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Do High Gas Prices Sell Small Cars? Performance: An Empirical Study of the Impact of Fuel Prices on Automotive Sales

Nate Wheatley, '10
Illinois Wesleyan University

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Abstract

This paper explores the impact of fuel prices on vehicle sales by model from 2005 to 2009 at quarterly intervals across four major auto manufacturers: Ford, Toyota, Honda and General Motors.

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NATE WHEATLEY

I. Introduction

How much is a gallon of gas this week? Only some people bother to ask that question and an even smaller number actually care months later how much gas costs today. A recent study by Kurani and Turrentine (2004) clarifies the relatively blasé attitude most people appear to have about fuel economy and it is stated thusly:

> "It is clear that for most households, fuel expenditures are not tracked over time, rather are perceived through refueling events. That is knowledge of fuel costs appears to more commonly be episodic and ephemeral; the largest group of people can recall the price of their last tank, and last gallon, of gasoline. However they do not sum or integrate these costs over time, and we observed that the certainty with which even these numbers were offered appeared to depend on how long ago the last refueling event occurred. Refueling done in the past few days appear to provoke quicker, more confident responses than refueling done earlier" (Kurani and Turrentine 2004).

Environmentalists complain that Americans care too little about the relatively poor mileage of our vehicle fleet. In a report by the World Resource Institute presented at the National Renewable Energy Laboratory, the United States had the lowest average fuel economy of all nations compared at a projected 25 miles per gallon for 2007 (Sauer 2005). Other nations' standards were planned to be much higher for the same time period, including Canada at 30 MPG, China at 35, the EU at 42, and Japan tops the list with a stratospheric 46 MPG (Sauer 2005). The United States is reliant on imports for 57% of net petroleum needs, and 32% of all petroleum is destined for transportation use (United States Energy Information Administration 2009). With this in mind, it is important to ask in what ways the United States can lower its petroleum imports. One method is to reduce petroleum usage, and a big target for reductions is the United States' vehicle fleet. Various proposals to accomplish this have included fuel taxes (Dahl 1979 p427-432), mileage taxes (Fullerton 2002 p135-157), engine-size taxes (Fullerton 2002 p135-157) and emissions taxes (Jansen 1999 p379-396). Most of these would apply on the consumer side, as federal gas guzzler taxes already exist to "discourage the production and purchase of fuel inefficient vehicles" (United States Environmental Protection Agency). For clarification, these taxes are collected directly "from car manufacturers or importers," not consumers, although such an entity may pass along the tax in the vehicle's purchase price (United States Environmental Protection Agency 2009). Fuel economy is mandated on the producer side, but what about consumers? We always say that we want more miles to the gallon, especially when gas prices jump. But do American consumers put their money where their mouths are? When gas prices rise, do vehicle sales change accordingly? This paper explores the impact of fuel prices on vehicle sales by model from 2005 to 2009 at quarterly intervals across four major auto manufacturers: Ford, Toyota, Honda and General Motors.

Between 2005 and 2009, the average nominal price for regular unleaded fuel in the United States changed drastically from a low of 159 cents/gallon to a high of 405.4 cents/gallon (United States Energy Information Administration 2009). Generally, economics demands that inflation be accounted for and prices converted from nominal to real using the CPI or similar index, but based on research by

