.10982	-0.08622
332	-0.01777	-0.10483	-0.08705
333	-0.01727	-0.10574	-0.08847
334	-0.01231	-0.11538	-0.10307
335	-0.01193	-0.1129	-0.10097
336	-0.01432	-0.12003	-0.10571
337	-0.00698	-0.10374	-0.09676
338	-0.01565	-0.10096	-0.08531
339	-0.00248	-0.09813	-0.09565
340	-0.01775	-0.11021	-0.09246
341	-0.00253	-0.09096	-0.08843
342	-0.00872	-0.10406	-0.09534
343	-0.00527	-0.10649	-0.10122
344	-0.00579	-0.10518	-0.09939
345	-0.0141	-0.10337	-0.08927
346	-0.01596	-0.09232	-0.07636
347	-0.01023	-0.10312	-0.09289
348	-0.01511	-0.09107	-0.07597
349	-0.00927	-0.09638	-0.08711
350	-0.01522	-0.08428	-0.06906
351	-0.00935	-0.09487	-0.08551

352	-0.0206	-0.11272	-0.09211
353	-0.02026	-0.09896	-0.0787
354	-0.00496	-0.09445	-0.08949
355	-0.00822	-0.10775	-0.09953
356	-0.02249	-0.11442	-0.09193
357	-0.01333	-0.11165	-0.09832
358	-0.00616	-0.09447	-0.08831
359	-0.01037	-0.10528	-0.09491
360	-0.00663	-0.10808	-0.10145
361	-0.01404	-0.10754	-0.09351
362	-0.02119	-0.09805	-0.07687
363	-0.01183	-0.10206	-0.09023
364	-0.01696	-0.09721	-0.08025
365	-0.01434	-0.10022	-0.08588
366	-0.02067	-0.11346	-0.09279
367	-0.01175	-0.10239	-0.09065
368	-0.01182	-0.08822	-0.0764
369	-0.02082	-0.12758	-0.10676
370	-0.01877	-0.11146	-0.09269
371	-0.02066	-0.13029	-0.10963
372	-0.0065	-0.11176	-0.10526
373	-0.01426	-0.10232	-0.08806
374	-0.01546	-0.10893	-0.09347
375	-0.0092	-0.09425	-0.08505
376	-0.00877	-0.08867	-0.0799
377	-0.01261	-0.10301	-0.0904
378	-0.0197	-0.08201	-0.06231
379	-0.01515	-0.12808	-0.11293
380	-0.00864	-0.09931	-0.09067
381	-0.01506	-0.10369	-0.08863
382	-0.01623	-0.11737	-0.10114
383	-0.00865	-0.10521	-0.09656
384	-0.0322	-0.12386	-0.09166
385	-0.0162	-0.11191	-0.09572
386	-0.02474	-0.10342	-0.07868
387	-0.01447	-0.09414	-0.07967
388	-0.01013	-0.09957	-0.08944
389	-0.01825	-0.1073	-0.08905
390	-0.0165	-0.09619	-0.07969
391	-0.01824	-0.10208	-0.08384
392	-0.01352	-0.09656	-0.08304
393	-0.00988	-0.09812	-0.08824
394	-0.01793	-0.12026	-0.10234
395	-0.01854	-0.11762	-0.09907
396	-0.02828	-0.10207	-0.07379
397	-0.01504	-0.09518	-0.08014
398	-0.01831	-0.09503	-0.07672
399	-0.01114	-0.09716	-0.08602
400	-0.00858	-0.10021	-0.09163
401	-0.01515	-0.11801	-0.10285
402	-0.01642	-0.11592	-0.0995
403	-0.02317	-0.12094	-0.09777
404	-0.00592	-0.08943	-0.08352
405	-0.00812	-0.11426	-0.10614
406	-0.01692	-0.08799	-0.07107
407	-0.01118	-0.08328	-0.07209
408	-0.01869	-0.13099	-0.1123
409	-0.02395	-0.12117	-0.09721
410	-0.01283	-0.12917	-0.11634
411	-0.0123	-0.10061	-0.08831
412	-0.01332	-0.11314	-0.09983
413	-0.01992	-0.1403	-0.12038
414	-0.0218	-0.1084	-0.08659
415	-0.02352	-0.10036	-0.07684
416	-0.02075	-0.11338	-0.09263
417	-0.01536	-0.09292	-0.07755

418	-0.00776	-0.10937	-0.10162
419	-0.01435	-0.13274	-0.11839
420	-0.01036	-0.11864	-0.10827
421	-0.01155	-0.11256	-0.10101
422	-0.01465	-0.09581	-0.08115
423	-0.0111	-0.10655	-0.09545
424	-0.01434	-0.10013	-0.08579
425	-0.01156	-0.09963	-0.08807
426	-0.01387	-0.11998	-0.10611
427	-0.01485	-0.11307	-0.09822
428	-0.02073	-0.12261	-0.10188
429	-0.00862	-0.09495	-0.08633
430	-0.00553	-0.08418	-0.07866
431	-0.00962	-0.10467	-0.09504
432	-0.01054	-0.09527	-0.08473
433	-0.01037	-0.10743	-0.09706
434	-0.00936	-0.0974	-0.08803
435	-0.00343	-0.09281	-0.08938
436	-0.01746	-0.0931	-0.07564
437	-0.01151	-0.11174	-0.10023
438	-0.01797	-0.11226	-0.09429
439	-0.02018	-0.11655	-0.09637
440	-0.01017	-0.11584	-0.10567
441	-0.01301	-0.11353	-0.10052
442	-0.01571	-0.07648	-0.06077
443	-0.01958	-0.11743	-0.09785
444	-0.01114	-0.09502	-0.08387
445	-0.01417	-0.10761	-0.09344
446	-0.01383	-0.10931	-0.09547
447	-0.01315	-0.12524	-0.1121
448	-0.01568	-0.11653	-0.10085
449	-0.01063	-0.10696	-0.09632
450	-0.01453	-0.11453	-0.1
451	-0.02305	-0.0996	-0.07655
452	-0.01208	-0.1157	-0.10363
453	-0.01013	-0.09018	-0.08005
454	-0.01061	-0.10955	-0.09894
455	-0.00299	-0.07699	-0.07399
456	-0.01184	-0.11723	-0.10539
457	-0.00789	-0.08973	-0.08184
458	-0.02022	-0.10931	-0.0891
459	-0.01911	-0.11402	-0.09492
460	-0.01706	-0.11025	-0.09319
461	-0.01634	-0.10905	-0.0927
462	-0.01054	-0.08474	-0.0742
463	-0.0116	-0.09086	-0.07925
464	-0.01343	-0.11671	-0.10328
465	-0.01329	-0.08355	-0.07025
466	-0.00822	-0.09791	-0.08969
467	-0.00335	-0.1078	-0.10445
468	-0.01089	-0.0932	-0.08231
469	-0.00717	-0.09622	-0.08905
470	-0.00042	-0.08977	-0.08935
471	-0.00654	-0.10263	-0.09609
472	-0.01531	-0.11108	-0.09577
473	-0.00501	-0.09563	-0.09062
474	-0.00949	-0.11095	-0.10146
475	-0.01054	-0.09488	-0.08433
476	-0.01306	-0.1342	-0.12114
477	-0.00563	-0.07634	-0.07071
478	-0.01639	-0.1083	-0.09191
479	-0.00492	-0.0893	-0.08439
480	-0.02247	-0.12452	-0.10205
481	-0.01005	-0.11943	-0.10938
482	-0.00908	-0.10157	-0.09249
483	-0.01298	-0.09446	-0.08149

