



POLICY & ACTION FROM CONSUMER REPORTS

Investigation of Relationship between Fuel Economy and Owner Satisfaction

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Executive Summary

In the spring of 2016 researchers at Consumer Reports decided to study the question: Does fuel economy impact owner satisfaction for cars, trucks and SUVs?

There are a number of factors that can affect satisfaction levels. For example, having a number of mechanical issues might lower overall satisfaction levels, even if a car is very efficient. And engine performance (horsepower) might increase satisfaction, at the expense of fuel economy.

To do their analysis, the research team looked at Consumer Reports car test data determine fuel economy levels and then analyzed survey responses from approximately 1 million Consumer Report members who owned a tested vehicle. The analysis measured satisfaction based on the number of owners who said they would buy their car again.

Using statistical modeling, the researchers were able to identify the association between several vehicle attributes – fuel economy, acceleration, horsepower, reliability and price – and owner satisfaction. Holding all other factors constant, their analysis found a strong positive correlation between owner satisfaction and fuel economy.

To help validate the statistical analysis, the report also looked at satisfaction compared to the fuel economy as reported by owners of the same vehicle. This helped isolated any difference that might exist across different types of vehicles. Again, owners who experienced better fuel economy reported higher levels of satisfaction.

For example, for the 2014-2015 Hyundai Genesis, 45% of owners who reported achieving 15 MPG were satisfied with their car. Satisfaction jumps to 70% for owners report achieving 30 MPG. Similarly, owner satisfaction for 2014-2015 Ford Fusions ranged from 45% (achieving 15 MPG) to 70% (30 MPG). The increase in satisfaction tied to higher fuel economy was found among owners of all vehicle types – cars, SUVs, pickup truck and vans.

Demonstrating that car and truck buyers value fuel economy over other characteristics is an important finding for federal and state regulators to consider as they review CAFE fuel economy requirements for model years 2022-2025.

Introduction

This report is a summary of the analysis of the surveys conducted by Consumers Union of U. S., Inc.¹ It evaluates the relationship between owner satisfaction and fuel efficiency. The analysis is based on responses to the 2015 Consumer Reports (CR) Annual Questionnaire (AQ) conducted in the spring of 2015; a follow-up survey conducted during the following summer; and road-test data performed by CR's Auto Test Center (ATC). The follow-up survey was sent to all 2015 AQ automobile respondents and a random subset of subscribers who did not respond to the initial survey. The final dataset consisted of approximately 1 million records and represents the population of CR subscribers.

Though many additional factors determine owner satisfaction, our analysis evaluates the relationship between owner satisfaction and the following vehicle attributes:

- a. Fuel economy
- b. Acceleration
- c. Horsepower
- d. Mechanical problems
- e. CR's road-test score
- f. CR's tested price

Since the ATC data is only available for a subset of vehicles, the analysis is done in two parts. The first part is an evaluation of vehicle factors affecting owner satisfaction vs. CR's fuel efficiency estimates using a statistical model to identify the association between the six vehicle attributes listed above and owner satisfaction.

The second analysis is a vehicle-specific evaluation of owner satisfaction vs. owner-reported fuel efficiency using the full survey dataset. It is based on differences in owner-reported fuel efficiency within the same vehicle model and hence is not affected by differences in vehicle attributes.

For both analyses, owner satisfaction is defined as the percentage of respondents who would definitely buy their vehicle again and mechanical problems is defined as the number of vehicle components with reported serious problems during the previous twelve months. As we show, the results of both analyses are mutually consistent.

¹ This work was supported in part by the Energy Foundation.

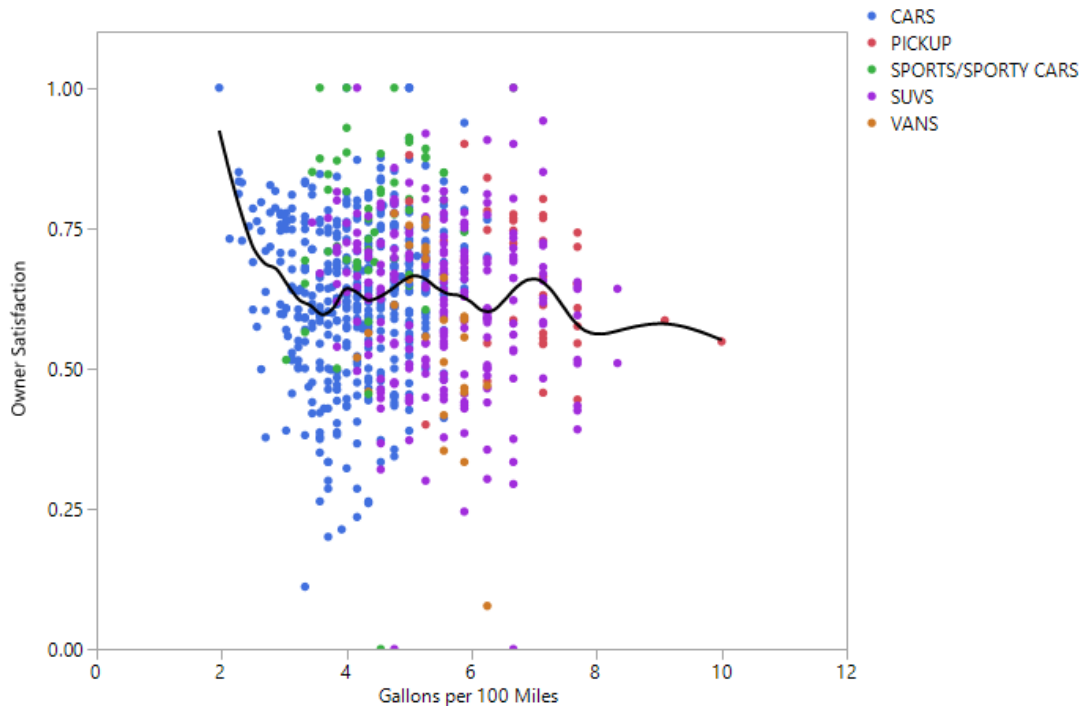
When analyzing and interpreting the importance of fuel efficiency and other attributes on owner satisfaction, three potential perspectives should be considered:

- (1) Given similar or identical vehicles, are consumers more satisfied with higher fuel efficiency?
- (2) Given vehicles that are substantially different, are consumers more satisfied with the more fuel-efficient vehicles?
- (3) Does fuel efficiency influence consumer decision to purchase one vehicle model over another? (Further research would be required to answer this question.)