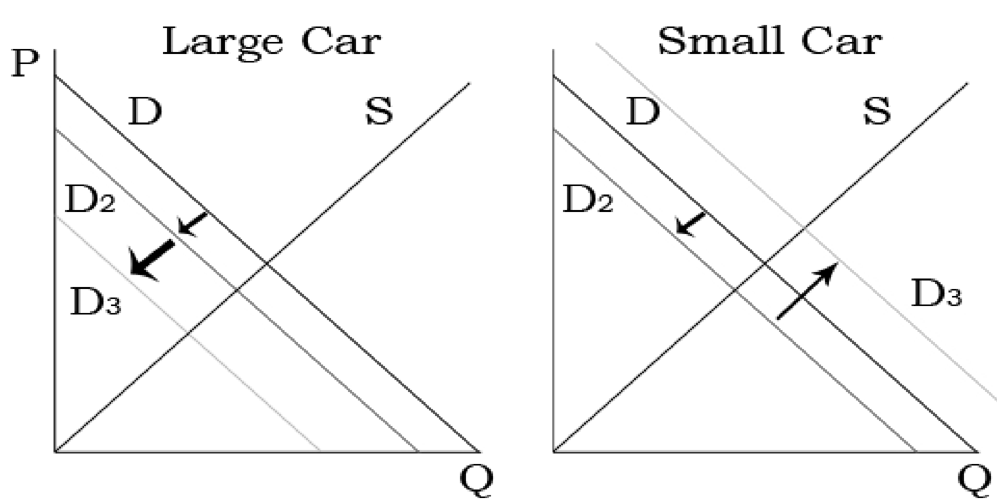
Kurani and Turrentine (2004), it is the belief of this author that because of the way consumers relate to fuel prices, use of "real" prices is not necessary. Consumers "do not sum or integrate [fuel] costs over time, and we observed that the certainty with which even these numbers were offered appeared to depend on how long ago the last refueling event occurred" (Kurani and Turrentine 2004). In fact, "knowledge of fuel costs appears to more commonly be episodic and ephemeral; the largest group of people can recall the price of their last tank, and last gallon, of gasoline" not the cost of gas last month, last year or when the most recent vehicle purchase was made (Kurani and Turrentine 2004). Consumers do not view fuel prices beyond the last gallon or last tank, so it is reasonable to conclude consumers respond to nominal fuel prices, rather than real fuel prices, at the time of a vehicle purchase. Hence, the regressions that will be performed for this study will contain nominal fuel prices.

II. Theory

"Economic theory predicts a direct link between fuel prices and SUV sales, and more broadly between fuel prices and vehicle sales" since a vehicle is a product which requires a constant input in order to obtain value from it (McManus 2007). Many products require some kind of "maintenance payment" in order to do what the consumer purchased the product to do. Homes need repair, computers use electricity, stoves require natural gas and college courses are only useful when the student has the necessary textbooks. Thus, when a consumer purchases a product, it would be rational to consider the cost of inputs to the product, as opposed to *only* the upfront sticker price of the product. More specifically, a "vehicle's services (mobility) require the ongoing input of fuel" which the rational consumer should consider before buying (McManus 2007). Further, when the price of fuel goes up, vehicle owners are worse off since the price of an input they require now uses more of their discretionary income than it did before. When consumers are worse off, they are less likely to spend, and consequently this would have a negative impact on auto sales. Gas costs more so people feel poorer. What does this do to vehicle sales? Theory suggests two effects: a negative income effect depressing the sales of *all* vehicles and a substitution effect which results from the higher price of the "ongoing input," shifting sales away from those products needing more of this input to products using less (McManus 2007).

These effects will alter the demand for automobiles. Both will work to reduce the demand for large vehicles as a result of an increase in fuel prices, but will have ambiguous effects on small vehicles. Income effects occur as a result of decreased consumer wealth. When people are worse off, they purchase fewer goods and services regardless of what those goods and services might be. Cars are an expensive item, so decreased incomes due to high fuel prices will tempt consumers to "make do" with the vehicles they have by putting off or even scrapping intended vehicle purchases. Substitution occurs when consumers swap one product for another which is functionally equivalent in the eyes of the substituting consumer. Theoretically, some vehicles that would have been purchased are not, and in other cases consumers choose a different vehicle than the one they were originally planning on. In both cases changes in demand are a reaction to fuel prices, pushing down sales of vehicles in the aggregate but also shifting sales among different models—some gain while others lose.

Figure 1: Hypothesized Change in Demand for Cars by Size



The graphs in Figure 1 above detail what happens to demand "D" for Large Cars and Small Cars as fuel prices increase. The "D_2" line on both graphs represents the income effect, while the "D_3" line on both graphs represents the hypothesized substitution effect. As fuel prices rise, consumers are relatively poorer since fuel costs soak up more of their disposable income. Demand across all vehicles drops from D to D_2 due to the income effect. However, since Large Cars and Small Cars differ in their required input of fuel, worse-off consumers will, if forced to purchase a vehicle, choose vehicles which are less expensive to run. Thus, some sales of large vehicles which would have taken place had fuel prices remained constant do not, while sales of small cars increase as reflected in the shift from D_2 to D_3 on both graphs.