484	-0.01094	-0.10082	-0.08987
485	-0.01874	-0.08196	-0.06322
486	-0.01441	-0.12709	-0.11268
487	-0.01499	-0.09362	-0.07864
488	-0.01646	-0.10012	-0.08366
489	-0.02166	-0.10516	-0.08351
490	-0.01624	-0.12488	-0.10863
491	-0.00895	-0.08765	-0.0787
492	-0.02039	-0.10783	-0.08744
493	-0.01725	-0.1134	-0.09615
494	-0.02205	-0.10102	-0.07897
495	-0.00424	-0.11707	-0.11284
496	-0.00041	-0.08464	-0.08423
497	-0.00357	-0.09989	-0.09631
498	-0.01106	-0.11402	-0.10296
499	-0.00699	-0.12055	-0.11356
500	-0.01496	-0.09331	-0.07835
501	-0.01518	-0.11584	-0.10066
502	-0.01396	-0.11189	-0.09794
503	-0.00576	-0.11031	-0.10456
504	-0.01804	-0.09656	-0.07852
505	-0.01712	-0.11595	-0.09883
506	-0.02038	-0.11599	-0.09561
507	-0.01502	-0.10702	-0.092
508	-0.00231	-0.10847	-0.10616
509	-0.02276	-0.11209	-0.08933
510	-0.01878	-0.10928	-0.09051
511	-0.00812	-0.08112	-0.073
512	-0.00979	-0.08858	-0.07879
513	-0.01523	-0.09767	-0.08244
514	-0.0002	-0.08914	-0.08894
515	-0.00246	-0.09376	-0.0913
516	-0.01722	-0.09612	-0.07889
517	-0.00058	-0.11528	-0.1147
518	-0.01891	-0.07742	-0.05851
519	-0.0161	-0.10045	-0.08436
520	-0.01243	-0.1275	-0.11507
521	-0.00682	-0.10757	-0.10075
522	-0.02099	-0.09552	-0.07453
523	-0.0104	-0.10532	-0.09493
524	-0.0153	-0.08472	-0.06941
525	-0.00535	-0.11681	-0.11145
526	-0.01221	-0.10559	-0.09338
527	-0.01073	-0.10254	-0.09181
528	-0.01261	-0.12377	-0.11116
529	-0.01526	-0.10767	-0.09241
530	-0.00729	-0.08975	-0.08246
531	-0.0146	-0.10333	-0.08873
532	-0.01377	-0.09053	-0.07676
533	-0.01298	-0.09775	-0.08477
534	0.006036	-0.06182	-0.06786
535	-0.0253	-0.12269	-0.09739
536	-0.01574	-0.08308	-0.06734
537	-0.01587	-0.09193	-0.07607
538	-0.00624	-0.10943	-0.10319
539	-0.02241	-0.11566	-0.09325
540	-0.01453	-0.11347	-0.09894
541	-0.01399	-0.1141	-0.10011
542	-0.01882	-0.10851	-0.0897
543	-0.00976	-0.1012	-0.09144
544	-0.00474	-0.08139	-0.07665
545	-0.00099	-0.099	-0.098
546	-0.01309	-0.0988	-0.08571
547	-0.01273	-0.11446	-0.10173
548	-0.00635	-0.09273	-0.08637
549	-0.01468	-0.09505	-0.08036

550	-0.01708	-0.09849	-0.08141
551	-0.01937	-0.10904	-0.08967
552	-0.01925	-0.10518	-0.08592
553	-0.0097	-0.11037	-0.10067
554	-0.0225	-0.11486	-0.09237
555	-0.01171	-0.11488	-0.10317
556	-0.01331	-0.10241	-0.0891
557	-0.01758	-0.11133	-0.09375
558	-0.01233	-0.09746	-0.08513
559	0.000458	-0.08635	-0.0868
560	-0.01645	-0.09378	-0.07733
561	-0.02056	-0.11663	-0.09607
562	-0.01433	-0.07686	-0.06253
563	-0.00585	-0.07037	-0.06452
564	-0.01565	-0.10473	-0.08908
565	-0.00618	-0.09948	-0.09329
566	-0.01431	-0.12269	-0.10837
567	-0.01674	-0.15173	-0.13498
568	-0.01818	-0.10989	-0.09171
569	-0.00937	-0.09494	-0.08557
570	-0.00974	-0.11629	-0.10655
571	-0.01748	-0.10583	-0.08835
572	-0.01437	-0.08746	-0.07309
573	-0.01798	-0.10384	-0.08586
574	-0.00623	-0.10702	-0.10079
575	-0.0196	-0.11022	-0.09062
576	-0.02128	-0.11052	-0.08924
577	-0.01766	-0.10153	-0.08387
578	-0.01648	-0.10294	-0.08646
579	-0.00692	-0.09511	-0.08819
580	-0.01463	-0.10169	-0.08706
581	-0.01026	-0.10277	-0.09251
582	-0.01344	-0.113	-0.09956
583	-0.02389	-0.09273	-0.06884
584	-0.00724	-0.12622	-0.11898
585	-0.01991	-0.12213	-0.10221
586	-0.0064	-0.09763	-0.09122
587	-0.01213	-0.09092	-0.07879
588	-0.01351	-0.10439	-0.09088
589	-0.01348	-0.11125	-0.09778
590	-0.01081	-0.10667	-0.09586
591	-0.01413	-0.11035	-0.09622
592	-0.01938	-0.09677	-0.07739
593	-0.01956	-0.12699	-0.10743
594	-0.01203	-0.09433	-0.0823
595	-0.01853	-0.10363	-0.0851
596	-0.0122	-0.10537	-0.09317
597	-0.02989	-0.12655	-0.09666
598	-0.01291	-0.07352	-0.06061
599	-0.00733	-0.10182	-0.09449
600	-0.01316	-0.11071	-0.09755
601	-0.01005	-0.10269	-0.09263
602	-0.02423	-0.11385	-0.08962
603	-0.01605	-0.11228	-0.09624
604	-0.01484	-0.08882	-0.07398
605	-0.01128	-0.08839	-0.07711
606	-0.01419	-0.09356	-0.07937
607	-0.00608	-0.11773	-0.11165
608	-0.01846	-0.10432	-0.08586
609	-0.01497	-0.10708	-0.09211
610	-0.0187	-0.10614	-0.08744
611	-0.019	-0.09553	-0.07652
612	-0.01767	-0.11353	-0.09586
613	-0.01581	-0.10349	-0.08768
614	-0.01255	-0.1172	-0.10465
615	-0.02499	-0.11726	-0.09227