Data Overview

An exploratory analysis was performed to identify potentially significant relationships. Responses were aggregated by unique vehicle model. Vehicles were categorized as cars (excluding electric and plug-in hybrids), sports/sporty cars, pickups, SUVs, and vans (minivans). Figure 1a shows the relationship between owner satisfaction and gallons per 100 miles driven,² grouped by vehicle type. The black smooth line is a “lowess” (locally weighted scatterplot smoother) curve that shows the general trend between owner satisfaction and gallons per 100 miles. Note: Vehicles that require more gallons per 100 miles are less fuel-efficient.

Figure 1a: Owner Satisfaction vs. CR Gallons per 100 Miles



² Gallons per 100 miles is a better metric because it is linear, rather than the asymptotic miles per gallon.

For clarity, Figure 1b displays the relationship between owner satisfaction and gallons per 100 miles, plotted separately for each vehicle type. While Figure 1a shows a positive trend between owner satisfaction and fuel efficiency, Figure 1b shows a more complex relationship that requires the use of statistical modeling. In particular, note that vehicles with high satisfaction can be found across the entire range of fuel efficiency.

Figure 1b: Owner Satisfaction vs. CR Gallons per 100 Miles

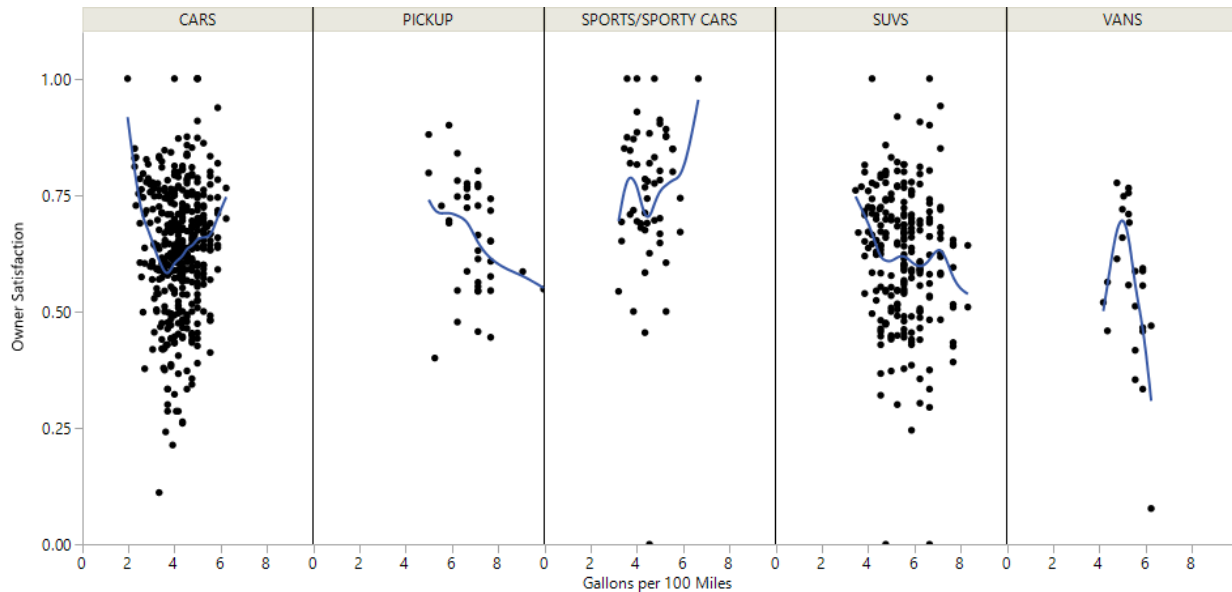


Figure 1c: CR Gallons Per 100 Miles vs. Mechanical Problems

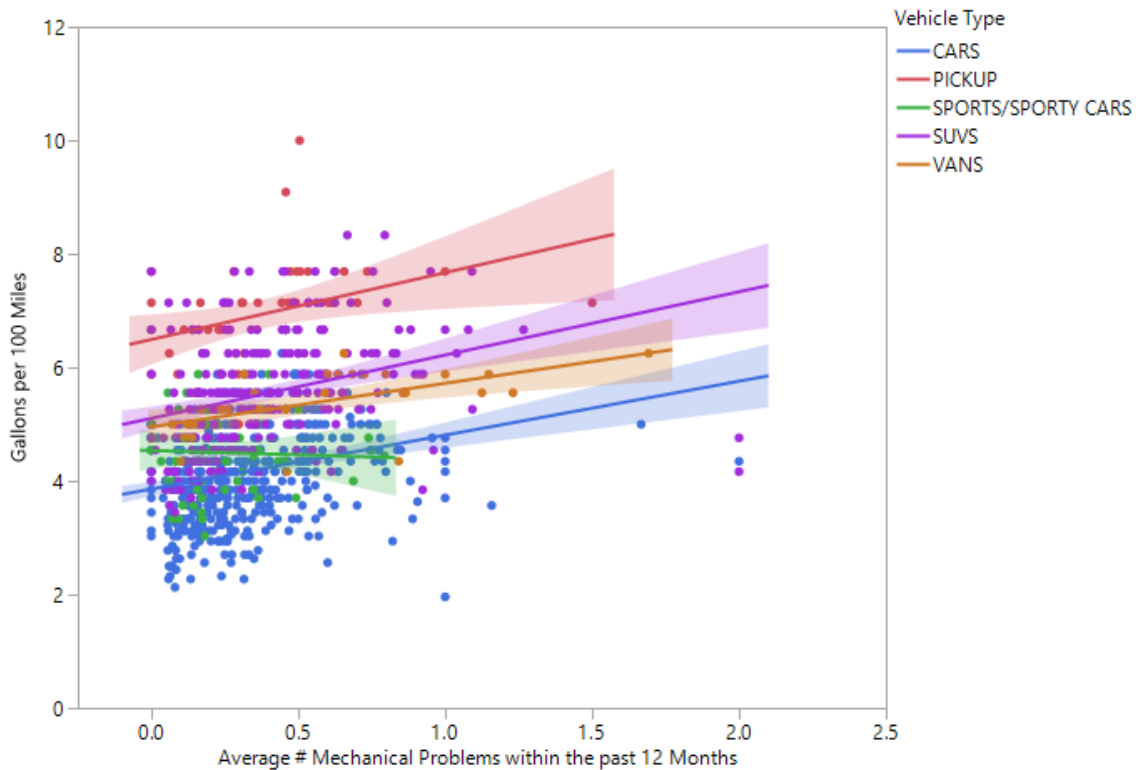


Figure 1c shows the relationship between fuel efficiency and the number of vehicle components experiencing a serious mechanical problem during the previous 12 months. Though the graph does not imply cause and effect, it does show the importance of adjusting for the impact of mechanical problems when evaluating owner satisfaction and fuel efficiency.