If consumers do in fact engage in substituting behavior, then an increase in fuel prices should shift demand for large cars to the left and shift demand for small cars to the right. Increasing fuel prices should then always decrease the sales of large cars but increase the sales of small cars if the substitution effect does in fact dominate the income effect.

I. Literature Review

Past research has focused on the demand for gasoline as a function of household variables (Kayser 2000), the economic impact of fuel economy standards such as CAFE (Portney et al. 2003), how attempts to increase gas prices in the United Kingdom through taxes have impacted demand for greater fuel efficiency (Witt 1997), how changing fuel prices affects market share of varying types of vehicle classes (Busse et. al. 2008), whether using rational choice theory in discussion of how consumers relate to fuel economy is appropriate (Kurani and Turrentine 2004) and finally commentary on the motivations of hybrid vehicle owners (Kurani and Turrentine 2004). There are two studies which concern themselves with a direct link between sales and gas prices using multiple regression (Witt and Busse). The first is dated as well as slightly off-topic, being from 1997 and discussing the United Kingdom (Witt 1997). The second is more relevant, because it is both recent and focused on the United States (Kurani and Turrentine 2004). Turrentine and Kurani ran a series of interviews for their 2004 study which covered fuel economy but the report contains no statistics and has a generalizability problem since the sample size was 57 households in California and thus not representative. Therefore my paper will try to take the discussion in a slightly different direction by looking at American sales data, which leaves a large amount of room for analysis.

Kayser's measurement of household demand for gasoline found "the price elasticity of gasoline demand is low in the short-run" in addition to noting that "income is a significant explanatory variable for the fuel efficiency of a household's car fleet" (Kayser 2000 p331-348). This suggests gasoline taxes might or might not achieve the desired goal of reducing fuel consumption. Kayser further writes that "there are clear differences in gasoline demand across the population" depending on several factors (all of which increase consumption) including living in a rural area, having no public transportation nearby and having both members of the household employed (Kayser 2000 p331-348). His conclusion for policy-makers was to treat different households differently. The working poor would be hit especially hard by a gasoline tax or carbon fee, but with this knowledge formulation of policy could take these factors into account to compensate those who would be unfairly disadvantaged (as determined by those writing the law) for the higher prices they would pay.

Portney's research, on the other hand, discussed the overall social-welfare impact of the Corporate Average Fuel Economy standard, while simultaneously writing of the rationale for fuel economy standards in general (Portney et al. 2003). On the grounds of macroeconomic stability against oil price shocks, mitigating the market power of unfriendly states controlling oil markets, concern for the environment and market failure regarding fuel economy, Portney's study supports some kind of intervention above and beyond what the market would provide on its own (Portney et al. 2003). There is also discussion of unintended consequences of the law, including the possibility of double-accounting for externalities by imposing standards on top of fuel taxes which theoretically might take care of the problem of gasoline overconsumption (Portney et al. 2003 p203-217). Further, by lowering the cost of driving by improving mileage, CAFE may actually be causing people to drive *more*, mitigating potential carbon and fuel use savings (Portney et al. 2003). The conclusion is that fuel economy standards *could* improve welfare in the future, but "mak[ing] a watertight case for tightening fuel economy standards now, based on externality grounds alone" is "difficult" (Portney et al. 2003 p203-217). Interestingly, alternatives to the CAFE standard are also discussed. A proposal not mentioned in any other literature found thus far consists of tradable "fuel economy credits" (similar to a cap-and-trade scheme to control pollution)