616	-0.02154	-0.10914	-0.08759
617	-0.01809	-0.11713	-0.09904
618	-0.0137	-0.10818	-0.09448
619	-0.0165	-0.09503	-0.07853
620	-0.01395	-0.11221	-0.09825
621	-0.00566	-0.09964	-0.09398
622	-0.01369	-0.10849	-0.09481
623	-0.01352	-0.12704	-0.11352
624	-0.01486	-0.11367	-0.09881
625	-0.01957	-0.12292	-0.10335
626	-0.01237	-0.11632	-0.10395
627	-0.01413	-0.10575	-0.09163
628	-0.01678	-0.1248	-0.10801
629	-0.01596	-0.10553	-0.08957
630	-0.00939	-0.09054	-0.08115
631	-0.01755	-0.09146	-0.07391
632	-0.01572	-0.11535	-0.09962
633	-0.00684	-0.1171	-0.11026
634	-0.01872	-0.1158	-0.09709
635	-0.01486	-0.11119	-0.09633
636	-0.0117	-0.10736	-0.09566
637	-0.01177	-0.11021	-0.09844
638	-0.00778	-0.09345	-0.08567
639	-0.01437	-0.08277	-0.0684
640	-0.00347	-0.09692	-0.09345
641	-0.01414	-0.08764	-0.0735
642	-0.00877	-0.11464	-0.10587
643	-0.0137	-0.11008	-0.09638
644	-0.00703	-0.12102	-0.11399
645	-0.01138	-0.10113	-0.08975
646	-0.01319	-0.1081	-0.09491
647	-0.01448	-0.09263	-0.07814
648	-0.02179	-0.10617	-0.08438
649	-0.0184	-0.10956	-0.09116
650	-0.00827	-0.09731	-0.08904
651	-0.00806	-0.09607	-0.08801
652	-0.02784	-0.12007	-0.09223
653	-0.01121	-0.09437	-0.08316
654	-0.0159	-0.11206	-0.09616
655	-0.01365	-0.09357	-0.07992
656	-0.01099	-0.10585	-0.09486
657	-0.01867	-0.0944	-0.07573
658	-0.00365	-0.10681	-0.10316
659	-0.01103	-0.10672	-0.09568
660	-0.01101	-0.1145	-0.10349
661	-0.00425	-0.09128	-0.08703
662	-0.01937	-0.10106	-0.08169
663	-0.00828	-0.11231	-0.10403
664	-0.01112	-0.09966	-0.08854
665	-0.01391	-0.11283	-0.09892
666	-0.00375	-0.10671	-0.10296
667	-0.01239	-0.1084	-0.09601
668	-0.0158	-0.1143	-0.0985
669	-0.02021	-0.11624	-0.09603
670	-0.01127	-0.10055	-0.08928
671	-0.01457	-0.11443	-0.09986
672	-0.01	-0.10315	-0.09314
673	-0.01072	-0.09739	-0.08667
674	-0.0197	-0.12235	-0.10265
675	-0.01823	-0.11419	-0.09596
676	-0.00399	-0.08188	-0.07789
677	-0.01335	-0.13018	-0.11683
678	-0.0126	-0.10348	-0.09088
679	-0.01948	-0.10191	-0.08242
680	-0.02279	-0.09926	-0.07647
681	-0.01876	-0.09626	-0.0775

682	-0.01081	-0.0852	-0.07439
683	-0.01619	-0.0871	-0.07092
684	-0.01116	-0.11263	-0.10146
685	-0.02219	-0.12795	-0.10576
686	-0.00677	-0.09759	-0.09082
687	-0.00789	-0.11506	-0.10717
688	-0.01419	-0.09331	-0.07912
689	-0.01201	-0.11168	-0.09968
690	-0.02433	-0.12124	-0.09691
691	-0.02363	-0.11273	-0.0891
692	-0.0198	-0.10353	-0.08372
693	-0.01234	-0.11112	-0.09878
694	-0.02348	-0.10764	-0.08416
695	-0.01358	-0.09868	-0.0851
696	-0.00654	-0.11015	-0.10361
697	-0.01084	-0.09811	-0.08727
698	-0.00797	-0.08458	-0.07661
699	-0.00507	-0.09112	-0.08605
700	-0.01272	-0.11219	-0.09947
701	-0.01495	-0.12515	-0.1102
702	-0.00942	-0.10467	-0.09524
703	-0.00263	-0.09949	-0.09686
704	-0.02347	-0.11811	-0.09463
705	-0.00348	-0.07374	-0.07026
706	-0.01895	-0.10136	-0.08241
707	-0.014	-0.08077	-0.06677
708	-0.00754	-0.09075	-0.08322
709	-0.00382	-0.08942	-0.0856
710	-0.01659	-0.11477	-0.09817
711	-0.01284	-0.11997	-0.10713
712	-0.01299	-0.12827	-0.11528
713	-0.01563	-0.10673	-0.09111
714	-0.00492	-0.10077	-0.09585
715	-0.0129	-0.11682	-0.10392
716	-0.01018	-0.09547	-0.08529
717	-0.01986	-0.13156	-0.1117
718	-0.01258	-0.11819	-0.10561
719	-0.02178	-0.10557	-0.0838
720	-0.02587	-0.10325	-0.07739
721	-0.01366	-0.10715	-0.09349
722	-0.01749	-0.11311	-0.09562
723	-0.02195	-0.10291	-0.08097
724	-0.01679	-0.10753	-0.09074
725	-0.01944	-0.10486	-0.08542
726	-0.00928	-0.12363	-0.11435
727	-0.0134	-0.08557	-0.07216
728	-0.01538	-0.08788	-0.0725
729	-0.01435	-0.11038	-0.09603
730	-0.00561	-0.07516	-0.06956
731	-0.01584	-0.11683	-0.10099
732	-0.01389	-0.11059	-0.0967
733	-0.021	-0.11508	-0.09409
734	-0.01229	-0.0974	-0.08511
735	-0.01524	-0.09227	-0.07704
736	-0.00967	-0.1078	-0.09813
737	-0.01563	-0.10704	-0.09141
738	-0.01587	-0.12703	-0.11116
739	-0.01568	-0.12675	-0.11107
740	-0.01191	-0.10734	-0.09543
741	-0.00867	-0.10453	-0.09586
742	-0.01083	-0.11017	-0.09935
743	-0.01607	-0.11164	-0.09557
744	-0.01291	-0.08605	-0.07315
745	-0.0088	-0.106	-0.0972
746	-0.00982	-0.10528	-0.09546
747	-0.01178	-0.09437	-0.08259

