ANALYSIS OF ELECTRIC VEHICLE PURCHASER SATISFACTION AND REJECTION REASONS

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Parasto Jabbari
University of Washington
More Hall
Box 352700, Seattle, WA, 98115
Tel: 330-573-9823; Email: jabbari@uw.edu

William Chernicoff
Toyota Motor North America Inc.
325 7th ST NW
Suite 1000
Tel: 202 462-6813; Email: william.chernicoff@toyota.com

Don MacKenzie
University of Washington
More Hall
Box 352700, Seattle, WA, 98115
Tel: 206-685-7198; Email: dwhm@uw.edu

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This study uses a matched data set drawn from more than 1 million new vehicle post-purchase consumer satisfaction surveys to test for differences in satisfaction and reasons for vehicle choice and rejection between conventional internal combustion engine (ICE) vehicles and plug-in electric vehicles (PEVs). We use the Wilcoxon signed rank test and the McNemar and chi-squared tests to evaluate consumer satisfaction and reasons for rejecting considered vehicles, respectively. Results show that PEV purchasers and considerers are less satisfied with their overall purchase experience, but those who considered and rejected a PEV were less likely than those who considered and rejected an ICE to cite the dealer’s attitude as the reason for rejection. Price and value were the most cited reasons and were similarly important for both groups. Reasons related to model availability and vehicle attributes were more often a concern for PEV considerers than ICE considerers. These results suggest that even with existing incentives, the limitations of the current technology (e.g. price and range) and variety of available vehicles are the most important challenges to market expansion.

**Keywords:** Electric vehicle, PEV, Customer satisfaction, Customer behavior, Consumer choice, Consumer rejection
INTRODUCTION AND BACKGROUND

Automakers are bringing an increasing number of plug-in electric vehicles (PEVs) to market, comprising both battery electric (BEVs) and plug-in hybrid electric vehicles (PHEVs). Even with substantial support from various government regulations and policies, sales volumes in the US continue to fall short of official goals (1), and modeled projections (2). Researchers, policy makers, and industry point to many barriers on the way to adoption of PEVs, including range anxiety, lack of charging infrastructure, high costs, and others. Numerous studies have tried to understand and address these barriers (3, 4, 5, 6, 7, 8).

In the last couple of years there have been noticeable improvements in battery technology, cost, and charging infrastructure availability (9). These improvements, and the resulting vehicle design changes may help to overcome range anxiety and unreliable access to charging facilities. Vehicle cost reduction along with federal and state tax incentives for PEVs, made purchasing more affordable, and PEV annual sales grew from 2011 to 2014 (10). However, sales are still far behind President Obama’s goal to have 1 million plug-in vehicles on the roads by 2015 (11).

Unfamiliarity with PEV technology is another key barrier for PEV adoption. As noted by Gould & Golob (5) “instead of embracing new energy technologies, some rely on notions of tradition and familiarity when they make consumer choices.” When consumers become familiar with new technology through media and expert opinion, interpersonal communications, or direct experience with vehicle, the investment in such technology feels less risky and consumers are more willing to adopt (6, 7, 12, 13, 14). The need for this exposure tends to concentrate potential PEV adopters among groups with specific demographics. Acceptance of new technology depends on individuals; and as expected, individuals’ characteristics such as gender, age, personality and other can be influential (7). Several studies recognize these characteristics among PEV adopters. Some studies indicate that being technophiles and having environmental concerns as PEV buyers’ notable characteristics (4, 15, 16). Being highly educated and a previous owner of a hybrid car are others (16). Even among “technologically minded” individuals, the perceptions of PEVs vary with demographics such as gender, level of education, and age (4).

For adoption to grow, awareness must turn into consideration, and consideration into purchase. Therefore, it is worthwhile to study what happens when people are considering purchasing PEVs: Did they ultimately buy a PEV? Were they satisfied with the experience? If they chose not to purchase a PEV, what aspects of the vehicle and purchase experience turned them off? Understanding this consumer decision process is important in order to broaden the PEV market from innovators to the early adopters who may be more sensitive to these rejection factors (17). However, there is a lack of systematic research in this area, mainly due to a lack of robust data. One study using data from the J.D. Power 2013 Sales Satisfaction Index looked into customer satisfaction of PEV purchasers. Mixed effects regression is used to adjust for race, gender, income, and selected other covariates, and concluded that PEV purchasers are less satisfied than conventional vehicle purchasers (18). However, comparing PEV purchasers with ICE purchasers does not provide insights into the choices or purchase experience of those who considered, but did not buy, a PEV.

