5-2020

Electric Vehicles and Behavioral Biases: The Case for a New Measure of Efficiency

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Keywords
electric vehicles

Disciplines
Business

Electric Vehicles and Behavioral Biases:

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An Undergraduate Thesis submitted in partial fulfillment of the requirements for the

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MAY 2020

I. INTRODUCTION

If we were to replace all cars on the road in the US with electric vehicles (EVs), transportation-associated greenhouse gas emissions could be cut by about 30% — with no change in technology or the existing energy mix (Needell et al. 2019). Naturally then, increasing EV adoption presents a potentially profound opportunity to stabilize greenhouse gas emissions in the face of climate change. The benefits of EVs, however, are not confined to the environment; consumers stand to gain, too. On average, driving an EV costs about half as much as driving a standard internal combustion engine vehicle (ICEV) that runs on gasoline (DOE 2013). EVs require less frequent maintenance and servicing, and when lifetime costs of vehicle ownership are considered, EVs are often more affordable than their comparable ICEV counterparts. For example, the Nissan Leaf, a popular EV model, falls below the average and median costs for 94 of the US market's most popular vehicles (Needell et al.). This is not insignificant when it comes to consumer costs, as the average American household spends about one-fifth of its yearly expenditures on transportation (DOE 2013). Despite the environmental and economic benefits conferred by EVs, however, adoption has consistently fallen short of expectations, with a market share of just 1.8% (EEI 2019; Bonges III and Lusk 2016).

So why aren't consumers buying EVs? The answer is ostensibly behavioral. A plethora of research indicates why the lifetime cost-savings of EV ownership may not be realized at the point of purchase: people are myopic and accordingly consistently demonstrate temporal discounting (Thaler 1981; John G. Lynch Jr. and Gal Zauberman; Critchfield and Kollins 2001). Practically speaking, however, consumers may also not be able to afford the upfront cost of an EV, even if the lifetime cost is theoretically affordable. Other behavioral biases are likely at play as well, such as the status quo bias in changing vehicle type and the availability bias in assessing EV performance (Frederiks, Stenner, and Hobman 2015). Misguided perceptions and lack of information also inhibit purchases and growth in adoption. One 2013 study of 21 different cities found that almost two-thirds of respondents incorrectly answered basic factual questions about EVs, 94.5% were not aware of local and state EV incentives, 75% underestimated private value or advantages, and a majority of respondents believed that EV maintenance costs were more expensive than those for ICEVs, not less (Krause et al. 2013).

Yet, historically the most significant hurdle to EV adoption stems from the behavior change required in charging vehicles to refuel, rather than filling up at the gas station. The key worry that results from this limitation, deemed "range anxiety", refers to the fear of running out of battery power in an EV mid-trip and becoming stranded (Neubauer and Wood 2014). This anxiety motivates consistent preferences for available ranges on cars far above what is actually needed (Franke and Krems 2016). Despite immense concern for range, EVs already on the market could meet driver needs for about 90% of vehicles used daily (at cost or cheaper than ICEVs) charging only overnight in homes (Needell et al.). Even more, ranges have been improving rapidly. For example, the Nissan Leaf's battery range has improved by 78% in just the last four years in the most basic model available (DOE 2019). With range improvements, this "range anxiety" will likely become a less prevalent practical concern. Further, the average number of vehicles per household in the US is 1.9, indicating that EVs could easily serve as a second vehicle in some households in case a longer-distance vehicle were required, potentially quelling "range anxiety" (DOT 2017). As range capabilities expand, communicating price advantage will likely be crucial in driving EV sales and positioning the vehicles as competitive and feasible alternatives to ICEVs. According to a 2019 McKinsey report, dealerships rarely communicate economic benefits of EVs to consumers, leaving ample opportunities to use a targeted "value-selling" approach in sales (Baik et. al 2019). We propose that one way to use a "value-selling" approach could be through meaningfully communicating the fuel efficiency and associated cost saving advantages of EVs.

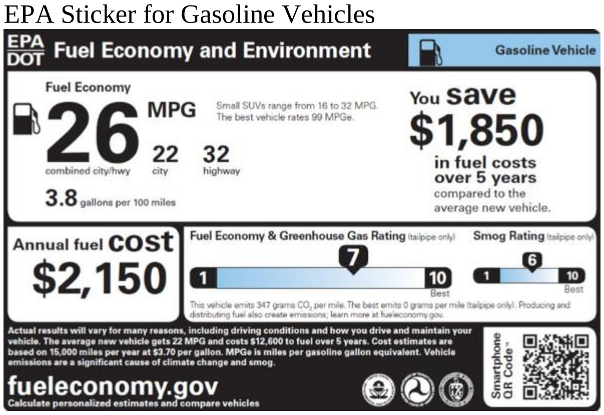
Consumers claim to be concerned with fuel efficiency in their buying decisions, though often lack the information and ability to incorporate it into purchase decisions. According to a 2017 Consumer Reports survey, nearly 90% of respondents want automakers to improve fuel economy and 35% saw it as the largest area for vehicle improvement, mainly with a desire for cost savings (Kurczewski 2017). Despite this, most people have no systematic way of calculating fuel costs and devote little attention to fuel cost at the time of vehicle purchase (Turrentine and Kurani 2007; Allcott 2011). Consumers also systematically misunderstand the US's standard fuel economy metric, miles per gallon (Larrick and Soll 2008). In what is well known as the "MPG Illusion", people incorrectly assume that changes in MPG values are linear. The "illusion" is as follows: while most people believe that a change in fuel economy from 11 MPG to 13 MPG is less significant than from 29 MPG to 49 MPG, they are actually approximately the same and therefore result in about the same difference in fuel costs (Allcott 2011). People far more easily comprehend gallons per mile, then, in assessing fuel economy and costs, as changes in gallons per mile demonstrate a linear progression. Insights like this one arise from different communications of efficiency and may ultimately nudge consumers to fall in line with their own preferences or intentions. Even if we consider environmental motivation, many consumers make choices disparate from their views, creating a value-action gap driven by perceived tradeoffs lost with "greener" options (Olson 2012). For EVs, minimizing perceived tradeoffs can thus help to bridge the value-action gap for environmentally-concerned individuals, as well as the temporal gap that leaves consumers underestimating private economic benefits of EVs and ultimately dampens EV sales. We propose a model for improving communicated value through fuel costs.

II. BACKGROUND AND HYPOTHESIS DEVELOPMENT

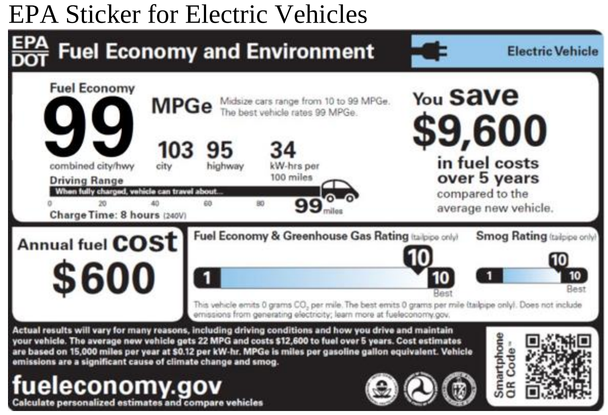
Since the mid-1970s, the EPA has utilized fuel economy stickers in new vehicle windows to help consumers make more informed purchase decisions regarding fuel efficiency (Figure 1). These stickers include, most prominently, the MPG figure. These stickers also include gallons per mile, annual fuel cost, savings or spending on fuel costs over five years, as well as a few other efficiency ratings. Given that EVs don't run on gallons of gasoline, the EPA calculates a comparable alternative. This is miles per gallon equivalent, or "MPGe". To calculate this figure, the EPA uses the equivalency that 1 gallon of gasoline holds the same energy content as 33.7 kilowatt-hours. Yet, this figure doesn't capture the massive cost discrepancy between gasoline and electricity. For every dollar spent, an EV will travel about twice as far as an ICEV (DOE 2013).