which would both permit the government to set a goal for fuel economy while allowing theoretically more efficient market forces to decide how to get there (Portney et al. 2003 p203-217). Reducing fuel consumption can also be accomplished by reducing driving. Insurance where "charges would be based on annual miles driven" as opposed static monthly bills would reduce fuel demand, with the caveat "that [the policy] provides no incentives to improve fuel economy, as it penalizes miles driven rather than fuel use" (Portney et al. 2003 p203-217). The final suggestion is raising or altering gasoline taxes. "The problem with gasoline taxes, of course, is not economic but political," and noting the relatively inelastic demand for gasoline, a high tax might only bring a small benefit (Portney et al. 2003 p203-217). Continuing with the topic of gasoline taxes, a study by Witt of drivers in the UK concluded "petrol price increases [whether from market forces or taxes] will have little effect on fuel efficiency" (Witt 1997). In fact, Witt cites another study which "provided some US evidence that corporate average fuel economy standards [are] more effective than petrol prices in influencing vehicle manufacturers to achieve increases in fuel economy" (Witt 1997). Though fuel taxes look like a solution to consumption problems on paper, they neither discourage driving nor influence suppliers in a significant enough manner to accomplish their goal within reasonable limits.

Busse et. al. have created a preliminary study evaluating changes in market share of various vehicle "segments" (which are defined as Compacts, Midsize, Luxury, Sporty Cars, SUVs, Pickups and Vans), found "a meaningful shift in the composition of segment shares in response to a gasoline price change that is well within the magnitude of changes seen in the last decade" (Busse et. al. 2008). Further, there was "no statistically significant effect for luxury or sporty cars" because either "luxury and sporty cars both gain and lose as a result of gasoline price changes" or "fuel efficiency is simply not a decision criterion for the purchase of luxury cars and sporty cars, or that buyers who buy such cars are fairly insensitive to the price of gasoline, perhaps because they are wealthier than the average car buyer" (Busse et. al. 2008). In either case, this study should show similar results: change in the sales of vehicles should be linked to fuel prices. If a vehicle is "luxurious" and/or "sporty" then such changes will be minimal, if they appear at all. It is important to note that some of these models, especially sporty vehicles, require premium gasoline. This paper will only deal with vehicles which use Regular Unleaded (which does include some luxury vehicles such as Cadillacs, but excludes the Chevrolet Corvette).

Kurani and Turrentine (2004) have done extensive research on consumer attitudes regarding vehicles. The principal finding of their 2004 study on California households was that "we can no longer afford the luxury of the assumption that so many consumers are behaving in an economically rational manner that such rationality is the sole sufficient basis for policy formulation and analysis" with regard to fuel economy (Kurani and Turrentine 2004). Either consumers are engaging in "limited" rationality, or more radically, they assert that should gasoline prices rise, "buyers respond in surprising, i.e., non-economically rational, ways" (Kurani and Turrentine 2004).

IV. Empirical Model

In order to test the impact of fuel prices directly on vehicle sales, one would expect many controls for factors such as brand, engine type/size, vehicle class and more since there is indeed great variance among the hundreds of choices in the market for automobiles. However, this study uses sampling selection to minimize the number of control variables required by breaking vehicles down by make, then model, and only after applying these sampling controls running regressions against sales data. For example, comparing a Honda Civic to a Chevy Silverado would require many controls for vast differences between the vehicles. However, holding a 2005 Honda Civic against another 2005 Honda Civic is not going to yield too many differences. While the 2010 Civic compact car is available in three basic trim levels (each split into two sub-levels), Honda's reported EPA ratings do not vary between the trim levels (American Honda Motor Co. 2009). Even the variance between automatic transmissions and manual transmissions is very small, 2 MPG or less depending on whether the comparison is city mileage or highway mileage (American Honda Motor Co. 2009). Such discussion is included to show that intra-model fuel economy variance is small enough to be ignored, in this author's opinion. Fuel prices only matter because of how much fuel a vehicle uses, and since the difference in fuel usage is negligible for the purpose of this study all vehicles within a single make/model can be compared against each other on this particular attribute, because it does not vary enough to warrant special attention. The goal is to explain vehicle sales by using the price of fuel. For the purposes of this study vehicle sales have been sampled (*not* averaged) on a quarterly basis (Jan-Apr-Jul-Oct). However, since fuel prices change during the same period when vehicle prices (as measured by MSRP) do not, they have been *averaged* on a quarterly basis. All vehicles in the

sample set run on regular fuel and the mean difference between the price of "regular unleaded" and "regular unleaded reformulated" which is required in certain areas to reduce pollution (United States Environmental Protection Agency 2008) is 5.7% since November 1994 when the EPA began measuring the price of Reformulated Gas (United States Energy Information Administration) the price of gas used will be regular non-reformulated unleaded. This is the best source of fuel price data available—it is the most comprehensive freely available database for this type of information.