Analysis of Cars:

This section reports on the analysis of responses from 281,146 car owners. A multiple regression analysis was used to account for the simultaneous effect of the variables on owner satisfaction. The results are summarized in Table 2a below. (Horsepower is not included in the final model since it is highly correlated with acceleration.) Although the number of mechanical problems has the largest effect on overall satisfaction, all of the variables included in Table 2a are highly statistically significant.

Table 2a: Multiple Regression Analysis Results Cars³

Type III Tests of Fixed Effects (Response: Overall Satisfaction)				
Effect	Num DF	Den DF	F Value	Pr > F
VehicleSubcat	7	91336	26.83	<.0001
Gal100Mil (VehicleSu)	8	91336	87.38	<.0001
Model Year	8	91336	50.96	<.0001
Mech Probs	1	91336	3163.56	<.0001
Price1000	1	91336	15.03	0.0001
CR Acceleration	1	91336	34.80	<.0001
CR RoadTestScore	1	91336	54.30	<.0001

Table 2b and 2c provide an intuitive way of displaying the relationship between owner satisfaction and fuel efficiency. These tables show predicted owner satisfaction at different fuel-consumption rates, while fixing all other vehicles attributes at an average level. Caution should be used when interpreting these tables because these attributes tend to vary simultaneously and it may not be possible to find vehicles with price, acceleration, and CR road-test score near their average values across the entire range of MPG. It is therefore most realistic to compare predictions between adjacent rows in these tables.

³ Tables 2a and 3a are based on the subset of respondents with CR road-test vehicles

Table 2b: Predicted Owner Satisfaction by MPG for 2014 Cars

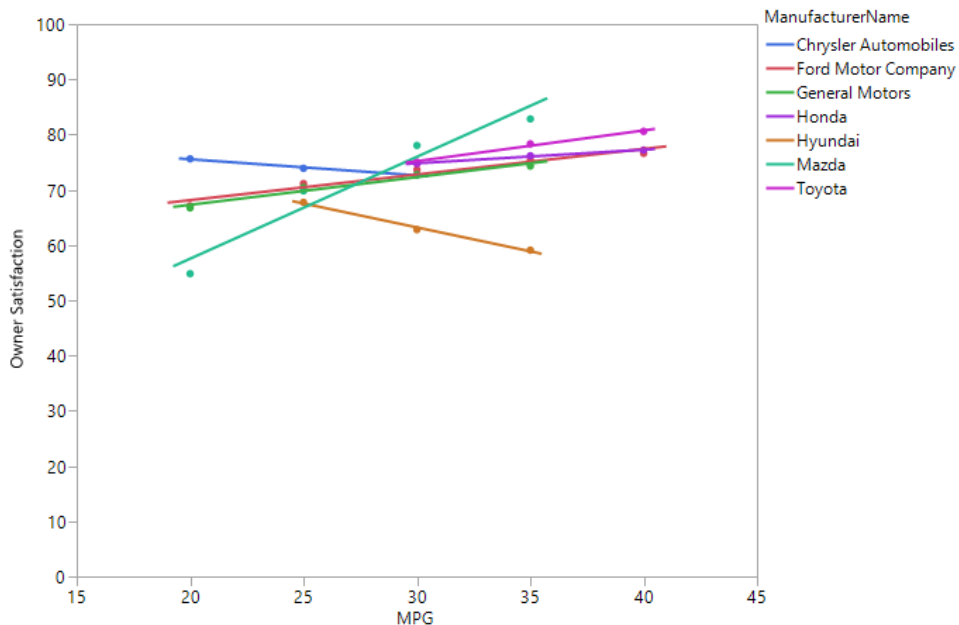
Model Year	MPG	Gal/100 Miles CR	Mech Probs	Price 1000	CR Acceleration	CR Road-Test Score	Satisfaction	Delta
2014	25.0	4.00	0.00	28.09	8.59	77.90	72.59	
2014	30.0	3.33	0.00	28.09	8.59	77.90	76.43	3.84
2014	35.0	2.86	0.00	28.09	8.59	77.90	78.94	2.51
2014	40.0	2.50	0.00	28.09	8.59	77.90	80.68	1.74

Table 2c: Predicted Owner Satisfaction by MPG (2009 to 2015)

MPG	Gal/100 Miles CR	Mech Probs	Price 1000	CR Acceleration	CR Road-Test Score	Satisfaction	Delta
25.0	4.00	0.00	28.09	8.59	77.90	69.45	
30.0	3.33	0.00	28.09	8.59	77.90	73.57	4.12
35.0	2.86	0.00	28.09	8.59	77.90	76.28	2.71
40.0	2.50	0.00	28.09	8.59	77.90	78.19	1.91

Figure 2a below shows predicted owner satisfaction vs. MPG for selected manufacturers based on their current car offerings. (We do not provide a similar analysis for other vehicle types because of the limited number of models that some manufacturers offer in those categories.)

Figure 2a: Owner Satisfaction vs. CR MPG by Manufacturer (Cars Only)

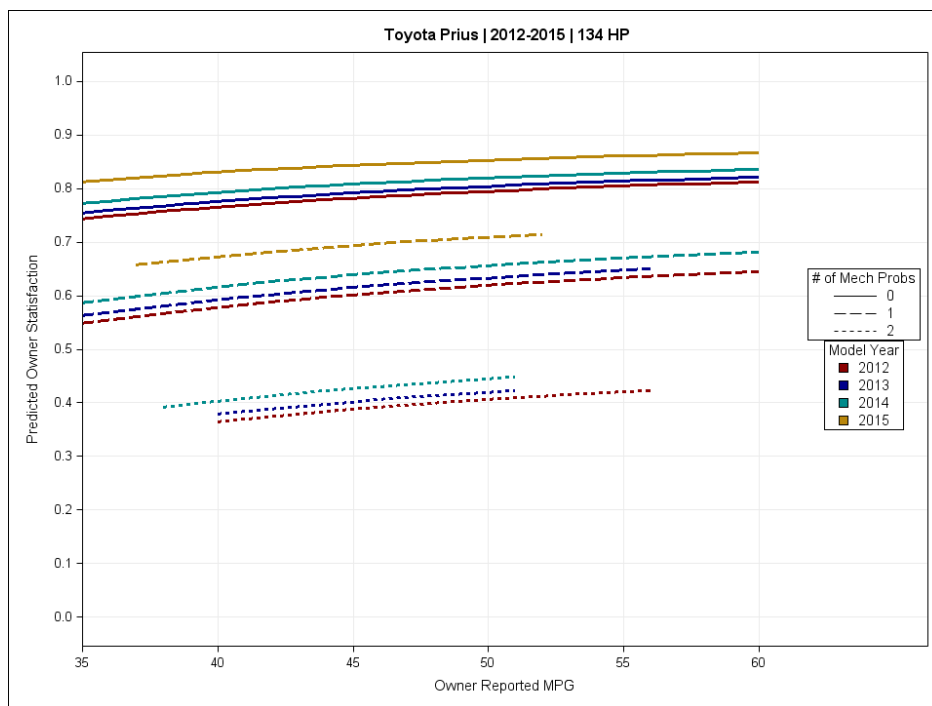


The results of our second analysis—vehicle-specific owner satisfaction vs. owner-reported MPG—is presented below. The advantage of this approach is that the relationship between owner satisfaction and MPG is unaffected by differences in vehicle type. This analysis is based on a generalized mixed model using unique car model as a random blocking factor.