Figure 1. EPA Fuel Economy Stickers

EPA Sticker for Gasoline Vehicles



EPA Sticker for Electric Vehicles



Thus, we hypothesize that MPGe, as it is currently calculated, is an insufficient figure to communicate fuel efficiency for electric vehicles. Specifically, assuming consumers care about fuel efficiency insofar as it conveys fuel costs, MPGe will lead consumers to underestimate cost-savings potentials for EVs, and thus undervalue potential personal economic benefits. We will explore how people perceive and understand the fuel economy metrics provided by the EPA, and how they calculate fuel costs. The implication of improved accuracy is that consumers may be better able to see private economic benefits of EVs and make more accurate comparisons between vehicles. Given the lower lifetime costs of EVs, if the effect is significant, then it could potentially lead consumers to more strongly consider EVs when purchasing new vehicles, which could economically benefit consumers while reducing greenhouse gas emissions in the long-run.

III. DATA AND METHODS

An Overview of Research Design

We conducted a survey on Amazon Mechanical Turk to test this hypothesis. We predicted that the effect of misunderstanding MPGe is not specific to any demographic or group, so we set no demographic constraints, other than residence in the United States, as that is the audience of the EPA stickers and metrics. However, some of the findings about fuel efficiency communication can likely be more broadly generalizable. The experiment consisted of five parts. One involved asking the respondents to perform a calculation task, and the others were informational. The first part asked for demographic information, which included state of residence, as well as information about car ownership history.

The second question is the calculation, which asks respondents to estimate fuel costs for a specified distance. They are told that they will be spending a month in a new place, driving 1,900 miles, and they have the option to select Vehicle A (Gasoline) or Vehicle B (Electric). Vehicle A and Vehicle B are comparable in features with the same cost. Respondents must calculate how much they will spend on fuel once they rent the vehicle. Vehicle A is an ICEV with 26 MPG. Vehicle B is an EV, with 99 MPGe. They are shown the EPA fuel economy sticker for Vehicle A and asked to calculate fuel costs, then shown the sticker for Vehicle B and asked to do the same (Figure 1). In the scenario, respondents are told that they charge at their accommodation at night, so don't need to worry about finding charging stations. They are also told that this charging will be sufficient for how far they must travel – "range anxiety" is not a concern. These specifications aim to make the two vehicles equivalent on all metrics except fuel costs (ceteris paribus). So, in theory, subjects would simply pick the one with the lowest fuel costs.

The third part identifies how respondents arrived at their fuel cost estimates. This involves them identifying which information on the EPA sticker that they used, as well as providing a "walk through" of their solution methods and calculations. The fourth part asks respondents to select a vehicle and provide an explanation. The fifth part presents a new scenario in which the respondent is purchasing a new car from the dealership. It asks for a ranking of the information that they would want in terms of importance. The full survey can be found in the appendix.

Experimental Task and Procedures

The survey has both descriptive and experimental elements, exploring the way that people calculate fuel costs for gasoline and electric vehicles when presented with the EPA fuel economy stickers. In the experimental portion, two possible conditions are applied: the "Gasoline Vehicle Sticker" condition and the "Electric Vehicle Sticker" condition. The structure is a within-subjects design. Given the real-world ubiquity of gasoline vehicles, the priming of calculating fuel costs for electric vehicles should not dampen results. The major difference between the information provided for the ICEV and the EV is the MPG/MPGe figure. The gas vehicle sticker also includes "gallons per 100 miles", while the EV sticker has the driving range in place of this figure. The magnitude of error in fuel cost estimates will be compared for the gas vehicle and the electric vehicle. Thus, the MPG or MPGe treatment is the manipulated variable, and the measured variable is error in fuel cost estimates. Additionally, we will explore how the information used, preferences, history of vehicle ownership, and values influence accuracy in estimating fuel costs. Fuel cost estimation accuracy will be measured by the magnitude of difference between the true fuel cost and the respondent's result, as well as in percent error.

To complete the calculation, respondents will be given the EPA's fuel economy stickers (depicted in Figure 1). These include miles per gallon, gallons per mile, annual fuel cost, five-year cost savings, fuel economy & greenhouse gas rating, and a smog rating. In the fine print, average figures of distance driven per year are given, as well as the cost of gas and electricity per unit used. The footnote information is crucial for arriving at the “correct” answer in the scenario. Instructions are given for each question, and a time limit of three days is applied. Questions are answered sequentially and on separate screens.

Our main null hypothesis was that there will be no difference in accuracy between Vehicle A (gas) and Vehicle B (electric) for each respondent. We tested additional hypotheses, which involved the following null hypotheses:

1. The EPA sticker as modified for electric vehicles with MPGe will have no effect on accuracy for fuel cost estimations between gasoline and electric vehicles.
2. Personal driving habits, as measured by self-reported weekly driving distance, have no effect on fuel cost estimate accuracy for Vehicle A (ICEV) or Vehicle B (EV).
3. Car ownership history, as measured by self-reported current or past ownership, has no effect on fuel cost estimate accuracy for Vehicle A (ICEV) or Vehicle B (EV).
4. The magnitude of the fuel cost estimate error has no effect on the vehicle selected.
5. Consumer preferences and values have no effect on fuel cost estimation accuracy for Vehicle A (ICEV) or Vehicle B (EV).
6. The information used for calculation has no effect on accuracy of fuel cost estimates.

A series of simple linear regressions and one logistic regression (for vehicle selection) were performed to test these hypotheses, supplemented by descriptive statistics.

IV. RESULTS

See appendix for additional analysis and notes on data treatment.

Data Treatment:

The survey run on Amazon Mechanical Turk had a sample size of N = 254 respondents after removing invalid responses and winsorizing the data. The data was modified using 95% winsorization, removing the top and bottom 2.5% of data points for weekly driven miles, Vehicle A fuel cost estimates, and Vehicle B fuel cost estimates. All hypothesis tests were conducted at the 95% confidence level, with an alpha of 0.05.

General Results:

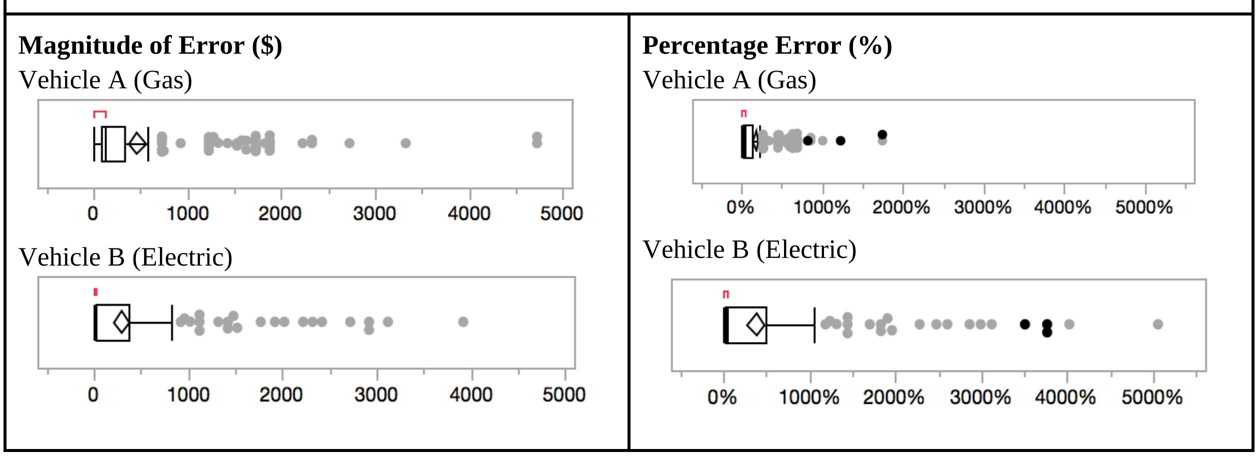
The error for Vehicle A (gas) had a mean of $458.53, a median of $120.38, and a standard deviation of $745.89. For Vehicle B (electric), the mean error in estimate was $285.55, the median was $27.52, and the standard deviation was $585.42. In terms of percent error, the mean percent error for Vehicle A (gas) was 169.59%, the median was 45%, and the standard deviation was 275.87%. For Vehicle B (electric), the mean percent error was 368.36%, the median was 36%, and the standard deviation is 755.18%. From this, we can see that subjects were quite inaccurate for both gasoline and electric vehicles. The percent error for electric vehicles, however, was significantly larger.

Table 1. Fuel Cost Estimate Summary

	Actual Cost ($)	Average Estimate ($)	Average Magnitude of Error ($)	Average Percent Error
Vehicle A (Gas)	270.38	600.71	458.53	169.59%
Vehicle B (Electric)	77.52	337.8	285.55	368.36%

In terms of error direction, 37.4% of respondents overestimated gas fuel costs, while 27.56% overestimated electric vehicle fuel costs. This leaves more than half of respondents underestimating fuel costs for both gas and electric vehicles. 62.6% of subjects underestimated gas costs, while 72.44% underestimated electric vehicle fuel costs. This contradicts our prediction that people underestimate private economic benefits of electric vehicles. However, this might be because many subjects referred to the annual cost on the sticker and divided this by twelve, which was based on a smaller distance and would yield lower fuel costs. The magnitude of errors, however, confirms the notion that people are not great at computing fuel costs, and they are even worse when it comes to electric vehicles. Using MPGe and the EPA fuel economy stickers, the mean percent error for the EV is 2.17 times that of the gasoline vehicle, with a standard deviation almost 2.74 times as large.

Figure 2. Spread of Fuel Cost Estimates



When it comes to how people calculate fuel costs, we can turn to the most common answers for each vehicle type, both of which were incorrect in the given scenario according to the EPA sticker. 10% of respondents estimated $200 for the gasoline vehicle (actual cost is $270.38). Most likely followed the correct methodology but used $2 per gallon as the fuel cost per unit. The EPA sticker specified $3.70 per gallon, so this led to an underestimation of fuel costs. 20% of respondents simply divided the annual fuel cost by 12 months for the EV, even though the distance specified in the scenario was different than that in the EPA footnotes. This indicates that while fuel cost calculations for both vehicles displayed a large degree of error, the error for the gasoline car was superficial. Subjects used the right methodology, but simply did not use the gas cost as specified in the footnotes. These subjects still came to reasonable answers that were potentially *more* accurate based on their region and current gas prices. However, the same was not true for EV cost calculations. If subjects lacked information about energy equivalence and electricity prices, their answers would be systematically incorrect. It is likely that they would have no basis for guessing. While they might have some semblance of electricity prices, though are likely *more* exposed to gas prices, it is unlikely that the average person would know that a gallon of gas has the same energy content as 33.7 kilowatt-hours. The mode of $50 is indication this. Otherwise, the most common answer would likely use the same methodology as was used for Vehicle A.

Table 2. Most Common Results of Fuel Cost Calculations

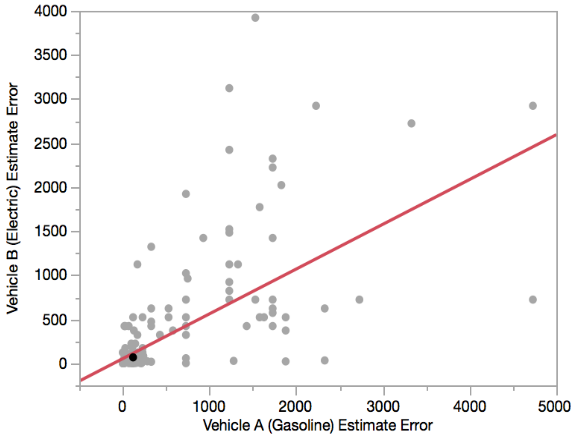
	Most Common Estimate	Frequency of Estimate (#)	Frequency of Estimate (%)
Vehcile A (Gas)	200	26	10%
Vehicle B (Electric)	50	50	20%

Differences in Estimating Fuel Costs for Gas and Electric Vehicles:

First, we compared the accuracy of fuel cost estimates for the gasoline vehicle (A) and the electric vehicle (B). We did this for both magnitude of error in dollars and percent error. There was a positive, linear relationship between error for Vehicle A and error for Vehicle B, as could be expected – if someone can calculate gasoline fuel costs, they are more likely to be able to calculate EV fuel costs, as the methodologies are similar with the right use of information. For the remainder of the analyses, percent error is used and will be shown as the measure of fuel cost estimate accuracy.

Figure 3. Fuel Cost Accuracy for Gas Vehicle and Electric Vehicle

Magnitude of Fuel Cost Estimation Error in Vehicle A (Gas) vs. Vehicle B (Electric)

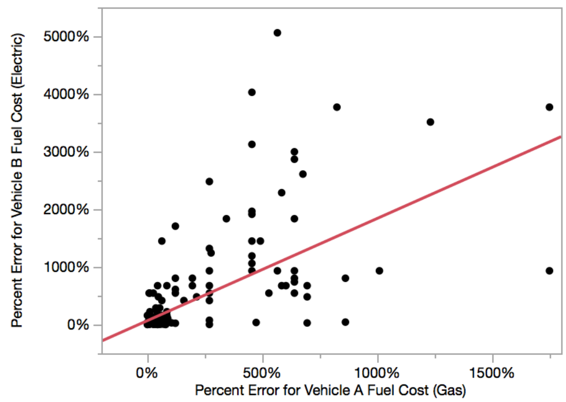


Linear Fit

Vehicle B (Electric) Estimate Error = 52.414948 + 0.5084504*Vehicle A (Gasoline) Estimate Error

Statistically Significant at the 95% Confidence Level
Coefficient p-value <.0001

Fuel Cost Estimation Percent Error in Vehicle A (Gas) vs. Vehicle B (Electric)



Linear Fit

Percent Error for Vehicle B Fuel Cost (Electric) = 0.6761532 + 1.7734048*Percent Error for Vehicle A Fuel Cost (Gas)

Statistically Significant at the 95% Confidence Level
Coefficient p-value <.0001

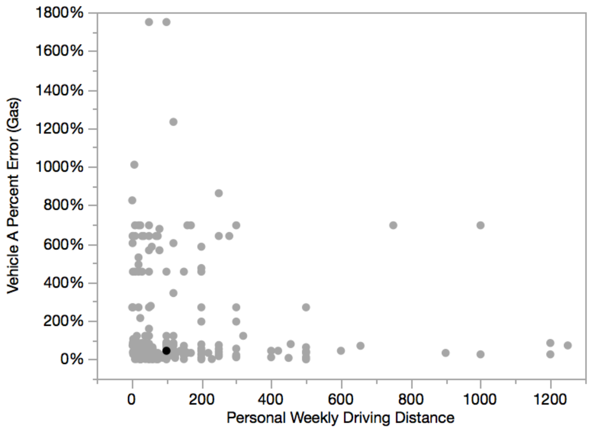
Personal Driving Habits:

There was a statistically significant, linear, slightly negative relationship between reported personal weekly driving distance and error in Vehicle B (electric) fuel costs. That is, the more people said they drove, the smaller their error in fuel cost estimates. However, there was not a statistically significant relationship between driving habits and fuel cost accuracy for Vehicle A (gas). This is surprising given that most people drive gasoline vehicles. Intuitively, the more subjects drive, the more familiar they are with mileages and fuel costs. It would also seem that there would be a large anchoring effect to gasoline prices, as compared to electricity prices, that would lead them to overestimate fuel costs for the electric vehicle, not become more accurate. One possible explanation is that people who drive frequently are more interested in cars, both electric and gas. They could have some existing familiarity with EV fuel economy or be interested in exploring it through the survey.