In this paper, we address the following questions:
Question 1: Do PEV purchasers report different levels of satisfaction with the dealership purchasing experience than do similar conventional vehicle purchasers?

Question 2: Do consumers who considered a PEV but ultimately purchased another vehicle report different levels of satisfaction with the dealership purchasing experience than do similar consumers who considered an ICE but ultimately purchased another vehicle?

Question 3: Do the reasons cited by consumers who considered a PEV but ultimately purchase another PEV or non-PEV differ from those cited by similar consumers who considered one ICE or non-ICE?

Question 4: What factors leading to rejection of a considered vehicle are significantly more common among those who considered a PEV than among those who considered a conventional vehicle?

We note here the important difference between statistical and practical significance, and where appropriate comment on the practical significance of the results.

The data used for this analysis is MaritzCX data held by Toyota Motor Sales, and used with permission of MaritzCX. The data include 1,007,040 consumer responses to the New Vehicle Consumer Satisfaction Survey for years 2011-2015 to a wide range of questions (78) on vehicle purchase decisions (table 3), satisfaction, and their background information (19). Table 1 shows the proportion of PEV purchasers and considerers by year. We have complete data on which powertrain each respondent purchased, but only a subset of respondents answered the questions about other vehicles considered.

Table 1 Counts of Purchasers and Considerers by Year and Powertrain

<table>
<thead>
<tr>
<th></th>
<th>Answered questions about vehicles considered</th>
<th>Total purchasers (implicit consideration)</th>
<th>Total considerers</th>
<th>Considered and purchased same powertrain</th>
<th>Considered but rejected the powertrain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PEV</td>
<td>ICE</td>
<td>PEV</td>
<td>ICE</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td>473</td>
<td>170,301</td>
<td>113</td>
<td>90,285</td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td>2,192</td>
<td>149,684</td>
<td>644</td>
<td>79,352</td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td>4,085</td>
<td>141,594</td>
<td>1,157</td>
<td>79,115</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td>3,980</td>
<td>126,219</td>
<td>1,183</td>
<td>66,889</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td>5,125</td>
<td>191,582</td>
<td>1,481</td>
<td>84,321</td>
</tr>
</tbody>
</table>

The numbers related to PEVs vary somewhat in the earlier years before stabilizing somewhat in the 2013-2015 period. Overall, about 2.8% of respondents chose a PEV, and the consider-then-reject rate for PEV powertrains in was 30% in 2013-15.
METHODOLOGY

The goal of our analysis is to identify differences in purchasing experience and reasons for choosing or rejecting vehicles due to the type of vehicle (PEV or ICE) purchased. A key challenge is selection bias: the customers who choose different powertrains may have different underlying values, preferences, and expectations, which themselves influence the customers’ satisfaction and confound differences due to the actual purchasing experience. We therefore want to control for differences in key observable characteristics such as income, location, and education level, which are likely to be correlated with the underlying preferences and expectations. Two general approaches to controlling for confounders are adjustment (regression) and balancing (matching). We use the latter approach in this paper.

The first step of our analysis is to match each member of the first group (e.g. PEV purchasers) with a similar individual from the second group (e.g. ICE purchasers) in terms of age, gender, income category, education level, and state of residence (21, 22). As discussed in the introduction, existing purchasers of PEVs appear to fall into several specific demographic archetypes that are meaningfully differentiated from the general purchasing public. For example, different groups of people have different expectations of their experience and what they are looking for. In addition, prior work shows that “psychographic and behavioral characteristics” can significantly influence vehicle choice (20). The matched groups are then compared to estimate the differences attributable to the vehicle choice.