748	-0.0187	-0.12834	-0.10964
749	-0.01047	-0.10437	-0.0939
750	-0.01126	-0.12084	-0.10958
751	-0.01123	-0.11812	-0.10689
752	-0.01601	-0.1181	-0.10209
753	-0.01401	-0.1194	-0.10539
754	-0.01342	-0.10999	-0.09658
755	-0.00623	-0.09898	-0.09275
756	-0.01798	-0.10434	-0.08636
757	-0.01208	-0.12117	-0.10908
758	-0.01722	-0.11281	-0.09559
759	-0.01631	-0.09261	-0.07631
760	-0.01286	-0.10117	-0.0883
761	-0.02067	-0.08455	-0.06388
762	-0.01419	-0.10111	-0.08692
763	-0.00856	-0.08996	-0.0814
764	-0.00418	-0.10577	-0.10159
765	-0.01212	-0.1081	-0.09598
766	-0.00957	-0.07961	-0.07004
767	-0.01489	-0.09913	-0.08424
768	-0.00981	-0.08873	-0.07892
769	0.000562	-0.10866	-0.10922
770	-0.01623	-0.12317	-0.10694
771	-0.00296	-0.09956	-0.09659
772	-0.01912	-0.10962	-0.0905
773	-0.01763	-0.10464	-0.08702
774	-0.01008	-0.08783	-0.07775
775	-0.01256	-0.10588	-0.09332
776	-0.0164	-0.09755	-0.08115
777	-0.00779	-0.08854	-0.08075
778	-0.00699	-0.08989	-0.0829
779	0.003386	-0.08066	-0.08405
780	-0.02339	-0.12071	-0.09732
781	-0.00889	-0.09971	-0.09082
782	-0.01178	-0.13915	-0.12737
783	-0.01354	-0.10947	-0.09594
784	-0.01149	-0.10719	-0.0957
785	-0.01094	-0.094	-0.08306
786	-0.01227	-0.10964	-0.09737
787	-0.01678	-0.10168	-0.0849
788	-0.01247	-0.11078	-0.09831
789	-0.00908	-0.09716	-0.08809
790	-0.01851	-0.11187	-0.09335
791	-0.00898	-0.09951	-0.09053
792	-0.0096	-0.10321	-0.09361
793	-0.0119	-0.12342	-0.11152
794	-0.01562	-0.0996	-0.08398
795	-0.01048	-0.09632	-0.08583
796	-0.00837	-0.12115	-0.11278
797	-0.01265	-0.10221	-0.08956
798	-0.01369	-0.09611	-0.08241
799	-0.02073	-0.11115	-0.09042
800	-0.00985	-0.09419	-0.08434
801	-0.01623	-0.11834	-0.10211
802	-0.00287	-0.10984	-0.10696
803	-0.01641	-0.11386	-0.09745
804	-0.0183	-0.09137	-0.07307
805	-0.01664	-0.11224	-0.0956
806	-0.0258	-0.10942	-0.08362
807	-0.01196	-0.11045	-0.09849
808	-0.00746	-0.10568	-0.09822
809	-0.01276	-0.10776	-0.095
810	-0.02066	-0.11313	-0.09248
811	-0.02249	-0.10914	-0.08666
812	-0.01353	-0.09548	-0.08195
813	-0.00769	-0.11119	-0.1035

814	-0.01535	-0.10181	-0.08645
815	-0.01629	-0.12199	-0.1057
816	-0.01639	-0.11487	-0.09848
817	-0.00794	-0.10907	-0.10113
818	-0.00762	-0.09741	-0.08979
819	-0.00795	-0.11614	-0.10819
820	-0.01354	-0.09332	-0.07978
821	-0.00763	-0.08509	-0.07745
822	-0.01666	-0.10339	-0.08673
823	-0.01134	-0.08681	-0.07547
824	-0.01413	-0.09547	-0.08135
825	-0.01906	-0.09891	-0.07985
826	-0.01012	-0.11468	-0.10457
827	-0.01773	-0.11477	-0.09704
828	-0.01406	-0.09602	-0.08195
829	-0.01007	-0.10969	-0.09962
830	-0.01598	-0.10579	-0.08981
831	-0.01494	-0.11124	-0.0963
832	-0.01071	-0.10531	-0.0946
833	-0.00809	-0.09668	-0.08859
834	-0.03099	-0.11861	-0.08762
835	-0.00967	-0.0997	-0.09003
836	-0.00864	-0.08715	-0.07851
837	-0.01629	-0.11071	-0.09442
838	-0.00698	-0.09735	-0.09037
839	-0.0181	-0.09975	-0.08166
840	-0.02125	-0.10345	-0.0822
841	-0.01988	-0.10876	-0.08888
842	-0.01792	-0.11944	-0.10152
843	-0.01055	-0.13715	-0.1266
844	-0.0186	-0.10748	-0.08888
845	-0.00869	-0.11903	-0.11034
846	-0.01333	-0.08683	-0.0735
847	-0.01103	-0.10519	-0.09415
848	-0.02681	-0.12045	-0.09364
849	0.000161	-0.09325	-0.09341
850	-0.00817	-0.1041	-0.09593
851	-0.01661	-0.10616	-0.08955
852	-0.01494	-0.10997	-0.09503
853	-0.02709	-0.11762	-0.09053
854	-0.01648	-0.10442	-0.08794
855	-0.01243	-0.07007	-0.05764
856	-0.01359	-0.09419	-0.08059
857	-0.03245	-0.10698	-0.07453
858	-0.01797	-0.11157	-0.0936
859	-0.00629	-0.10487	-0.09858
860	-0.01077	-0.10247	-0.0917
861	-0.0058	-0.09014	-0.08434
862	-0.02005	-0.11741	-0.09736
863	-0.01162	-0.10733	-0.09571
864	-0.00983	-0.09898	-0.08915
865	-0.02109	-0.12502	-0.10393
866	-0.0122	-0.10043	-0.08823
867	-0.01362	-0.11829	-0.10467
868	-0.01862	-0.12643	-0.10781
869	-0.01279	-0.09963	-0.08684
870	-0.01126	-0.11308	-0.10181
871	-0.0167	-0.10741	-0.09071
872	-0.01036	-0.09572	-0.08535
873	-0.01976	-0.09989	-0.08013
874	-0.00783	-0.08314	-0.07531
875	-0.02344	-0.13336	-0.10992
876	-0.01715	-0.08464	-0.06749
877	-0.0145	-0.0892	-0.0747
878	-0.01015	-0.10872	-0.09858
879	-0.0183	-0.10283	-0.08453