There also seem to be a fair number of respondents who drive infrequently but estimate very high fuel costs for both electric and gas vehicles, but especially for electric vehicles. This is consistent with and might be explained by existing research and the notion that "inflated estimates of fuel savings are usually the result of overestimating how much fuel they consume" (Turrentine and Kurani 2007).

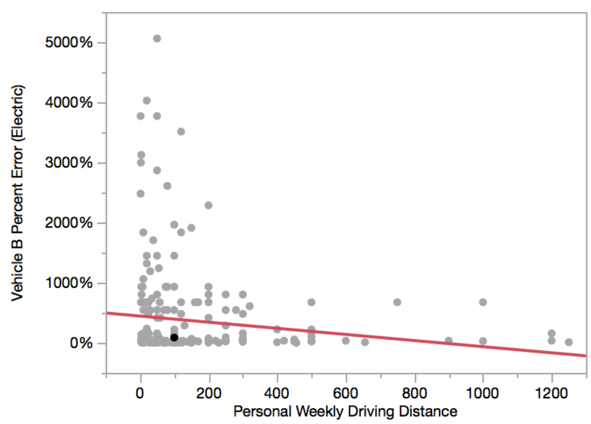
Figure 4. Driving Habits as a Predictor of Fuel Cost Accuracy

Personal Weekly Driving Distance vs. Vehicle A (Gas) Fuel Cost Estimates



Linear Fit
No statistically significant relationship

Personal Weekly Driving Distance vs. Vehicle B (Electric) Fuel Cost Estimates



Linear Fit
Vehicle B Percent Error (Electric) = 4.4558373 - 0.005096*Personal Weekly Driving Distance

Statistically Significant at the 95% Confidence Level
Coefficient p-value = 0.0302

Car Ownership History:

There is no statistically significant relationship between car ownership or history of purchase and accuracy. 96.06% of respondents have purchased a car and about 94.88% own a car.

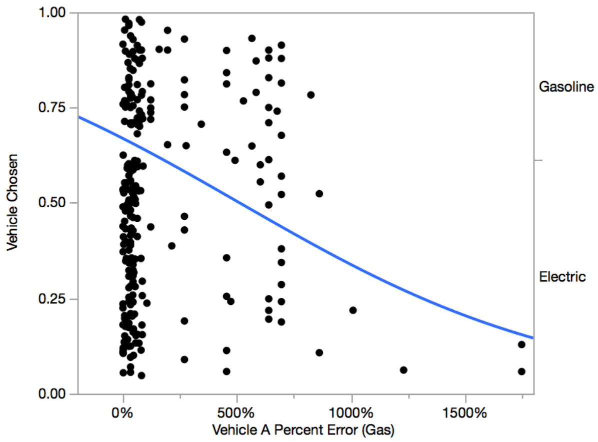
Vehicle Selection:

38.58% of respondents chose the gasoline vehicle, while 61.42% chose the electric vehicle. Yet, 85.83% of respondents correctly found that the gas costs would be greater than the electricity costs for running each vehicle. So, what accounts for the discrepancy between those who found the electric vehicle to be cheaper and those who chose it? While the survey intended to make the electric vehicle and gasoline equivalent in all metrics aside from fuel costs, some respondents did not interpret it in this way, choosing the gasoline vehicle over the electric vehicle with the explanation that they didn't want to find charging stations. Among the 14.57% of subjects that calculated the electric vehicle fuel car costs as greater than the gasoline costs, 25% of those subjects still chose the electric vehicle. This indicates that subjects' perceptions of the benefits and costs associated with electric vehicles, as well as the gas vehicles more broadly, may be so deeply ingrained that even if the fuel costs less, their values and preferences will prevail against economic reason as presented in this experiment's scenario. At the same time, however, the survey may have been unclear or respondents may not have remembered this detail in the survey.

A logistic regression was used to predict gasoline or electric vehicle selection based on error in fuel cost estimates. There was a statistically significant relationship between error in calculating the gas vehicle fuel costs and the vehicle chosen, as well as with percent error in calculating electric vehicle fuel costs and the vehicle chosen (Figure 5). Greater error increases the probability that a subject will have chosen the electric vehicle over the gasoline vehicle. This might be explained by the fact that subjects tended to underestimate electric vehicle costs – so, the greater the error, the lower the cost estimated.

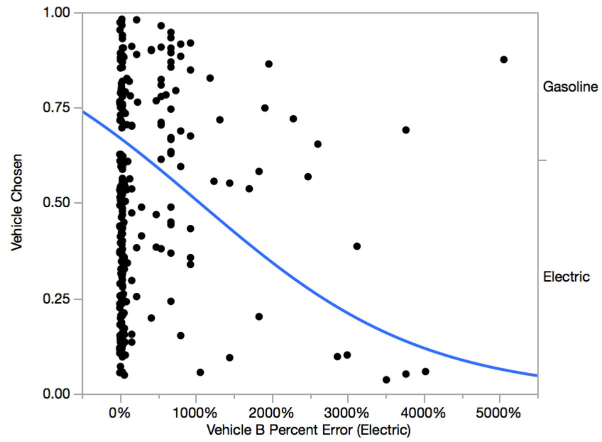
Figure 5. Predicting Vehicle Choice by Fuel Cost Estimation Accuracy

Vehicle A (Gas) Percent Error vs. Vehicle Chosen



Log odds of Choosing Electric = 0.7035 - 0.1373 (Vehicle A Percent Error)
P-value < 0.01

Vehicle B (Electric) Percent Error vs. Vehicle Chosen



Log odds of Choosing Electric = 0.7117 - 0.0676 (Vehicle B Percent Error)
P-value < 0.01

Preferences and Values:

In the survey, subjects were told to rank various preferences by importance if they were considering personally buying a car. There are several statistically significant relationships between preferences or values and fuel cost estimate accuracy. If fuel costs or efficiency were in the top two or three concerns for individuals, they had lower error. If this was only in the top two, then error for the EV was also decreased. If environmental footprint was the top concern, subjects had greater error in fuel cost estimations. 50% of the respondents with environmental footprint as a top priority underestimated costs and 50% overestimated - for both the gasoline and electric vehicle. While concern for fuel efficiency might mean greater knowledge of the subject and therefore greater accuracy, the connection between environmental concern and error is not readily clear.