Matching (otherwise known as selection on observables) is a less model-dependent approach than regression-based techniques. Whereas regression controls for differences in covariates through adjustment (adding together estimated effects of covariates on the outcome of interest), matching controls for differences in covariates through balancing (comparing members of one group with similar members of another group, so that on average the covariate distributions in both groups are approximately the same). In contrast to regression-based methods, the validity of this matching approach is not contingent upon assuming the correct model specification, and is more robust to the myriad nonlinearities and interactions that may link the covariates and outcome variables (23). Matching has been widely applied to problems such as measuring changes in vehicle technology (24,25), the effects of smoking (26), the effects of carsharing (27) and residential location choice (28) on travel demand, and the economic impacts of new roads (29), among many other problems.

Our data set contained a large number of covariates on which to match respondents. To obtain valid estimates of the effect that vehicle choice has on subsequent decisions and satisfaction, respondents should be matched on covariates that are determined before the vehicle choice occurs (26). We exactly matched individuals with the same genders, who are in the same education and income categories, in the same state, whose age difference is not more than 3 years. There might be other factors, such as number of vehicles in the household, affecting vehicle type choice (20). However, most of these factors have some sort of correlation with the factors we observed. Except for California, other states, and specific geographic location did not have enough data to extend the analysis to include other covariates. Due to the large number of respondents, we had no problems finding matches for most of the questions; we were able to find at least one match from the “control group” for our “treated group” individuals. Based on the
specific research question, the definition of treated and control group varies throughout this paper. In general, the treated group is the group who purchased or considered purchasing a PEV. Summary statistics of the matching method for each question are in the results section.

For the questions about overall satisfaction with purchasing experience, the dependent variable (level of satisfaction) is ordinal and not normally distributed. Consequently, we cannot use the most common tests such as the t-test, and instead used the Wilcoxon signed rank test for paired data (30). The Wilcoxon signed rank test is used to test whether the medians for two paired samples are the same or not (30, 31) The null and alternative hypotheses for our questions are:

H₀: The median levels of satisfaction in the two matched groups are equal.
H₁: The median levels of satisfaction in the two matched groups are not equal.

Levels of satisfaction with overall purchase/lease experience at dealership are reported on a Likert type scale with the following values:

1: Very Dissatisfied
2: Somewhat Dissatisfied
3: Satisfied
4: Very Satisfied
5: Completely Satisfied

We used a significance level of α = 0.05 to assess statistical significance.

To determine whether the reasons cited by consumers who considered but rejected a PEV differ from those cited by similar consumers who considered but rejected an ICE, the Wilcoxon signed rank test is no longer appropriate since the dependent variable is no longer ordinal. Therefore, we use both chi-squared and McNemar tests.

The Chi-squared test tells us if the probability of selecting a reason is independent of the powertrain chosen, and allows us to consider all (matched) observations. However, the downside of chi-squared is that it does not account for the paired structure of our data. Moreover, since it uses all of the control units, our data set is unbalanced in the covariates and self-selection bias may affect the results. To overcome this limitation, we use the McNemar test which is designed for paired data.

The McNemar test is used to test “marginal homogeneity in 2x2 tables” which means that marginal frequencies in the table are equal or not. It is widely used in medical and human behavior research or other areas when the impact of a treatment or before-after differences for a paired sample is targeted (23, 32, 33). The problem with the McNemar test is that it requires 1 control unit per treatment unit, but because of our large sample size many of our treated units have multiple (up to 63) equally appropriate control units. Our matching algorithm (the matching() function in R) randomly selects one control unit from all eligible matches, but the specific control unit selected can lead to differences in statistical results (i.e. p-values). To address this issue we ran 150 repetitions of the matching algorithm, conducted the McNemar test on each resulting matched set, and have reported the average p-value from these 150 runs.
A 2x2 McNemar table looks like table 2:

**TABLE 2 McNemar 2X2 Table Sample**

<table>
<thead>
<tr>
<th></th>
<th>ICE considerers</th>
<th>PEV considerers</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>a</td>
<td>+</td>
</tr>
<tr>
<td>-</td>
<td>c</td>
<td>-</td>
</tr>
<tr>
<td>total</td>
<td>a + c</td>
<td>b + d</td>
</tr>
<tr>
<td>Total</td>
<td>a + b</td>
<td>a + b + c + d</td>
</tr>
</tbody>
</table>