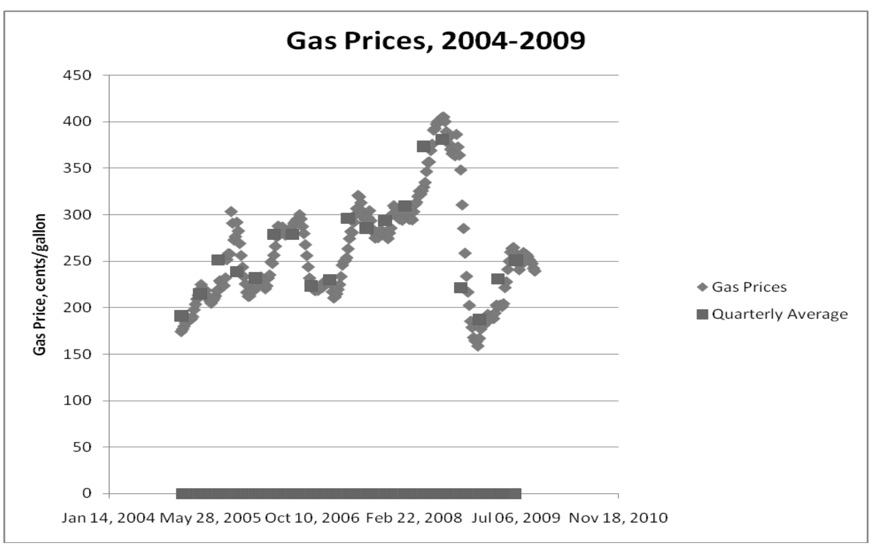
Vehicle sales have been pulled from publically-available information, mostly press releases from the automakers themselves. Because different automakers make available varying data-sets in varying forms, the period of analysis for each automaker is slightly different. However, the period of analysis for each vehicle within a single automaker is constant. It would be ideal to have a larger sample of automakers as well as a longer time period, but because of the paucity of freely available data before 2005, this is not possible. Further, not all automakers make sales data readily available—Chrysler comes to mind for their scatter-shot approach to sales figures which are handled by a third party. Only a year's worth of data is available for this automaker, which led me to exclude them from the sample. The final weakness of this data set is that it had to be generated by copying data from Adobe PDF files and Excel files into a single master database, so transcription errors are possible.

The model itself is extremely simple since it has been established that sampling selection controls for relevant vehicle-characteristic variables, in addition to the fact that intra-model variance (leather trim high-end versus cloth trim basic, for example) does not contribute to significant variance in fuel economy.

$$\text{Sales} = \beta_0 + \beta_1(\text{Fuel Price}) + \varepsilon$$

In this model, Sales is the monthly sale of a specific car model sampled quarterly between the time periods of January 2005 to April 2009. The time period varies between automakers due to the availability of data but within each automaker, the time period is held constant. Fuel prices are measured in nominal cents per gallon, averaged across each quarter. Figure 2 shows the difference between "quarterly average" and "monthly" gas prices is not large.

Figure 2: Nominal Gas Prices, 2004 to 2009



Note: The large number of "zero" points in the Quarterly Average is due to an Excel aberration that I cannot fix; it thus insists on displaying "zero" cents per gallon on all months that are not the quarterly sample (i.e. not January, April, July, October

V. Results

An abbreviated table without all of SPSS 18's output is produced in Table 1 below, divided by vehicle size.