Information Used:

For the gas vehicle, 12.2% of respondents used the footnotes that include gasoline prices. For the electric vehicle, 11.81% of respondents used this information. For the gas vehicle, without the footnote information about the gas price used, the respondent could still use a reasonable estimate for price per gallon. Yet, given that this survey was run during April-May of 2020, when fuel prices were uncharacteristically low, respondents would have needed to reference the EPA assumptions in order to come to the "right" answer according to the EPA sticker. This indicates that the error is realistically smaller than estimated for the gasoline vehicle. For the electric vehicle, however, without looking to the footnote to see the cost of electricity, or the key information that underpins MPGe – that 1 gallon of gas is equivalent to 33.7 kilowatt-hours in terms of energy equivalence – subjects would not have been able to make any meaningful calculations. It should be noted that there was an error on the survey, which required users to input that they used the footnote, rather than selecting from a list with the rest of the information (see appendix for more notes on this).

There was not a statistically significant relationship between information used (either annual fuel cost or cost per unit as listed in the footnotes) and accuracy of fuel cost estimates. This indicates that the information containing the essential elements for fuel cost calculation may have been used incorrectly, corroborating the notion that people have no systematic way of calculating fuel costs (Turrentine and Kurani 2007; Allcott 2011).

V. CONCLUSION

While an existing body of research provides the framework of our understanding that people are ill-equipped to calculate fuel costs, this survey extends and amplifies the notion to electric vehicles, where fuel efficiency is communicated in the complicated, non-intuitive metric of MPGe. We find that the MPGe is particularly insufficient in communicating fuel efficiency and posit that it should be modified to better reflect the fuel costs. While we hypothesized that people would underestimate the private economic benefit of EVs, in this experiment, the majority of subjects *overestimated* cost savings. However, we did find evidence suggesting that MPGe leads to large errors in fuel cost estimation, relative to MPG. In this experiment, the overestimation of cost savings may have been due to the specific scenario, but indicated that the most saliently available information might influence error in fuel cost calculation. So, value remains in further exploring how to better communicate electric vehicle fuel efficiency, as perceptual anchors outside of this experiment often indicate that EVs are more expensive. While we focused on electric vehicle fuel cost calculation, we found corroboration that even for gasoline vehicles, fuel cost calculation error is large, though to a lesser extent.

In exploring some of the mechanisms that might be at play in these inaccuracies, we found some interesting relationships. Even subjects who used the correct and relevant information to calculate fuel costs (i.e. the footnote) came to the wrong answer. If people correctly found gasoline as more expensive than the electricity for fuel, some still chose the more expensive option. The same was true for those who found the electric vehicle cheaper. These seemingly inconsistent behaviors indicate the strength of the non-economic forces and additional considerations at play in purchase decisions involved with personal vehicles.

Through a better understanding *how* people make such errors and come to these economically irrational decisions, we can help to build the choice architecture to influence "better" decision making that it aligns with consumer's own preferences and holds the potential for positive environmental impact. For future research, an emphasis should be placed on testing various methods aside from MPGe that are more effective for communicating electric vehicle fuel efficiency. Additionally, it might be beneficial to further remove electricity costs from the electric vehicle scenario. That is, many of this experiment's subjects provided explanations that were outside of the scope of the survey, contingent upon their preexisting beliefs about electric vehicles. So, creating a scenario that replicates the structure of fuel cost payments for electric vehicles, but is presented in a new way could be beneficial for exploring MPGe alternatives. Additionally, we suggest further research to advance our understanding of the direction and magnitude of fuel cost calculation errors as informed by MPGe. As electric vehicles become more efficient and common in the marketplace, this question of MPGe alternatives will be increasingly important to both public and private stakeholders, so they can effectively leverage targeted "value-selling" of EVs (Baik et. al 2019).

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VII. APPENDIX

Data Used and Omitted:

Several survey responses included missing data or data in the incorrect form (e.g. answering “yes” to a question that asked for fuel cost estimation), which was removed, leaving a sample size of N = 291 (started with N = 304). After removal of unusable or concerning responses, the data was winsorized. A 95% winsorization was done, removing the top and bottom 2.5% of data from the three quantitative response categories, personal driving distances and fuel cost estimates for Vehicle A and Vehicle B. This resulted in a sample size of N = 254 after cleaning and winsorization.

Survey Design:

One problematic element may have muddied the results was that users could not select “7” on the information used question, but had to write it in after selecting “other”. 31 respondents specified “7” on the survey for Vehicle A, and 30 specified this for Vehicle B (N=254). While the magnitude of error suggests that a small proportion of users actually relied on the information in element “7” (the footnote with fuel costs per unit), this survey could be improved by running again with the ability to select the “7” option.

The survey is provided below.

This is a research project being conducted by Megan Kyne, a student at the Wharton School. It is being advised by Benjamin Lockwood, an Assistant Professor of Business Economics and Public Policy at the Wharton School.
For this study, we will ask you a series of questions related to fuel costs and vehicle ownership. Your participation is voluntary, but you will be paid if you complete our survey.
BENEFITS: You will be compensated for participating for completing this survey, according to the rate posted with this task on its online listing.
RISKS: There are minimal risks of participating other than those faced in daily life.
OVERVIEW: You will then be asked a series of questions that include calculations. None of the tasks are intended to measure your intelligence.
CONFIDENTIALITY: Your responses will be stored on a secure server and only accessible to the researchers via password-protected electronic format. Once the project has concluded, any information which could tie your identity to your responses (such as your MTurk user ID) will be removed from the data set, so no one will know how you responded, or whether you participated in the project.
CONTACT: If you have any questions, concerns, or complaints, please contact Megan Kyne at mkyne@wharton.upenn.edu. You may contact the Office of Regulatory Affairs with any question, concerns or complaints at the University of Pennsylvania by calling (215) 898-2614.

ELECTRONIC CONSENT: Please select your choice below. Clicking on the “I Agree” button indicates that: 1) you have read the above information; 2) you agree to participate; and 3) you are at least 18 years of age.

○ I agree. (1)

○ I do not agree. (2)

Skip To: End of Survey If ELECTRONIC CONSENT: Please select your choice below. Clicking on the “I Agree” button indicates t... = I do not agree.

Before you proceed to the survey, please complete the captcha below.

In which state do you currently reside?

▼ Alabama (1) ... I do not reside in the United States (53)

Do you own a car?

- ◯ Yes (1)
- ◯ No (2)

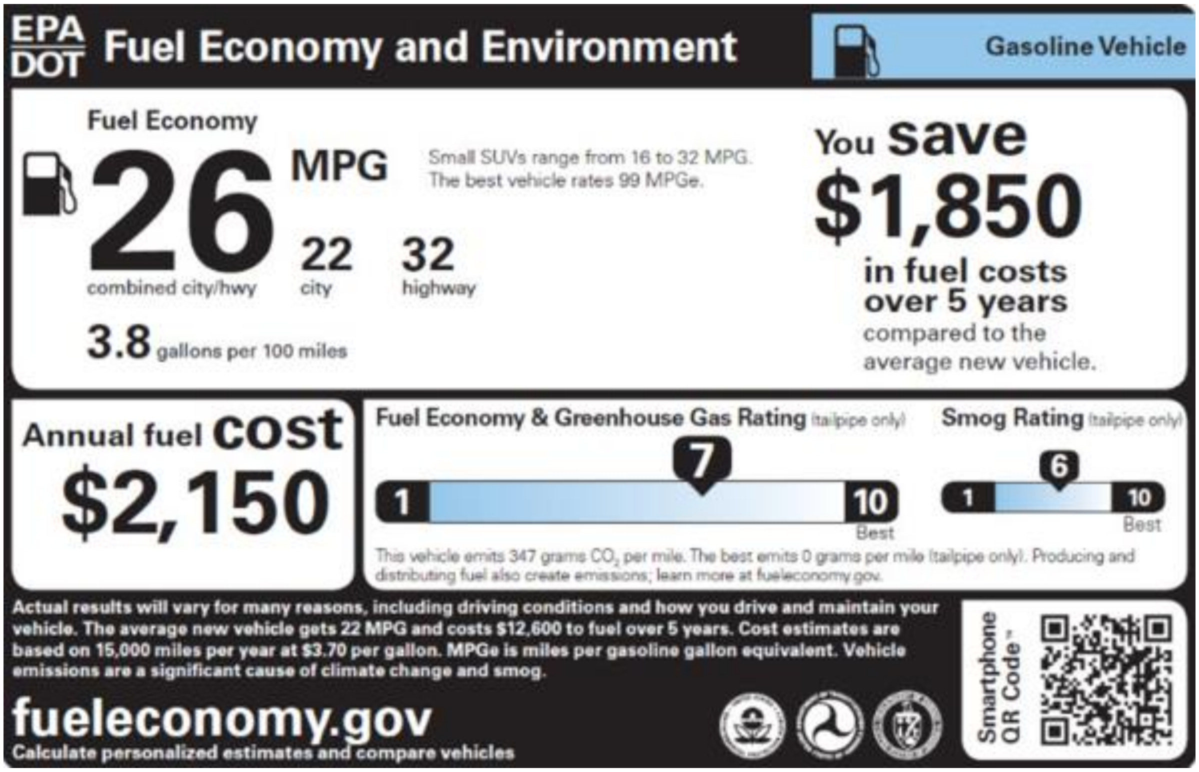
Have you ever purchased a car?