The graphs below display the results of this analysis. For brevity, we include only graphs for a subset of representative car models. As shown, owner satisfaction is positively associated with reported MPG, although the strength of the relationship varies for different car models. This implies that owners who experience better fuel economy—or think they do—are more likely to purchase the same vehicle again. Overall, this provides an independent confirmation of the results in the first analysis.

Figure 2b shows predicted owner satisfaction vs. reported MPG based on 5,234 Toyota Prius owners. Separate curves are shown for each model year and for vehicle components with 0, 1, and 2 or more serious mechanical problems.

**Figure 2b: Predicted Owner Satisfaction vs. Reported MPG
(Toyota Prius: Model Years 2012 to 2015, 134 HP)**



Note the strong negative relationship between owner satisfaction and reported serious mechanical problems as illustrated by the three groupings of curves. The top grouping shows the relationship between owner satisfaction and reported MPG for cars that have zero components with a serious mechanical problem. For that case, the predicted owner satisfaction ranges from a low of approximately 77 percent for a reported 35 MPG to a high of approximately 83 percent for a reported 60 MPG.

Figure 2c shows the predicted owner satisfaction vs. reported MPG based on 196 Ford Fusion owners. For cars that have zero components with a serious mechanical problem, the predicted owner satisfaction ranges from a low of approximately 65 percent for owners who reported 20 MPG to a high of approximately 80 percent for drivers who reported 35 MPG.

**Figure 2c: Predicted Owner Satisfaction vs. Reported MPG
(Ford Fusion: Model Years 2014 to 2015, 181 HP)**

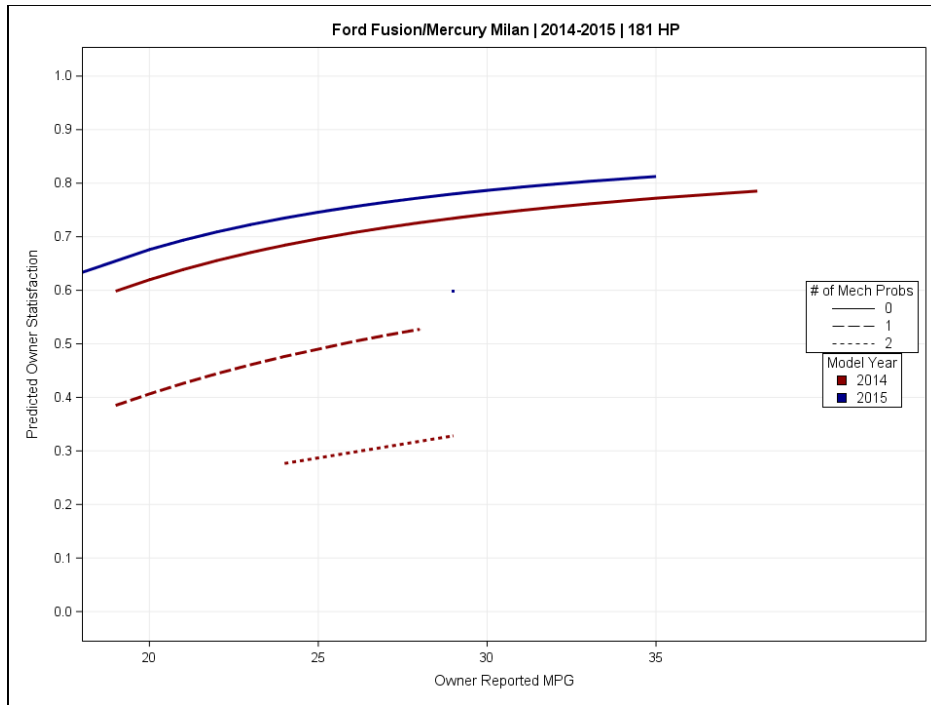
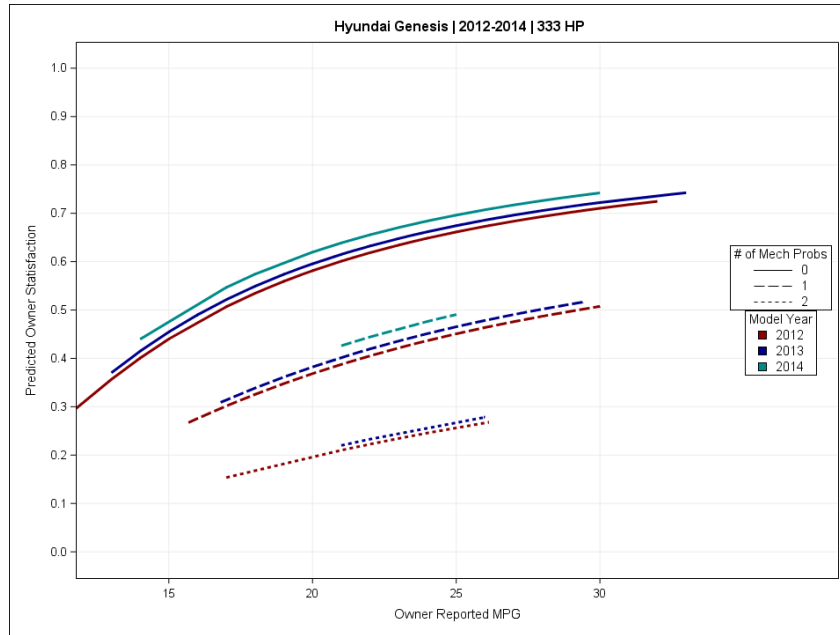


Figure 2d shows predicted owner satisfaction vs. reported MPG based on 701 Hyundai Genesis owners. For cars that have zero serious mechanical problems, the predicted owner satisfaction ranges from approximately 45 percent for owners who reported 15 MPG to approximately 70 percent for drivers who reported 30 MPG.

**Figure 2d: Predicted Owner Satisfaction vs. Reported MPG
(Hyundai Genesis: Model Years 2012 to 2014, 333 HP)**



Overall, this analysis shows that owners tend to report higher satisfaction as their reported MPG increases.

Analysis of SUVs

This section reports on the analysis of responses from 224,455 SUV owners. The results of the multiple regression analysis are shown in Table 3a.