Table 1: Regression Results

Dependent: Quarterly Sales by Model, Independent: Average Quarterly Gasoline price

Model	Constant	Coefficient	T-Statistic	Adj. R-Squared	Time Period
Small Cars					
Chevy Aveo	183.085	17.902***	3.006	0.321***	Jan05-Apr09
Honda Civic	-1473.796	105.660***	3.780	0.425***	Jan05-Jul09
Honda Civic Hybrid	-586.861	11.242**	2.765	0.270**	Jan05-Jul09
Toyota Yaris	26.838	25.808***	3.397	0.448***	Jan06-Jul09
Toyota Corolla	14037.627	55.506	1.596	0.100	Jan06-Jul09
Midsize Cars					
Model	Constant	Coefficient	T-Statistic	Adj. R-Squared	Time Period
Chevy Cobalt	3073.074	47.182*	1.888	0.131*	Jan05-Apr09
Ford Focus	3776.687	40.601*	2.028	0.147*	Jan05-Jul09
Ford Mustang	8114.829	8.239	0.480	-0.045	Jan05-Jul09
Honda Accord	2014.554	105.174***	4.516	0.519***	Jan05-Jul09
Toyota Camry	14379.328	77.845**	2.162	0.208**	Jan06-Jul09
Toyota Prius Hybrid	-1812.673	51.217***	3.167	0.392***	Jan06-Jul09
Large Cars					
Model	Constant	Coefficient	T-Statistic	Adj. R-Squared	Time Period
Buick LaCrosse	5917.196	-4.74	-0.353	-0.054	Jan05-Apr09
Cadillac CTS	1895.588	10.298**	2.2292	0.200**	Jan05-Apr09
Chevy Impala	15911.901	18.712	0.810	-0.021	Jan05-Apr09
Ford Crown Victoria	2833.246	7.162	1.121	0.014	Jan05-Jul09
Ford Taurus	19264.210	-40.129	-1.424	0.060	Jan05-Jul09
Toyota Avalon	4892.582	0.113	0.003	-0.077	Jan06-Jul09
Small and Midsize SUVs/Crossovers					
Model	Constant	Coefficient	T-Statistic	Adj. R-Squared	Time Period
Chevy Equinox	8000.814	-0.511	-0.031	-0.062	Jan05-Apr09
GMC Envoy	7823.595	-12.409	-0.774	-0.024	Jan05-Apr09
Ford Escape	-42043.565*	228.101***	2.912	0.294***	Jan05-Jul09
Honda Pilot	8039.765	6.442	0.403	-0.049	Jan05-Jul09
Honda CRV	5738.589	36.264**	2.871	0.287**	Jan05-Jul09
Honda Element	3256.485	-0.495	-0.077	-0.058	Jan05-Jul09
Toyota RAV4	8908.905	13.929	1.163	0.025	Jan06-Jul09
Toyota FJ Cruiser	3622.118	-0.711	-0.074	-0.083	Jan06-Jul09
Toyota 4Runner	4927.638	2.476	0.182	-0.074	Jan06-Jul09
Toyota Highlander	6527.068	10.027	0.982	-0.003	Jan06-Jul09
Full-Size SUVs					
Model	Constant	Coefficient	T-Statistic	Adj. R-Squared	Time Period
Cadillac Escalade	1797.301	2.214	0.497	-0.046	Jan05-Apr09
Cadillac Escalade ESV	692.280	1.083	0.498	-0.046	Jan05-Apr09
Chevy Suburban	4726.238	3.667	0.329	-0.055	Jan05-Apr09
Chevy Tahoe	7840.381	9.585	0.468	-0.048	Jan05-Apr09
Chevy Avalanche	3762.522	0.595	0.061	-0.062	Jan05-Apr09
Ford Expedition	8394.319	-7.663	-0.485	-0.044	Jan05-Jul09
Ford Explorer	15809.306	-18.361	-0.595	-0.037	Jan05-Jul09
Toyota Sequoia	801.995	4.772	1.610	0.102	Jan06-Jul09