- ◯ Yes (1)
- ◯ No (2)

How many miles do you drive per week, on average?

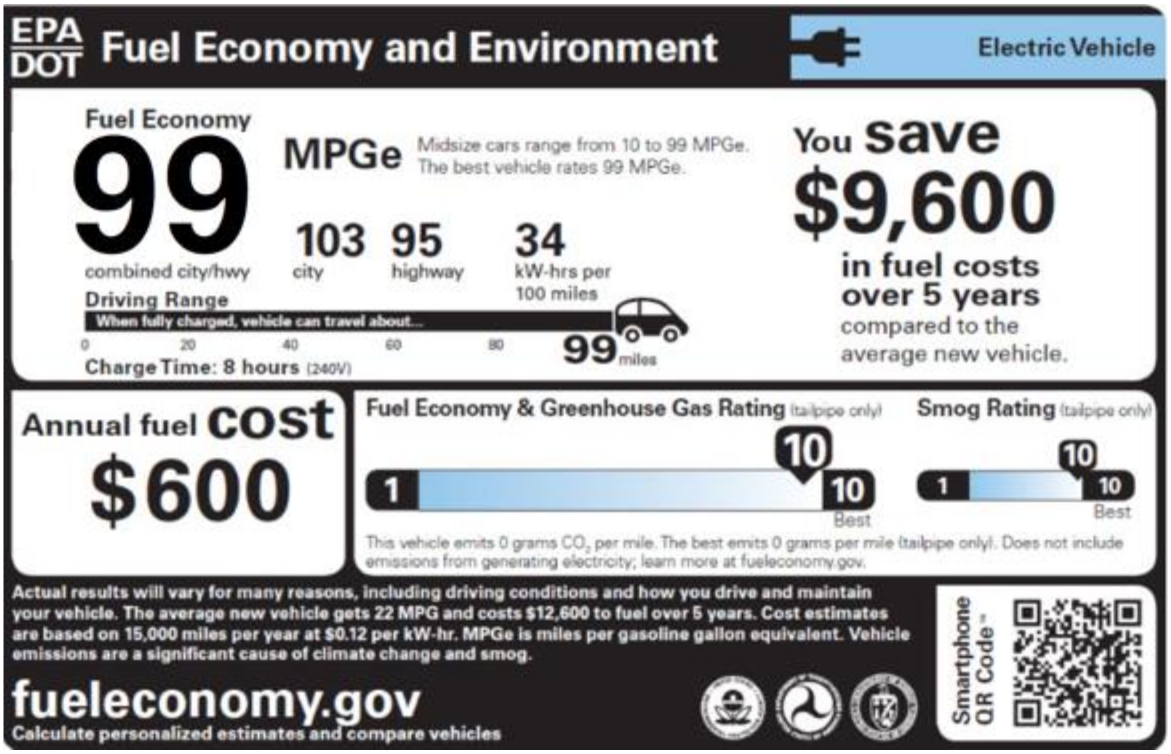
____

You are spending a month in a new place, and you need to rent a car. You have found two cars that are comparable in features with the same cost. You are trying to determine how much you will spend on fuel for each. One vehicle has a standard gasoline engine (Vehicle A) and the other is electric (Vehicle B). For the electric vehicle, you charge it every night at your accommodation in your parking spot, so you do not need to worry about finding charging stations. Charging at night will be enough to get you where you need to go, so you don't run the risk of becoming stranded. You will pay for the associated electricity – these are your "fuel costs" for the electric vehicle, while you will be purchasing regular grade gasoline for the other vehicle. You will be traveling a total of 1,900 miles. You are given the following information about each vehicle.



How many dollars do you think you'll spend on gasoline over the course of the month, driving 1,900 miles in Vehicle A?

____

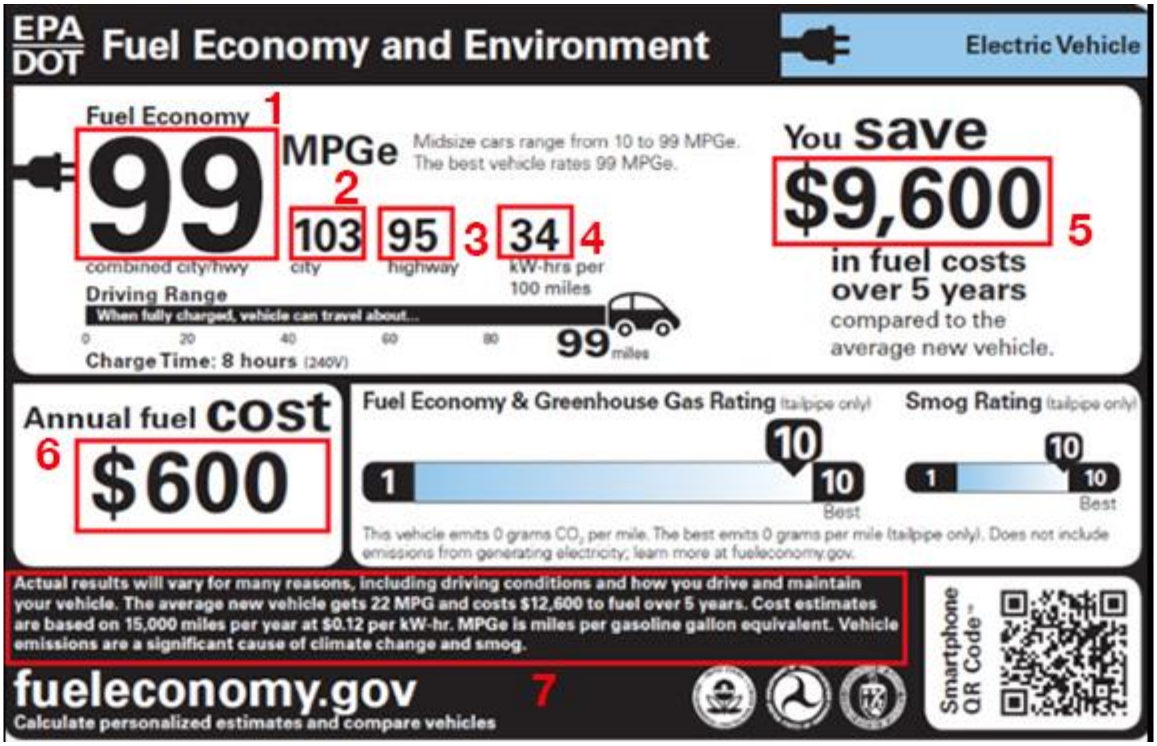


How many dollars do you think you'll spend on fuel (electricity) over the course of the month, driving 1,900 miles in Vehicle B?