Table 3a: Multiple Regression Analysis Results, SUVs⁴

Type III Tests of Fixed Effects (Response: Owner Satisfaction)				
Effect	Num DF	Den DF	F Value	Pr > F
VehicleSubcat	8	66346	20.30	<.0001
Gal100Mil (VehicleSu)	9	66346	22.43	<.0001
Model Year	6	66346	34.97	<.0001
Mech Probs	1	66346	2681.49	<.0001
Price1000	1	66346	44.22	<.0001
CR Acceleration	1	66346	2.55	0.1106
CR_Road-Test Score	1	66346	16.89	<.0001

⁴ Supra n.3

Table 3b and 3c below show the predicted owner satisfaction for MPG ratings between 15 and 30 MPG. The tables show an increase in owner satisfaction as fuel efficiency increases at a decreasing rate.

Table 3b: Predicted Owner Satisfaction by MPG for 2014 SUVs

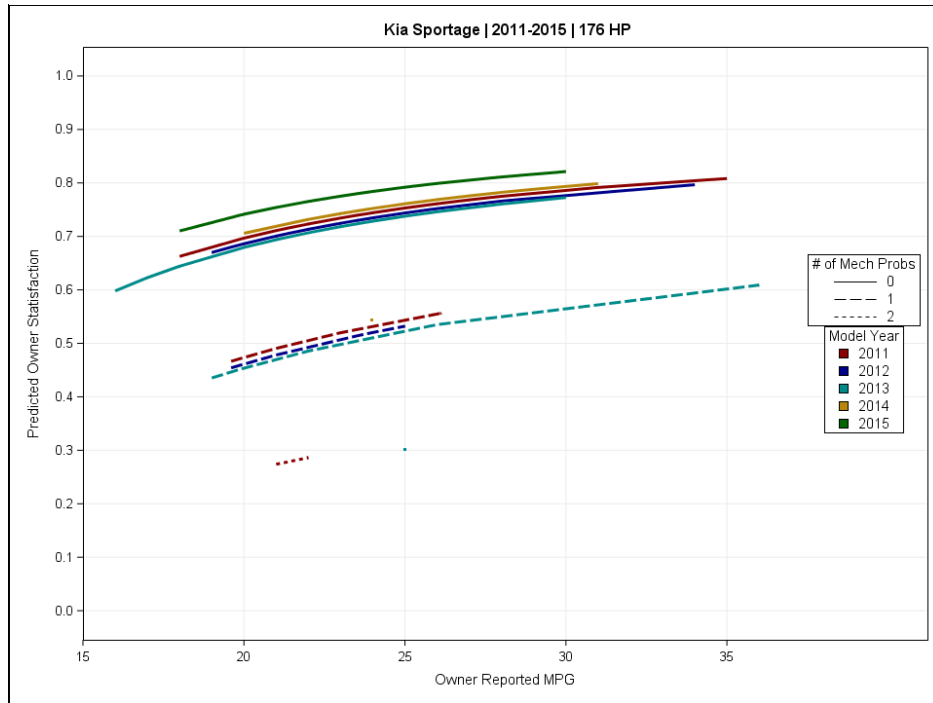
Model Year	MPG	Gal/100 Miles CR	Mech Probs	Price 1000	CR Acceleration	CR Road-Test Score	Satisfaction	Delta
2014	15.0	6.67	0.00	35.98	8.49	75.91	67.72	
2014	20.0	5.00	0.00	35.98	8.49	75.91	73.05	5.38
2014	25.0	4.00	0.00	35.98	8.49	75.91	75.97	2.92
2014	30.0	3.33	0.00	35.98	8.49	75.91	77.80	1.83

Table 3c: Predicted Owner Satisfaction by MPG (2009 to 2015)

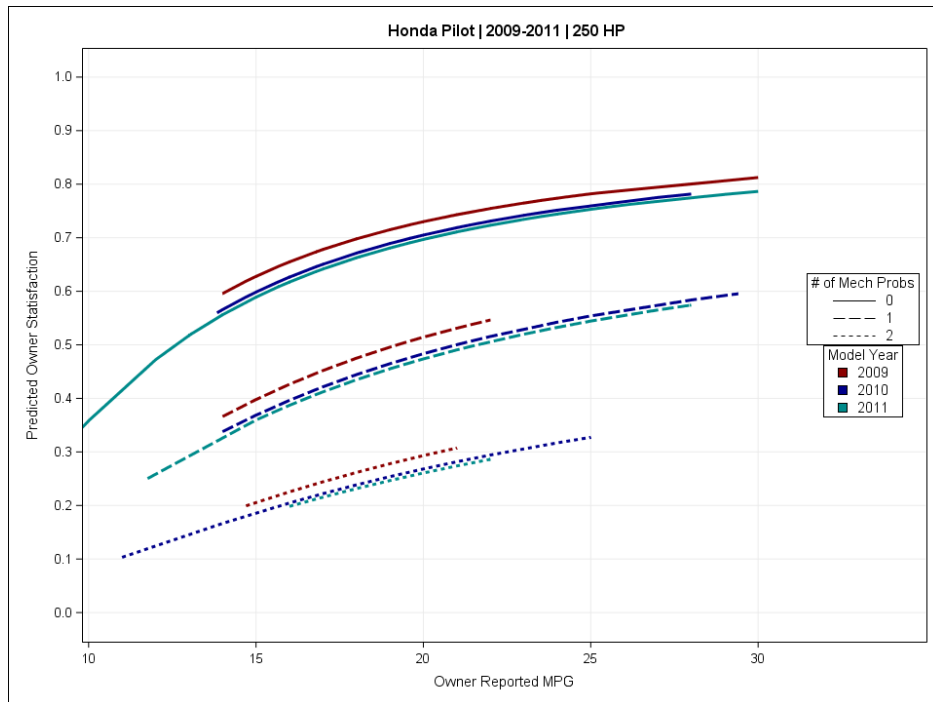
MPG	Gal/100 Miles CR	Mech Probs	Price 1000	CR Acceleration	CR Road-Test Score	Satisfaction	Delta
15.0	6.67	0.00	35.98	8.49	75.91	67.77	
20.0	5.00	0.00	35.98	8.49	75.91	73.10	5.33
25.0	4.00	0.00	35.98	8.49	75.91	76.02	2.92
30.0	3.33	0.00	35.98	8.49	75.91	77.84	1.82

Figures 3a to 3c display owner satisfaction vs. reported MPG for three representative SUVs: small, midsized, and large. As seen in the analysis of cars, there is a strong statistically significant positive association between owner satisfaction and owner-reported MPG.