Table 1 Continued

Trucks / Vans

Model	Constant	Coefficient	T-Statistic	Adj. R-Squared	Time Period
Chevy Colorado	8761.974	-7.025	-0.444	-0.050	Jan05-Apr09
Chevy Silverado	41601.824	12.529	0.161	-0.061	Jan05-Apr09
GMC Canyon	2581.416	-2.690	-0.640	-0.036	Jan05-Apr09
GMC Sierra	12108.059	10.989	0.426	-0.051	Jan05-Apr09
Ford F-Series	52881.994	3.434	0.035	-0.059	Jan05-Jul09
Ford Ranger	6898.475	-0.139	-0.010	-0.059	Jan05-Jul09
Ford E-Series	9806.482	9.222	0.610	-0.036	Jan05-Jul09
Honda Odyssey Minivan	6129.400	22.771	1.492	0.064	Jan05-Jul09
Honda Ridgeline	2099.543	3.972	0.699	-0.031	Jan05-Jul09
Toyota Sienna Minivan	6915.607	12.593	1.066	0.010	Jan06-Jul09
Toyota Tacoma 2WD	3415.066	13.634*	1.803	0.138*	Jan06-Jul09
Toyota Tacoma 4WD	3649.243	6.713	1.746	0.128	Jan06-Jul09
Toyota Tundra	-1971.137	48.143**	2.419	0.257**	Jan06-Jul09

* - Significant at 0.10 level   ** - Significant at 0.05 level   *** - Significant at 0.01 or better

It is interesting to note that the hypothesis of dueling effects which would have seen the coefficient of gas prices on large vehicles show up as negative and the coefficients on smaller vehicles be positive as fuel prices increase *did not hold*. In fact, with many larger vehicles the sign of the coefficient was the opposite of what the hypothesis predicted. This was not a wash, however, as a different effect was observed. Sales of smaller vehicles are quite responsive to changes in nominal fuel prices. For each cent increase in fuel prices, all Small and Midsize Cars have positive coefficients, which was as predicted. All but two (Toyota Corolla in the Small Cars category and the Ford Mustang in the Midsize Cars category) are significant. All Small Car regressions which have significance reach the 0.01 level or better. The best example of a smaller car's sales being explained by nominal fuel prices is actually a Midsize Car, the Honda Accord sedan. The regression itself explains 51.9% of the variance while maintaining significance at the 0.01 level. This general trend carries across all four automakers: the bigger the vehicle, the lower the significance and explanatory power of fuel prices in the sales of said vehicle. There are two stand-outs in the chart above: the Toyota Tundra and Toyota Tacoma 2WD trucks have statistically significant coefficients and unexpected positive signs. While outliers are not something to ignore, further analysis is beyond the scope of this paper and is best saved for future research.

VI. Conclusion

The hypothesis of substitution effects outweighing income effects was sustained, since regressions for smaller and midsized vehicles generally had the expected coefficient direction and were statistically significant. However, there were many unexpected signs on coefficients for larger cars, though very few rose to any level of statistical significance. These findings support the 2008 study of Busse et. al. who found significant changes in market share of varying types of vehicles with a specific note that "Overall there is a meaningful shift in the composition of segment shares in response to a gasoline price change that is well within the magnitude of changes seen in the last decade" (Busse et. al. 2008). Kurani and Turrentine's contention that "consumers…engage in a limited or bounded type of economically rational decision making" doesn't hold up as well since buyers of small cars seem to be quite rational (Kurani and Turrentine 2004). Furthermore, if a consumer understands that a vehicle will use a large amount of gasoline, but purchases said vehicle anyway during a time of high nominal fuel prices, said input prices are not deterring the person from the purchase and so these prices would have little explanatory power over said purchase. It is worth noting that since small car sales respond positively to higher gas prices while sales of large cars are statistically indeterminate against fuel prices, some substitution may be occurring even if the model used in this study did not detect it. Cars are not inexpensive goods, which makes the market for them much more finite and limited than, say, the market for chewing gum. If consumers are definitively purchasing more of one type of vehicle (smaller cars) then the sales have to be subtracted from someplace else in the market (larger vehicles), unless one creates a theory that high gas prices brought in a whole new crop of consumers who bought all the small cars (but weren't active in the market before the fuel price

surge), leaving sales of larger cars unchanged. This seems highly improbable, so while no firm statistical evidence was found for substitution, it is unwise to assert that it did not take place based solely on this model's not finding any. Witt's 1997 work lends some credibility to the previous logical inference, as his conclusion states "an increase in the price of petrol decreases demand for larger cars" (Witt 1997). It is important to note, though, that this study does *not* support Witt's work during the analyzed time period as no negative relationship between fuel prices and sales of larger vehicles was observed.