____

What information did you use to find your answer for Vehicle A? Select all that apply.

- ☐ 1 (1)
- ☐ 2 (2)
- ☐ 3 (3)
- ☐ 4 (4)
- ☐ 5 (5)
- ☐ 6 (6)
- ☐ Other, please specify: (7) ____



What information did you use to find your answer for Vehicle B? Select all that apply.

- ☐ 1 (1)
- ☐ 2 (2)
- ☐ 3 (3)
- ☐ 4 (4)
- ☐ 5 (5)
- ☐ 6 (6)
- ☐ Other, please specify: (7) ____

How did you arrive at your answer? Please walk through your solution and include any relevant calculations. Refer to the above areas of the information sheet if useful.

____

____

____

____

____

Which vehicle would you purchase?

- ○ Vehicle A (Gasoline) (1)
- ○ Vehicle B (Electric) (2)

Why did you choose the specified vehicle?

____

Now, suppose you are thinking about buying a new car from a dealership. What information would you want to make your purchase decision? Please rank the following with 1 being most important and 11 being least important.

______ Vehicle price (1)
______ Getting good mileage (2)
______ Seating capacity and storage space (3)
______ Performance (4)
______ Design (5)
______ Safety (6)
______ Environmental footprint (7)
______ Reliability and warranty (8)
______ Comfort (9)
______ Maintenance costs (10)
______ Annual fuel costs (11)
______ Fuel cost per mile travelled (12)

Here is your ID: ${e://Field/Random%20ID}

Copy this value to paste into MTurk.

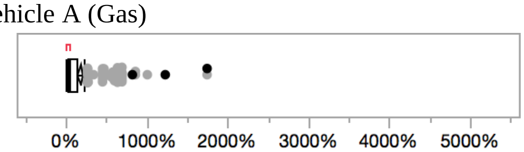
When you have copied this ID, please click the next button to submit.

Analytical Appendix:

Appendix Figure 1. Fuel Cost Error Spread

Percentage Error (%)

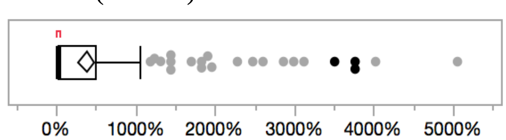
Vehicle A (Gas)



Quantiles

100.0%	maximum	1749%
99.5%		1749%
97.5%		848%

Vehicle B (Electric)



Quantiles

100.0%	maximum	5060%
99.5%		4776%

90.0%		640%
75.0%	quartile	122%
50.0%	median	45%
25.0%	quartile	26%
10.0%		8%
2.5%		0%
0.5%		0%
0.0%	minimum	0%

Summary Statistics

Mean	169.59%
Std Dev	275.87%
Std Err Mean	17.31%
Upper 95% Mean	203.68%
Lower 95% Mean	135.50%
N	254

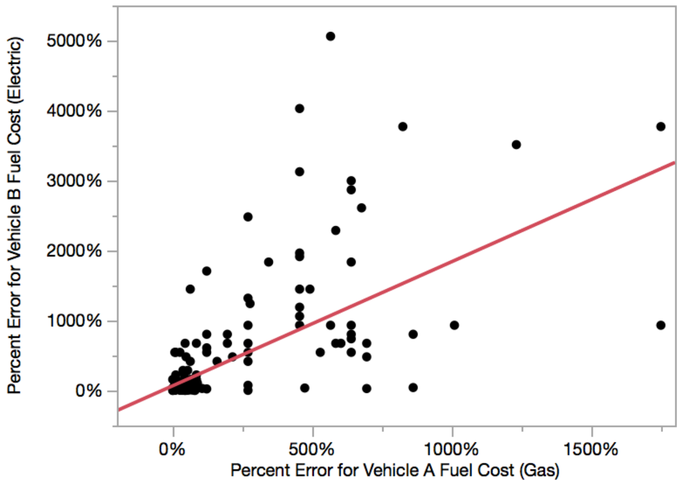
97.5%		3077%
90.0%		932%
75.0%	quartile	481%
50.0%	median	36%
25.0%	quartile	29%
10.0%		5%
2.5%		1%
0.5%		0%
0.0%	minimum	0%

Summary Statistics

Mean	368.36%
Std Dev	755.18%
Std Err Mean	47.38%
Upper 95% Mean	461.68%
Lower 95% Mean	275.04%
N	254

Appendix Figure 2. Vehicle A (Gas) Fuel Cost Error vs. Vehicle B (Electric) Fuel Cost Error

Percent Error



Linear Fit

Percent Error for Vehicle B Fuel Cost (Electric) = 0.6761532 + 1.7734048*Percent Error for Vehicle A Fuel Cost (Gas)

Summary of Fit

RSquare	0.419676
RSquare Adj	0.417373
Root Mean Square Error	5.764299
Mean of Response	3.68362
Observations (or Sum Wgts)	254

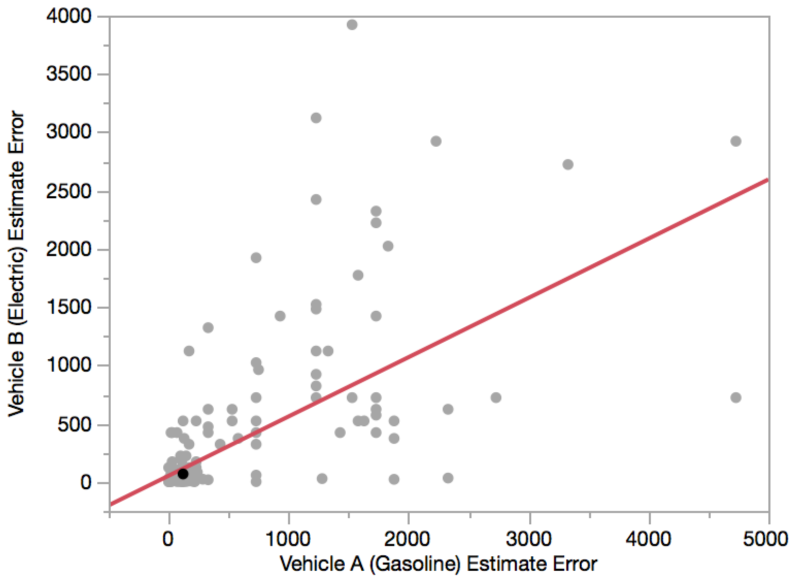
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	6055.316	6055.32	182.2401
Error	252	8373.239	33.23	**Prob > F**
C. Total	253	14428.555		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.6761532	0.424791	1.59	0.1127
Percent Error for Vehicle A Fuel Cost (Gas)	1.7734048	0.131367	13.50	<.0001*

Magnitude of Error ($)



Linear Fit

Vehicle B (Electric) Estimate Error = 52.414948 + 0.5084504*Vehicle A (Gasoline) Estimate Error

Summary of Fit

RSquare	0.419679
RSquare Adj	0.417376
Root Mean Square Error	446.8473
Mean of Response	285.5545
Observations (or Sum Wgts)	254