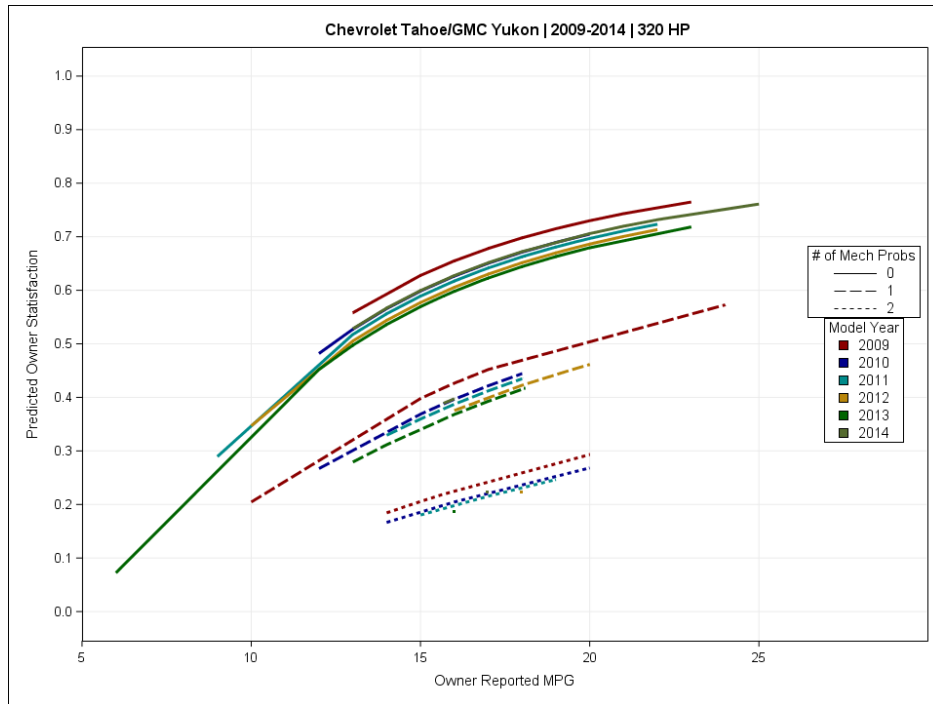
**Figure 3a: Predicted Owner Satisfaction vs. Reported MPG
(Kia Sportage: Model Years 2011 to 2015, 176 HP)**



**Figure 3b: Predicted Owner Satisfaction vs. Reported MPG
(Honda Pilot: Model Years 2009 to 2011, 250 HP)**



**Figure 3c: Predicted Owner Satisfaction vs. Reported MPG
(Chevrolet Tahoe/GMC Yukon: Model Years 2009 to 2014, 320 HP)**

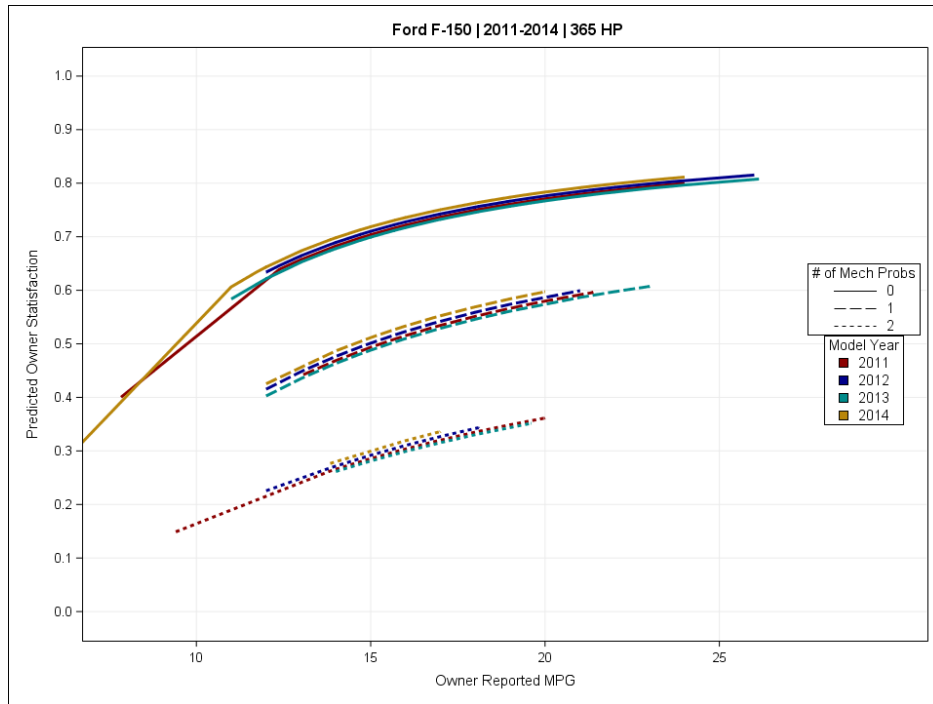


Analysis of Pickup Trucks

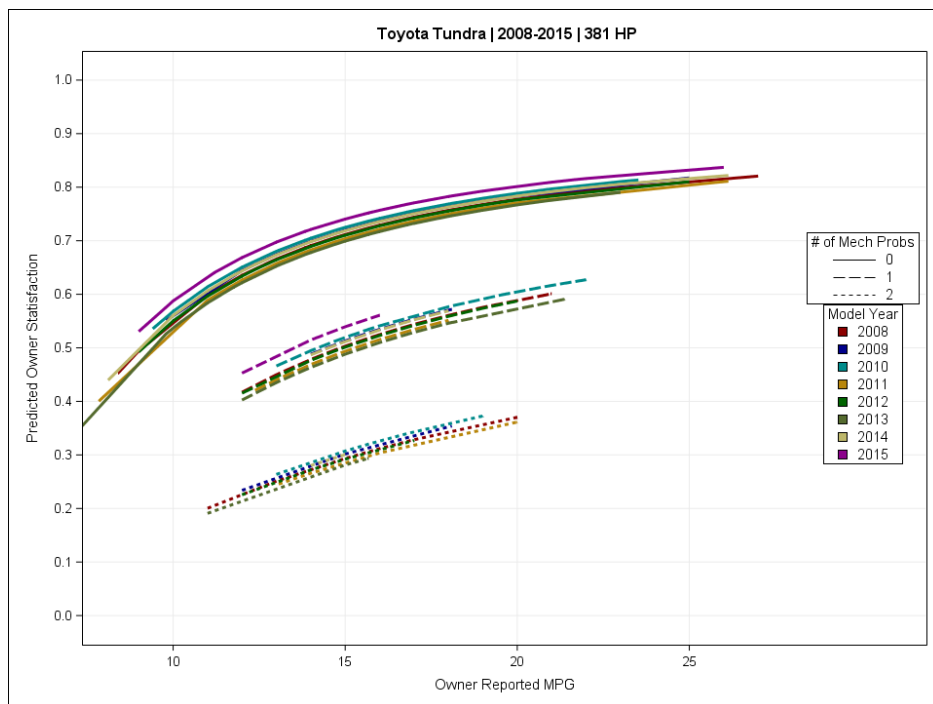
This section reports on the analysis of responses from 63,474 pickup truck owners. Because the number of pickup models is very small, only the second approach is appropriate.