880	-0.00393	-0.08048	-0.07656
881	-0.01288	-0.11249	-0.09961
882	-0.01164	-0.10507	-0.09344
883	-0.0208	-0.11219	-0.09139
884	-0.00635	-0.08488	-0.07853
885	-0.00644	-0.10474	-0.09829
886	-0.00519	-0.08278	-0.07759
887	-0.01696	-0.11113	-0.09417
888	-0.01711	-0.12223	-0.10512
889	-0.01581	-0.0994	-0.0836
890	-0.01703	-0.1126	-0.09558
891	-0.00435	-0.11653	-0.11218
892	-0.01907	-0.10995	-0.09088
893	-0.00141	-0.09547	-0.09406
894	-0.00057	-0.0928	-0.09223
895	-0.00779	-0.10233	-0.09454
896	-0.00822	-0.11902	-0.1108
897	-0.00918	-0.08287	-0.07369
898	-0.00797	-0.0923	-0.08433
899	-0.0226	-0.1215	-0.0989
900	-0.01164	-0.10726	-0.09562
901	-0.01539	-0.08447	-0.06908
902	-0.00703	-0.09288	-0.08585
903	-0.01673	-0.10955	-0.09282
904	-0.013	-0.09318	-0.08018
905	-0.01611	-0.11081	-0.0947
906	-0.01812	-0.12893	-0.11081
907	-0.02101	-0.07866	-0.05765
908	-0.01995	-0.10079	-0.08084
909	-0.00663	-0.09524	-0.08862
910	-0.01454	-0.12828	-0.11374
911	-0.01897	-0.11837	-0.0994
912	-0.02253	-0.09109	-0.06856
913	-0.01964	-0.1235	-0.10386
914	-0.01393	-0.0967	-0.08278
915	-0.00646	-0.10242	-0.09596
916	-0.01835	-0.10912	-0.09078
917	-0.02179	-0.11895	-0.09716
918	-0.01985	-0.11221	-0.09236
919	-0.00477	-0.11035	-0.10557
920	-0.02469	-0.10355	-0.07886
921	-0.01873	-0.11514	-0.0964
922	-0.01266	-0.07882	-0.06616
923	-0.02059	-0.10288	-0.08229
924	-0.01949	-0.10204	-0.08255
925	-0.01697	-0.10392	-0.08695
926	-0.00688	-0.10481	-0.09793
927	-0.0139	-0.10641	-0.09251
928	-0.01372	-0.09657	-0.08285
929	-0.01135	-0.10125	-0.0899
930	-0.01018	-0.11015	-0.09996
931	-0.00327	-0.09934	-0.09608
932	-0.02196	-0.12287	-0.10091
933	-0.01908	-0.12705	-0.10797
934	-0.00425	-0.12052	-0.11627
935	-0.01661	-0.11531	-0.0987
936	-0.01408	-0.12042	-0.10634
937	-0.00737	-0.08724	-0.07987
938	-0.018	-0.12358	-0.10558
939	-0.01916	-0.11726	-0.0981
940	-0.02447	-0.11444	-0.08998
941	-0.01006	-0.09702	-0.08695
942	0.000373	-0.09028	-0.09065
943	-0.00773	-0.11201	-0.10427
944	-0.01701	-0.09677	-0.07976
945	-0.01298	-0.10222	-0.08925

946	-0.00026	-0.08894	-0.08868
947	-0.01829	-0.10184	-0.08354
948	-0.01867	-0.09557	-0.0769
949	-0.01104	-0.10511	-0.09407
950	-0.00803	-0.11514	-0.1071
951	-0.00818	-0.09796	-0.08978
952	-0.00809	-0.10453	-0.09644
953	-0.01473	-0.08973	-0.075
954	-0.01366	-0.11338	-0.09972
955	-0.00798	-0.10584	-0.09786
956	-0.01457	-0.10532	-0.09075
957	-0.0174	-0.09226	-0.07486
958	-0.01839	-0.10051	-0.08211
959	-0.02093	-0.1159	-0.09496
960	-0.01177	-0.11999	-0.10822
961	-0.01251	-0.12042	-0.10791
962	-0.02338	-0.1068	-0.08342
963	-0.01819	-0.09899	-0.0808
964	-0.01735	-0.1156	-0.09825
965	-0.00779	-0.08466	-0.07687
966	-0.01444	-0.12405	-0.10961
967	-0.00979	-0.11115	-0.10136
968	-0.01589	-0.11603	-0.10014
969	-0.02223	-0.10259	-0.08036
970	-0.01972	-0.12794	-0.10822
971	-0.00933	-0.09657	-0.08725
972	-0.00993	-0.08614	-0.07621
973	-0.01684	-0.12322	-0.10638
974	-0.00832	-0.10251	-0.0942
975	-0.00731	-0.10178	-0.09447
976	-0.01715	-0.11979	-0.10264
977	-0.01991	-0.11836	-0.09845
978	-0.01342	-0.10603	-0.09261
979	-0.01453	-0.10281	-0.08828
980	-0.02369	-0.13197	-0.10828
981	-0.01683	-0.10371	-0.08689
982	-0.00811	-0.1102	-0.10209
983	-0.01104	-0.10799	-0.09696
984	-0.01595	-0.10661	-0.09065
985	-0.01916	-0.12985	-0.11068
986	-0.01571	-0.09026	-0.07455
987	-0.02299	-0.11107	-0.08808
988	-0.00983	-0.09705	-0.08723
989	-0.01254	-0.10588	-0.09333
990	-0.00917	-0.11019	-0.10102
991	-0.0177	-0.11063	-0.09293
992	-0.01601	-0.10258	-0.08657
993	-0.00869	-0.10251	-0.09382
994	-0.02318	-0.11537	-0.09219
995	-0.00709	-0.10577	-0.09869
996	-0.01016	-0.11415	-0.10399
997	-0.02462	-0.09987	-0.07526
998	-0.01622	-0.11937	-0.10315
999	-0.01866	-0.1237	-0.10505
1000	-0.0226	-0.11732	-0.09471

A4. Data Cleaning Methods

Here we discuss in more detail the data merging and cleaning steps performed. Details about modifying variables for regression purposes, i.e types to factors, strings, etc or aggregating specific education data to those with a bachelors or not are not discussed here but can be seen in the actual code.

1. Extracting the Raw NVCS Data of Interest

The raw NVCS Data is provided to us in one csv file per year containing all observations and variables. A typical year contains ~200,000 observations with 1190 variables. Due to the size of these files we first proceed by extracting the variables of interest for demographics, purchased vehicle, 1^{st}, 2^{nd} and 3^{rd} considered vehicles, and purchase reason questions for each year. These files are then merged to provide 6 files containing all years of data for demographics, purchased vehicle, 1^{st}, 2^{nd} and 3^{rd} considered vehicles, and purchase reason. Each observation is assigned an id number in each file to ensure they are matched correctly. In total, we have 1,497,873 observations at this point.

2. Creating and Cleaning the Fuel Economy Table

Next, we load the fuel economy data as downloaded from the fueleconomy.gov website. This file begins with 38,889 vehicles. We modify some vehicle make and model names in the table to account for inconsistencies between the NVCS naming and fueleconomy.gov. Where we have multiple observations that are identical in make, model, year, cylinders, drive and fuel type we keep only the vehicle with the lowest fuel economy. This leaves us with 20,676 unique vehicles with fuel economies.