Analysis of Variance

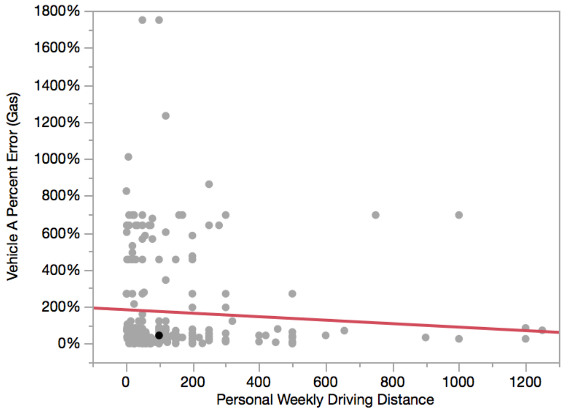
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	36388788	36388788	182.2423
Error	252	50317474	199672.51	**Prob > F**
C. Total	253	86706262		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	52.414948	32.92968	1.59	0.1127
Vehicle A (Gasoline) Estimate Error	0.5084504	0.037664	13.50	<.0001*

Appendix Figure 3. Personal Weekly Driving Distance vs. Fuel Cost Estimate Error

Vehicle A (Gas) Percent Error vs. Personal Weekly Driving Distance



Linear Fit

Vehicle A Percent Error (Gas) = 1.8391282 - 0.0009454*Personal Weekly Driving Distance

Summary of Fit

RSquare	0.00477
RSquare Adj	0.000821
Root Mean Square Error	2.75754
Mean of Response	1.695872
Observations (or Sum Wgts)	254

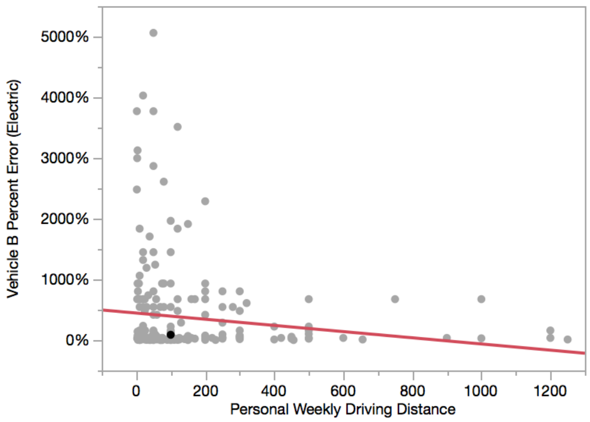
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	9.1851	9.18510	1.2079
Error	252	1916.2153	7.60403	**Prob > F**
C. Total	253	1925.4004		0.2728

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.8391282	0.216626	8.49	<.0001*
Personal Weekly Driving Distance	-0.000945	0.00086	-1.10	0.2728

Vehicle B (Electric) Percent Error vs. Personal Weekly Driving Distance



Linear Fit

Vehicle B Percent Error (Electric) = 4.4558373 - 0.005096*Personal Weekly Driving Distance

Summary of Fit

RSquare	0.018497
RSquare Adj	0.014603
Root Mean Square Error	7.496471
Mean of Response	3.68362
Observations (or Sum Wgts)	254

Analysis of Variance

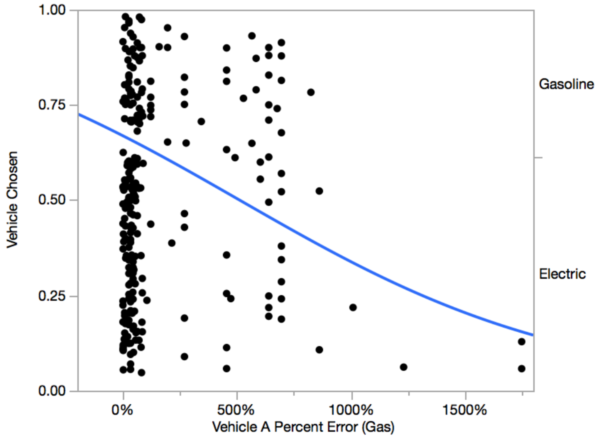
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	266.891	266.891	4.7492
Error	252	14161.664	56.197	**Prob > F**
C. Total	253	14428.555		0.0302*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	4.4558373	0.588906	7.57	<.0001*
Personal Weekly Driving Distance	-0.005096	0.002338	-2.18	0.0302*

Appendix Figure 4. Predicting Vehicle Chosen with Fuel Cost Estimation Accuracy

Vehicle A (Gas) Percent Error vs. Vehicle Chosen



Log odds of Electric = 0.7035 - 0.1373 (Vehicle A Percent Error)

Parameter Estimates

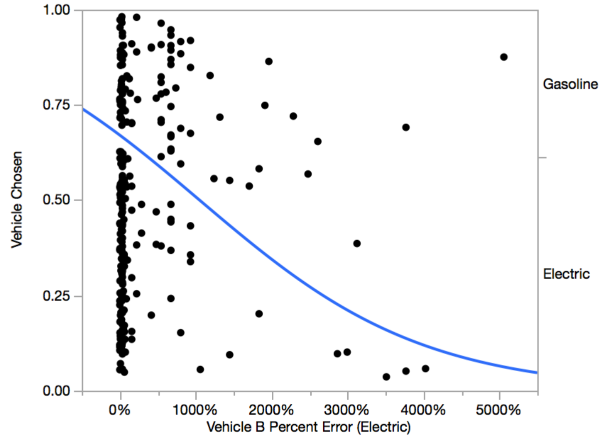
Term	**Estimate**	**Std Error**	**ChiSquare**	**Prob>ChiSq**
Intercept	0.70350776	0.1565231	20.20	<.0001*
Vehicle A Percent Error (Gas)	-0.1373171	0.0498987	7.57	0.0059*

For log odds of Electric/Gasoline

Confusion Matrix

Actual	**Predicted Count**	
Vehicle Chosen	**Electric**	**Gasoline**
Electric	143	13
Gasoline	75	23

Vehicle B (Electric) Percent Error vs. Vehicle Chosen



Log odds of Electric = 0.7117 - 0.0676 (Vehicle B Percent Error)

Parameter Estimates

Term	**Estimate**	**Std Error**	**ChiSquare**	**Prob>ChiSq**
Intercept	0.71172976	0.1495073	22.66	<.0001*
Vehicle B Percent Error (Electric)	-0.0676258	0.0211014	10.27	0.0014*

For log odds of Electric/Gasoline

Confusion Matrix

Actual	**Predicted Count**	
Vehicle Chosen	**Electric**	**Gasoline**
Electric	148	8
Gasoline	83	15

Appendix Figure 5. Values and Preferences vs. Fuel Cost Calculation Error

Fuel Efficiency in Top 2 vs. Error in A (Gas)

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.2875733	0.254261	5.06	<.0001*
Fuel2[No]	0.7515057	0.344951	2.18	0.0303*

Fuel Efficiency in Top 3 vs. Error in A (Gas)

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.4109237	0.222405	6.34	<.0001*
Fuel3[No]	0.7095763	0.350963	2.02	0.0443*

Fuel Efficiency in Top 2 vs. Error in B (Electric)

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.4541974	0.694657	3.53	0.0005*
Fuel2[No]	2.2628504	0.942427	2.40	0.0171*

Environmental Footprint in Top 1 vs. Error in A (Gas)

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.85965	0.785625	4.91	<.0001*
Env1[No]	-2.271073	0.804867	-2.82	0.0052*

Environmental Footprint in Top 1 vs. Error in B (Electric)

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	8.8659667	2.158585	4.11	<.0001*
Env1[No]	-5.439322	2.211456	-2.46	0.0146*