It is also possible to assert that fuel prices are better for explaining the sale of smaller vehicles than larger ones. As to why, there are many possible explanations. One involves selection bias—those who purchase smaller vehicles care more about fuel prices in the first place and this is a demonstration of that attitude. Another may revolve around vehicle price since smaller vehicles tend to be priced lower (a Focus is cheaper than an F150 if the trim is comparable, since it takes fewer materials to build a physically smaller vehicle). Though this is a rough guess on "small is always less expensive than large" since there was no vehicle pricing in this study, as a general rule the more expensive the vehicle, the lower the explanatory power of fuel prices. This supports a study mentioned by Kurani and Turrentine, which said "In general, the higher the price of the vehicle, the less important is fuel economy" so it can be inferred that fuel prices matter little to the purchasers of luxury vehicles such as the Cadillac Escalade (standard and ESV) whose beta coefficients against fuel prices were positive (Kurani and Turrentine 2004).

VII. Policy Implications

This paper can be interpreted as qualified support for high fuel taxes. It is a definite conclusion that sales of small vehicles rise with the price of gas, so overall fuel economy should increase under a situation where fuel is taxed heavily as people try to avoid the tax by using less fuel (by buying more fuel-efficient vehicles). What is missing is definitive statistical proof that these smaller car sales are eating into the total number of larger vehicles sold, as discussed in the Conclusion. There is another subject which merits discussion at this point. CAFE standards have affected driver safety since the mandate for greater fuel economy has led to lighter vehicles (Yun 2002). The quickest method for getting more miles per gallon is to decrease the amount of weight the engine has to move around. The highest recorded EPA mileage in a gasoline non-hybrid vehicle was the 1989 Honda CRX at 50MPG, but that was due mostly to its lack of features such as air conditioning, passenger compartment reinforcements and the like (Gold 2006). In the modern day, Ford "ran a computer simulation on what would happen to the mileage of a Ford Focus small car if you built it entirely out of lightweight aluminum" and found "fuel economy on this fabulous Focus went from 35mpg to 50mpg" (Naughton 2008). The downside is that machining the vehicle from aluminum would cost $50,000, "not a sum the typical economy-car buyer is willing to pay" (Naughton 2008). As of the writing of this paper, the same fuel economy can be had for half this price in the form of a 2010 Toyota Prius Hybrid (Edmunds.com 2009). Imagine what an aluminum Prius would be capable of! Making cars lighter does save fuel, but there is a trade-off in vehicle safety. Larger cars tend to "crash better" since there is more steel to get in the way of an oncoming vehicle and stop it from smashing the occupants of the vehicle it is hitting. However, the "lightening" of the United States vehicle fleet has not had nearly as grim of consequences as one might think. An empirical study by John Yun shows CAFE standards can be directly credited for a 6.11% net *decrease* in accident fatalities (Yun 2002 p260-270). This is because consumers engage in so-called "offsetting behavior," summed up as in terms of safety thus: "regulations do reduce the probability of death given an accident, but drivers offset this gain with more risky driving" (Yun 2002). Yun applies this same principle to the supposedly-less-safe vehicles produced under CAFE and finds though vehicles are lighter, drivers in aggregate are more careful because of this, leading to a decrease in annual fatalities. It appears people who consider, consciously or subconsciously, fuel prices in vehicle purchases are willing to buy lighter, supposedly-less-safe vehicles. Fuel economy standards are not harmful market distortions like some opponents claim, since it appears there is a class of people for which fuel prices and economy are important who will gladly buy the smaller, "less safe" cars which are influenced by the Corporate Average Fuel Economy standard.

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