3. Merge Fuel Economies with Survey Data

We then merge, based on year, make, model, cylinder count, drive type, and fuel type, the fuel economy data with each of the purchased and considered vehicle data frames. This gives each vehicle in our data a fuel economy if we have one that can be matched based on the information provided.

Table A-4: Percentage of Vehicles Matched with Fuel Economy

	Purchased Vehicle	Considered #1	Considered #2	Considered #3
Observed	1,497,873	348,425	136,558	63,122
Matched	1,380,121	316,861	124,591	57,789

Percentage Matched	92.14%	90.94%	91.24%	91.55%

4. Gas Price Data

Weekly historical gasoline price data is downloaded from the EIA website. For states which are not provided individually in the EIA data, we create variables named by state, to which we assign the corresponding PADD prices. For each state and region, we average the weekly prices to come up with a monthly price. Gas prices are then merged into our main survey dataframe by month, year and state.

5. Removing NAs from Data.

With all fuel economies matched and gas data added, we remove observations missing data for variables needed in any of our regressions. This ensures the same data is used for every model in the paper. The steps and observations after each removal are shown below.

Variable NAs are Removed From	**Number of Observations after Step**
Baseline	1,497,873
Education	1,186,491
Sex	1,131,774
Income	928,140
Age	915,298
Miles Driven	814,652
Principle Vehicle	810,143
Purchase or Lease	798,521
Final Purchase Price	670,537
State	670,532
Location Type	667,012
Family Size	667,012
Marital Status	664,725
Purchase Reason – Environment	654,799
Purchase Reason – Price	651,513
Purchase Reason – Maintenance	649,988
Fuel Economy of Purchased Vehicle	600,998
Consideration Set Size >= 2	210,885

The maintenance purchase reason was used in early data exploration but not included in this paper as its results did not provide meaningful related insight. However, we still dropped those observations from our dataset which did not report a maintenance purchase reason response.

A5. Gasoline Price States and Regions

States by PADD Region are listed in Table A-5 per the EIA ("PADD Regions Enable Regional Analysis of Petroleum Product Supply and Movements - Today in Energy - U.S. Energy Information Administration (EIA)" 2020)

Table A-5: PADD Regions

PADD 1A: New England	**PADD 1B: Central Atlantic**
Maine	New York
New Hampshire	New Jersey
Vermont	Delaware
Massachusetts	Maryland
Rhode Island	Pennsylvania
Connecticut	District of Columbia
PADD 1C: Lower Atlantic	**PADD 2: Midwest**
West Virginia	Ohio
Virginia	Michigan
North Carolina	Indiana
South Carolina	Kentucky
Georgia	Illinois
Florida	Tennessee
PADD 3: Gulf Coast	Minnesota
Alabama	Iowa
Mississippi	Missouri
Arkansas	North Dakota
Louisiana	South Dakota
Texas	Nebraska
New Mexico	Kansas
PADD 4: Rocky Mountain	Wisconsin
Montana	Oklahoma
Wyoming	**PADD 5: West Coast**
Colorado	Washington
Utah	Oregon
Idaho	Nevada
	California
	Arizona
	Alaska
	Hawaii

Table A-6 shows for each state if we used the PADD region value or the individual state value in our models.

Table A-6: Gas Value Used by State

State	Gas Value Used
Maine	PADD - 1A
New Hampshire	PADD - 1A
Vermont	PADD - 1A
Massachusetts	PADD - 1A
Rhode Island	PADD - 1A
Connecticut	PADD - 1A
New York	New York
New Jersey	PADD – 1B
Delaware	PADD – 1B
Maryland	PADD – 1B
Pennsylvania	PADD – 1B
District of Columbia	PADD – 1B
West Virginia	PADD – 1C
Virginia	PADD – 1C
North Carolina	PADD – 1C
South Carolina	PADD – 1C
Georgia	PADD – 1C
Florida	Florida
Ohio	PADD - 2
Michigan	PADD - 2
Indiana	PADD - 2
Kentucky	PADD - 2
Illinois	PADD - 2
Tennessee	PADD - 2
Minnesota	Minnesota
Iowa	PADD - 2
Missouri	PADD - 2
North Dakota	PADD - 2
South Dakota	PADD - 2
Nebraska	PADD - 2
Kansas	PADD - 2
Oklahoma	PADD - 2
Wisconsin	PADD - 2
Alabama	PADD - 3
Mississippi	PADD - 3
Arkansas	PADD - 3
Louisiana	PADD - 3
Texas	Texas

New Mexico	PADD - 3
Montana	PADD - 4
Wyoming	PADD - 4
Colorado	Colorado
Utah	PADD - 4
Idaho	PADD - 4
Washington	Washington
Oregon	PADD - 5
Nevada	PADD – 5
California	PADD – 5
Arizona	PADD – 5
Alaska	PADD – 5
Hawaii	PADD – 5

A6. Environmental Purchase Reason Interaction Regression

Regressions that follow the form of equations (2) and (3) where separate terms for gasoline price and purchase reason have been included, as well as their interaction terms.

Table A-7: Environmentally Friendly and Gasoline Price Interaction Coefficients for Purchased Vehicle Fuel Economy

	Variable	(1)	(2)	(3)	(4)
	EIA_Gas_Price	-0.022	-0.023	-0.001	-0.004
		(0.016)	(0.015)	(0.005)	(0.016)
Extremely	PR_ENVIR_5	-0.045	0.013	-0.010	0.001
Important		(0.039)	(0.038)	(0.040)	(0.038)
Very	PR_ENVIR_4	-0.045	-0.063*	-0.047	-0.063*
Important		(0.038)	(0.037)	(0.039)	(0.037)
Somewhat	PR_ENVIR_3	0.002	-0.055	-0.045	-0.055
Important		(0.044)	(0.037)	(0.038)	(0.037)
Not Very	PR_ENVIR_2	0.002	-0.013	0.003	-0.014
Important		(0.044)	(0.042)	(0.044)	(0.042)
Extremely	PR_ENVIR_5*	-0.219***	-0.163***	-0.216***	-0.161***
Important	EIA_Gas_Price	(0.013)	(0.012)	(0.013)	(0.012)
Very	PR_ENVIR_4*	-0.095***	-0.064***	-0.094***	-0.064***
Important	EIA_Gas_Price	(0.013)	(0.012)	(0.013)	(0.012)
Somewhat	PR_ENVIR_3*	-0.026**	-0.016	-0.026**	-0.016
Important	EIA_Gas_Price	(0.013)	(0.012)	(0.013)	(0.012)
Not Very	PR_ENVIR_2*	-0.006	-0.002	-0.007	-0.001
Important	EIA_Gas_Price	(0.014)	(0.014)	(0.014)	(0.014)
Fixed Effects		State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted		No	Yes	No	Yes
R2		0.308	0.326	0.313	0.331
Adjusted R2		0.308	0.325	0.310	0.327

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table A-8: Environmentally Friendly and Gasoline Price Interaction Coefficients for Consideration Set Vehicle Fuel Economy