Figures 4a and 4b display owner satisfaction vs. reported MPG for two representative pickups. Again, there is a strong statistically significant positive association between owner satisfaction and owner-reported MPG.

**Figure 4a: Predicted Owner Satisfaction vs. Reported MPG
(Ford F-150: Model Years 2011 to 2014, 365 HP)**



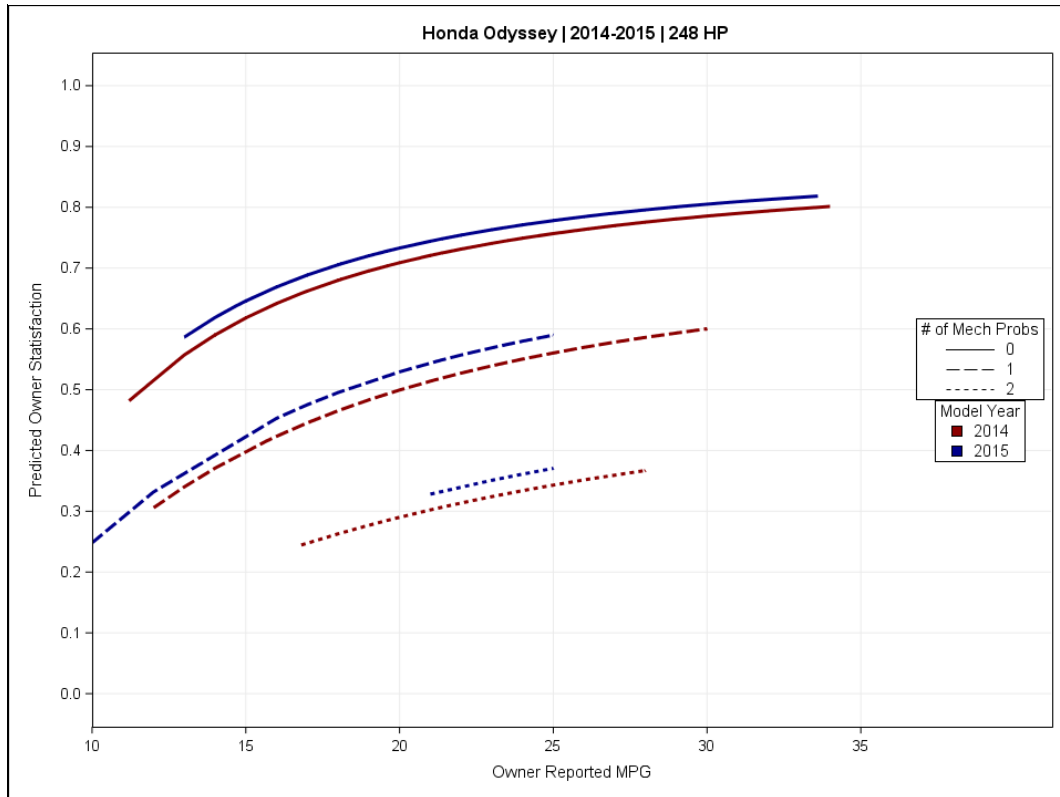
**Figure 4b: Predicted Owner Satisfaction vs. Reported MPG
(Toyota Tundra: Model Years 2008 to 2015, 381 HP)**



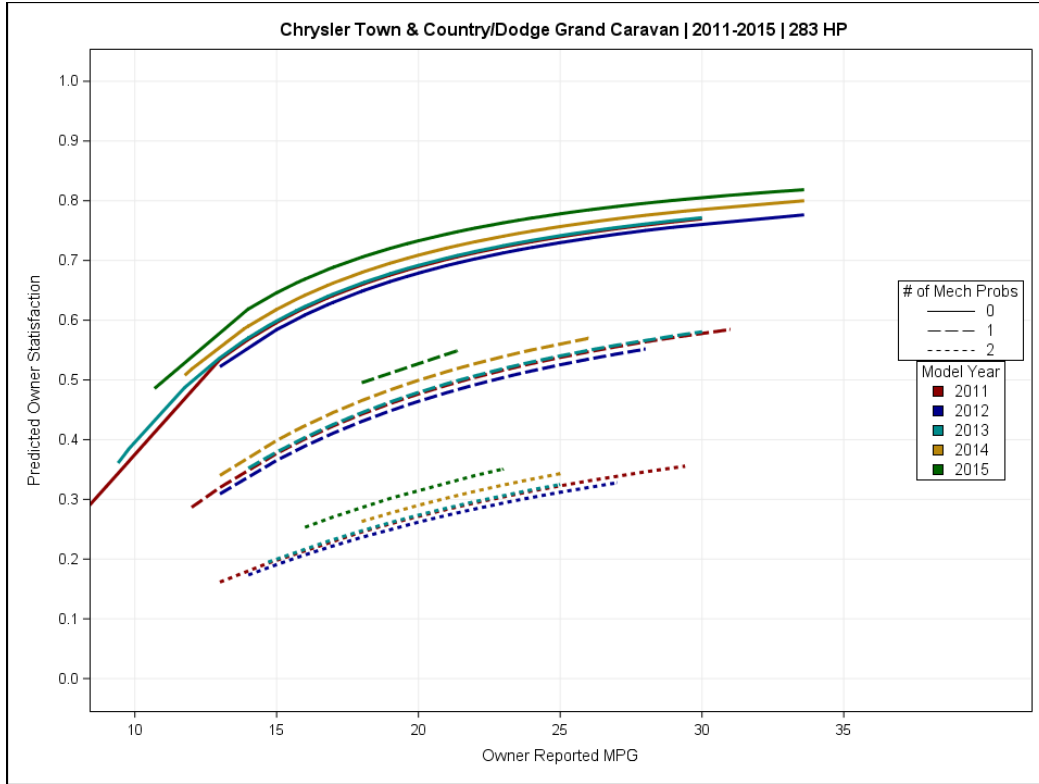
Analysis of Vans

This section reports on the analysis of responses from 34,216 minivan owners. Because the number of minivan models is very small, only the second approach is appropriate. Figures 5a and 5b display owner satisfaction vs. reported MPG for two representative minivans. As shown for other vehicle categories, there is a strong positive association between owner satisfaction and owner-reported MPG.