	Ind. Variable	(1)	(2)	(3)	(4)
	EIA_Gas_Price	0.000	0.006	0.018	0.021
		(0.015)	(0.014)	(0.016)	(0.015)
Extremely	PR_ENVIR_5	0.053	0.095***	0.048	0.089**
Important		(0.038)	(0.036)	(0.038)	(0.036)
Very	PR_ENVIR_4	0.007	0.005	0.006	0.005
Important		(0.037)	(0.035)	(0.037)	(0.035)
Somewhat	PR_ENVIR_3	-0.021	-0.018	-0.021	-0.016
Important		(0.036)	(0.035)	(0.036)	(0.035)
Not Very	PR_ENVIR_2	0.021	0.024	0.021	0.023
Important		(0.042)	(0.040)	(0.042)	(0.040)

Extremely Important	PR_ENVIR_5* EIA_Gas_Price	-0.225*** (0.013)	-0.182*** (0.012)	-0.222*** (0.013)	-0.180*** (0.012)
Very Important	PR_ENVIR_4* EIA_Gas_Price	-0.107*** (0.012)	-0.084*** (0.011)	-0.106*** (0.012)	-0.084*** (0.011)
Somewhat Important	PR_ENVIR_3* EIA_Gas_Price	-0.035*** (0.012)	-0.031*** (0.011)	-0.035*** (0.012)	-0.031*** (0.011)
Not Very Important	PR_ENVIR_2* EIA_Gas_Price	-0.020 (0.014)	-0.021 (0.013)	-0.020 (0.014)	-0.020 (0.013)
Fixed Effects		State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted		No	Yes	No	Yes
R2		0.316	0.331	0.320	0.336
Adjusted R2		0.315	0.331	0.317	0.334

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

A7. Weighting Methodology

The weighted regressions used throughout the paper, typical referred to as models (2) and (4), use a weighting vector that was constructed as follows in an attempt to make our data match the representation given by the 2017 Federal Highway Administrations National Household Travel Survey (NHTS). Below we list the steps taken to construct this vector.

1. Determining NHTS Mean Values

We start by downloading the household, vehicle and person files for the 2017 survey from http://nhts.ornl.gov. Households that have purchased a vehicle in the last year are then determined by filtering the vehicle file to only include vehicles that are model 2016 or 2017. Since the survey is conducted in 2017 we include vehicles from 2016 as they could be within a year old. The full NHTS vehicle file contains 256,115 observations and we are left with 16,179 after excluding vehicles older than one year. Each vehicle is provided a household ID (HOUSEID) and a person ID (WHOMAIN) representing who the primary driver is. We merge the NHTS person file with our new vehicle households file by HOUSEID and WHOMAIN/PERSONID. From this we calculated mean age, race, household size, gender, income, vehicle mileage and education by taking the sum product of the respective value and the NHTS household weight and dividing it by the sum of the household weights. Since some households have more than one vehicle they will get counted twice with this method. Income is reported at the household level. For both the NHTS and the Maritz surveys, respondents indicate their income by checking a box corresponding to a range of incomes. In calculating the mean income, for both sets, we take the midpoint of this range to be the income of the respondent. The highest income option in the NHTS survey is over $200,000, while in the Maritz survey it is over $500,000. In both of these cases we take those values to be the respondent's income and as a result the NHTS mean income value will be artificially lower than the Maritz value. Therefore, we do not use it in our weighting vector and only include it in the table as a reference.

We perform the same calculation for vehicle fuel type using the FUELTYPE and HFUEL categories of the survey. In the Maritz data, we have lumped vehicles identified as flex fuel, those capable of running on E85 gasoline, with the gasoline fuel type. We do this for a couple of reasons. First, while our dataset identifies purchased vehicles as flex fuel, the Martiz survey doesn't give flex fuel as possible fuel type for the respondent to identify when listing their considered vehicles. Including flex fuel with gasoline cars doesn't pose a serious issue to our models as most consumers likely don't differentiate between the two either. Since flex fuel vehicles can run on both regular gasoline and E85, and there are approximately 3,500 E85 gas stations in the United States, compared to 111,000 conventional fuel stations it is also likely that the majority of the time flex fuel cars are fueled with regular gasoline ("Alternative Fuels Data Center: E85 (Flex Fuel)" 2020; "Number of Gasoline Stations in the U.S." 2020). This is supported in a 2014 study, that showed even when E85 was available drivers only refuel with it around 25% of the time(Daley et al. 2014). Finally, while E85 has a lower fuel intensity and fewer emissions, its average fuel economy is lower than a conventional gasoline vehicle. Therefore, the effect of gasoline prices on the adoption of a flex fuel vehicle should behave similarly to conventional gasoline vehicles.

2. Determining Weights

The weights for our regression were then determined using the anesrake package in R. We use the default values raking with the "total" method, type "pctlim" and a convergence criterion of 0.01. We achieve convergence in 12 iterations. Our target weight vectors are set from the NHTS means as follows:

Gender = (Male = 0.486, Female = 0.514)

Race = (White = 0.807, Non-White = 0.193)

Education = (Bachelor's Degree or Higher = 0.529, Less than a Bachelor's = 0.471)

Vehicle Fuel Type = (Gasoline = 0.943, Diesel = 0.020, Hybrid = 0.022, Plug-in Hybrid = 0.007, Electric =0.006, Other = 0.002)

A8. Purchase Reason Weighting Demographics

	PR_ENVIR_1	PR_ENVIR_2	PR_ENVIR_3	PR_ENVIR_4	PR_ENVIR_5
Observations	18,034	27,300	66,407	57,914	41,230
% Male	82.1%	79.2%	73.4%	68.7%	62.1%
% White	86.1%	87.4%	85.6%	82.4%	75.5%
Bachelor’s Degree or Higher	62.9%	67.4%	64.3%	63.3%	59.5%
Avg. Income	$149,593	$151,403	$139,252	$138,667	$119,542

	PR_PRICE_1	PR_PRICE_2	PR_PRICE_3	PR_PRICE_4	PR_PRICE_5
Observations	938	2,500	22,658	75,190	109,599
% Male	74.6%	80.1%	77.7%	74.4%	67.8%
% White	82.3%	87.6%	87.4%	86.0%	80.0%
Bachelor’s Degree or Higher	64.5%	72.3%	69.1%	66.0%	60.1%
Avg. Income	$158,246	$178,255	$159,245	$141,167	$124,473

A9. Consideration Set Minimum, Maximum, and Purchase Percent of Range Segmented by Purchase Reasons

Table A-9: Gasoline Coefficients for Consideration Set Minimum, Maximum and Purchase Percent of Range Segmented by Environmental Purchase Reason