**Figure 5a: Predicted Owner Satisfaction vs. Reported MPG
(Honda Odyssey: Model Years 2014 to 2015, 248 HP)**



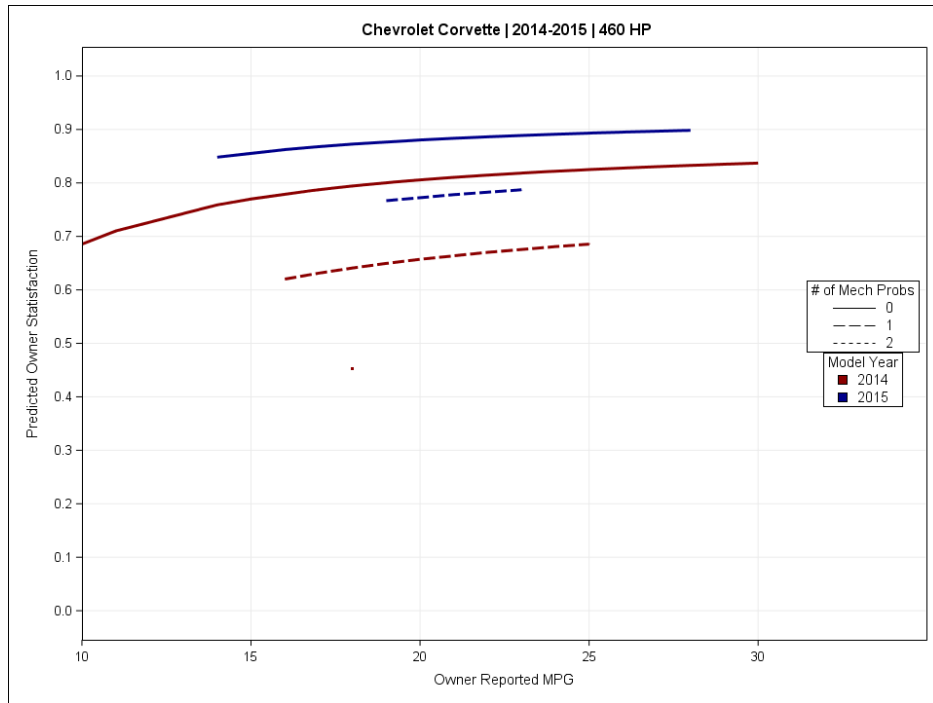
**Figure 5b: Predicted Owner Satisfaction vs. Reported MPG
(Chrysler Town & Country/Dodge Grand Caravan: Model Years 2011 to 2015, 283 HP)**



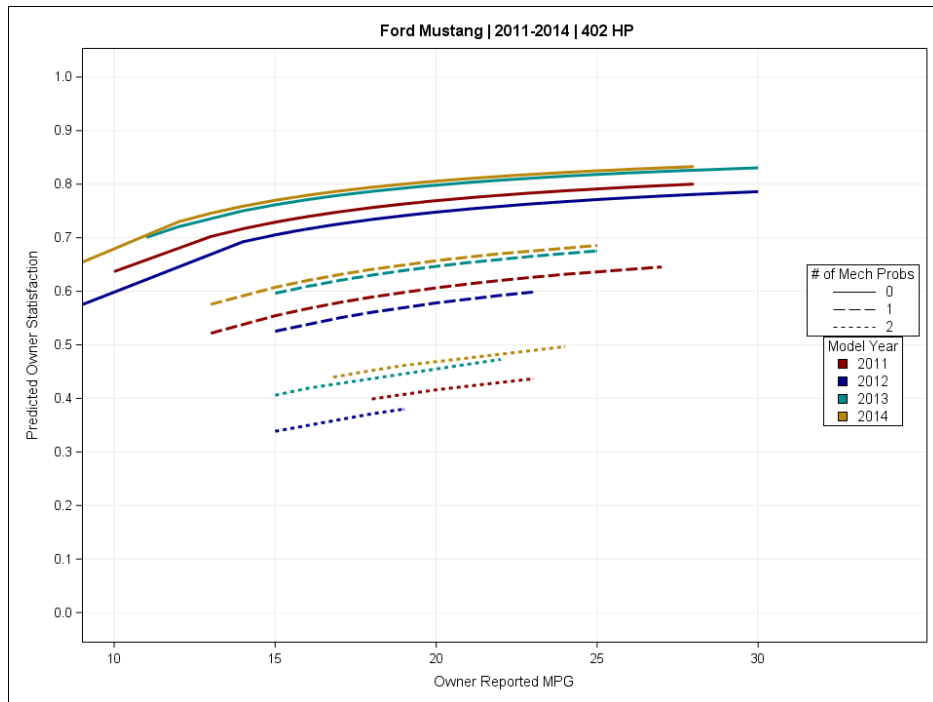
Analysis of Sports Cars

This section reports on the analysis of responses from 17,234 sports car owners and includes 16 road-tested sports car models. Because the number of sports car models is very small, only the second approach is appropriate. Shown in Figures 6a and 6b, there is a positive relationship between owner satisfaction and owner-reported MPG. Note, however, that the relationship is not as strong as in other vehicle categories.

**Figure 6a: Predicted Owner Satisfaction vs. Reported MPG
(Chevrolet Corvette: Model Years 2014 to 2015, 460 HP)**



**Figure 6b: Predicted Owner Satisfaction vs. Reported MPG
(Ford Mustang: Model Years 2011 to 2014, 402 HP)**



Conclusions

The results of our analyses show that when holding other factors constant, higher owner satisfaction is positively associated with higher fuel efficiency in almost all cases. Both analyses support that conclusion. For cars, the relationship between owner satisfaction and fuel efficiency varies by manufacturer. For other vehicle types there were too few models to evaluate with respect to manufacturer.

Notwithstanding the above findings, models with a high level of satisfaction can be found along the entire MPG range for most vehicle types. This is particularly true for cars and SUVs, where there are many different models.

All six attributes examined in the first analysis, show significant association with owner satisfaction for cars and SUVs. Recall that the first analysis is an evaluation of vehicle factors affecting owner satisfaction vs. CR's fuel efficiency estimates. The number of serious mechanical problems was the most important factor, though fuel efficiency was also significantly related. The significance of the other attributes is one indicator of why vehicles with low MPG can still have high satisfaction. For other vehicle categories, i.e., sporty cars, pickups, and vans there were too few unique models to statistically evaluate the significance of the study attributes.

The second analysis is based on vehicle specific owner reported MPG and therefore, not affected by differences in vehicle attributes. It also shows a significant relationship between owner satisfaction and increases in MPG for all vehicle types.

Caveats

This study evaluates responses from CR subscribers regarding the likelihood of repurchasing the same vehicle and may not be representative of nonsubscribers.

Predicting owner satisfaction from vehicle attributes is not straightforward due to the high correlation among vehicle attributes. Assessing the impact of attributes on owner satisfaction is further complicated by differing usage patterns and personal preferences.

Acknowledgement

Thanks to Anita Lam for substantial effort in data preparation.