	Variable		(1)	(2)	(3)	(4)
Extremely Important	PR_ENVIR_5	CS Min	-0.222***	-0.160***	-0.208***	-0.150***
			(0.012)	(0.011)	(0.013)	(0.012)
		CS Max	-0.184***	-0.127***	-0.161***	-0.108***
			(0.013)	(0.012)	(0.014)	(0.013)
		CS Perc	0.025***	0.029***	0.025***	0.023***
		Range	(0.006)	(0.006)	(0.007)	(0.007)
Very Important	PR_ENVIR_4	CS Min	-0.112***	-0.084***	-0.099***	-0.075***
			(0.012)	(0.011)	(0.013)	(0.012)
		CS Max	-0.089***	-0.065***	-0.066***	-0.046***
			(0.013)	(0.012)	(0.014)	(0.013)
		CS Perc	0.018***	0.023***	0.018**	0.017**
		Range	(0.006)	(0.006)	(0.007)	(0.007)
Somewhat Important	PR_ENVIR_3	CS Min	-0.045***	-0.037***	-0.033**	-0.027**
			(0.012)	(0.011)	(0.013)	(0.012)
		CS Max	-0.032***	-0.022*	-0.009	-0.004
			(0.013)	(0.012)	(0.014)	(0.013)
		CS Perc	0.010	0.015**	0.006	0.009
		Range	(0.006)	(0.006)	(0.007)	(0.007)
Not Very Important	PR_ENVIR_2	CS Min	-0.018	-0.015	-0.005	-0.005
			(0.012)	(0.011)	(0.013)	(0.012)
		CS Max	-0.002	-0.003	0.021	0.022*
			(0.013)	(0.012)	(0.014)	(0.013)
		CS Perc	0.004	0.011*	0.001	0.005
		Range	(0.006)	(0.006)	(0.007)	(0.007)
Not at All Important	PR_ENVIR_1	CS Min	-0.008	-0.005	0.005	0.005
			(0.012)	(0.011)	(0.014)	(0.013)
		CS Max	0.017	0.022*	0.040***	0.040***
			(0.013)	(0.012)	(0.014)	(0.013)
		CS Perc	0.011*	0.019***	0.008	0.012*
		Range	(0.006)	(0.006)	(0.007)	(0.007)
Fixed Effects			State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted			No	Yes	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

Table A-10: Gasoline Coefficients for Consideration Set Minimum, Maximum and Purchase Percent of Range Segmented by Price Purchase Reason

	Ind. Var.	Dep	(1)	(2)	(3)	(4)
Extremely Important	PR_PRICE_5	CS Min	-0.088*** (0.012)	-0.064*** (0.011)	-0.073*** (0.014)	-0.051*** (0.013)
		CS Max	-0.067*** (0.013)	-0.043*** (0.012)	-0.041*** (0.014)	-0.022* (0.013)
		CS Perc Range	0.015** (0.006)	0.021*** (0.006)	0.011 (0.007)	0.014** (0.007)
Very Important	PR_PRICE_4	CS Min	-0.100*** (0.012)	-0.075*** (0.011)	-0.086*** (0.014)	-0.063*** (0.013)
		CS Max	-0.079*** (0.013)	-0.054*** (0.012)	-0.054*** (0.014)	-0.034** (0.013)
		CS Perc Range	0.015** (0.006)	0.020*** (0.006)	0.011 (0.007)	0.013* (0.007)
Somewhat Important	PR_PRICE_3	CS Min	-0.131*** (0.012)	-0.099*** (0.011)	-0.116*** (0.014)	-0.087*** (0.013)
		CS Max	-0.103*** (0.013)	-0.071*** (0.012)	-0.077*** (0.014)	-0.050*** (0.013)
		CS Perc Range	0.017*** (0.006)	0.021*** (0.006)	0.013* (0.008)	0.015** (0.008)
Not Very Important	PR_PRICE_2	CS Min	-0.185*** (0.014)	-0.141*** (0.013)	-0.171*** (0.015)	-0.129*** (0.014)
		CS Max	-0.135*** (0.014)	-0.100*** (0.013)	-0.110*** (0.016)	-0.080*** (0.015)
		CS Perc Range	0.022*** (0.007)	0.027*** (0.007)	0.018** (0.008)	0.020*** (0.008)
Not at All Important	PR_PRICE_1	CS Min	-0.168*** (0.016)	-0.122*** (0.015)	-0.154*** (0.017)	-0.111*** (0.016)
		CS Max	-0.125*** (0.017)	-0.080*** (0.016)	-0.100*** (0.018)	-0.059*** (0.017)
		CS Perc Range	0.022** (0.008)	0.027`*** (0.008)	0.019** (0.009)	0.020** (0.009)
Fixed Effects			State, Month, Year	State, Month, Year	State, Month, Year State x Month State x Year	State, Month, Year State x Month State x Year
Weighted			No	Yes	No	Yes

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis

A10. Gasoline Coefficient for Purchasing from the Bottom, Top and Upper Half of the Consideration Set Fuel Economy

Table A-11: Logit Gasoline Coefficients and Percent Odds Change by Segment for Purchases from the Top, Bottom and Upper Half of Consideration Set Range

Data Segment	Top of Range	Bottom of Range	Upper Half of Range
All Observations	0.063**	-0.062**	0.060**
	(0.026)	(0.027)	(0.018)
	6.5%	-6.0%	6.1%
Low Fuel Economy Purchases	0.057	-0.065	0.057
	(0.034)	(0.033)	(0.034)
	5.9%	-6.3%	5.9%
High Fuel Economy Purchases	-0.008	0.046	-0.027
	(0.045)	(0.050)	(0.048)
	-0.8%	4.7%	-2.7%
PR_ENVIR_5	0.104***	-0.098***	0.098***
	(0.026)	(0.027)	(0.027)
	11.0%	-9.3%	10.3%
PR_ENVIR_4	0.076***	-0.073***	0.071***
	(0.026)	(0.027)	(0.026)
	7.9%	-7.1%	7.4%
PR_ENVIR_3	0.043	-0.042	0.039
	(0.026)	(0.027)	(0.026)
	4.3%	-4.1%	4.0%
PR_ENVIR_2	0.016	-0.024	0.015
	(0.027)	(0.027)	(0.027)
	1.7%	-2.3%	1.6%
PR_ENVIR_1	0.044	-0.048*	0.047*
	(0.027)	(0.027)	(0.027)
	4.5%	-4.6%	4.9%
PR_PRICE_5	0.063**	-0.059**	0.059**
	(0.026)	(0.027)	(0.026)
	6.5%	-5.7%	6.1%
PR_ PRICE _4	0.061**	-0.061**	0.057**
	(0.026)	(0.027)	(0.026)
	6.3%	-5.9%	5.9%
PR_ PRICE _3	0.069***	-0.070***	0.068**
	(0.027)	(0.027)	(0.027)
	7.1%	-6.7%	7.0%
PR_ PRICE _2	0.078***	-0.098***	0.088***
	(0.029)	(0.030)	(0.030)
	8.1%	-9.3%	9.2%
PR_ PRICE _1	0.099***	-0.084**	0.085**
	(0.034)	(0.035)	(0.035)
	10.4%	-8.0%	8.9 %

***Significant at the 1% level, ** Significant at the 5% level, *Significant at the 10% level, SE's in parenthesis