+ means that the individual chose it as one of the reasons for rejecting the considered vehicle and – means that individual did not choose it as one of the reasons for rejecting the considered vehicle. If both individuals (both PEV considerer and ICE considerer who are matched) in a pair have chosen that reason they would belong to N++ category. If they both have not chosen that reason they would belong to N--. If an individual who belongs to the PEV considerers sample has chosen that reason but the individual from ICE considerer has not, the pair would belong to N+- and if an individual who belongs to the ICE considerers group has chosen that reason but the other individual have not, the pair would belong to N-+. The number of pairs in each category would enter the 2x2 table. “a” is number of pairs N++, “b” is count of pairs in N--, “c” is number pairs in N+, and “d” is number of pairs in N-. N++, N-+, and N+- are called discordant cells. The null hypothesis for McNemar test is: the discordant has equal values. This means that the outcome of the test is independent from treatment.

In our analysis the null and alternative hypotheses are:

H0: Reasons for rejecting a considered vehicle are independent from the powertrain considered
H1: Reasons for rejecting a considered vehicle are dependent on the powertrain considered.

We repeated this test for all the rejection reasons indicated by consumers. Table 3 shows the available reasons for respondents to choose from. In order to determine whether the reasons are independent of powertrain or not we used a significance level of $\alpha = 0.05$. However, since we are conducting these tests on multiple reasons, we apply a Bonferroni correction to reduce the risk of false positives. Thus, we judged statistical significance by a p-value of less than $0.05 / 27 = 0.00185$ (34). Analysis for all tests was done in R statistical software package.
TABLE 3 Reasons for Not Selecting the Most Serious Considered Vehicle Provided By MaritzCX Consumer Survey \( (19) \)

<table>
<thead>
<tr>
<th>Reasons For Not Selecting the Most Considered Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>25. Model Not Available at Dealership</td>
</tr>
<tr>
<td>26. Environmental Friendliness</td>
</tr>
<tr>
<td>27. Other</td>
</tr>
</tbody>
</table>

RESULTS

**Matching Result**

Figure 1 contains the summary statistics of the four chosen characteristics of individuals for unmatched samples of ICE purchasers and PEV purchasers. We also used gender for matching. Before matching, ICE purchasers were 31% females, 48% males and 21% not answered; PEV purchasers were 22% females, 57% males and 21% not answered. Compared with ICE purchasers, PEV purchasers in our sample tend to be either very young or very old, wealthier, more highly educated, and concentrated in California. Table 4 contains the summary statistics after the matching. Because we used exact matching on state, education level, income bracket, and gender, the distributions for the matched data sets are identical.
FIGURE 1 Summary of demographics before matching

- Age distribution among buyers:
  - Average age of ICE buyers: 53.6
  - Average age of PEV buyers: 52.1

- Income distribution among buyers:
  - ICE income median
  - PEV income median

- Education level among buyers:
  - ICE (n=779380, no response= 170113)
  - PEV (n=15855, no response= 3179)

- 8 top states for PEV (67% of all sales)
  - CA
  - NY
  - GA
  - FL
  - TX
  - WA
  - MI
  - NJ

- ICE before matching (n=779380, no response=168864)
- PEV before matching (n=15855, no response=3514)
For example, Table 4 shows that 11987 PEV purchasers were matched with a similar person from the ICE purchasers group based on their age, gender, education, income and state. However, 223 people could not be matched with anyone from the ICE purchasers group based on our criteria. The reason that the counts of considerers in question 3/question 4 is different from question 2 is that there were some people who did not respond to the satisfaction question and we had to eliminate them for question 2 but their responses can be used for question 3/question 4.

Since the control groups (ICE purchasers or considerers) are very large, it is possible to have several equally appropriate matches for each individual in the treated group. The matching() command in R was used to randomly choose one of them for Wilcoxon and McNemar tests. For chi-squared test the command was modified to return all suitable matches.

**Consumer Satisfaction with Purchase Experience**

Figure 2 shows the distribution of level of satisfaction for each group of purchasers with very little difference between the matched and unmatched samples. In the unmatched data, 26.8% of PEV purchasers reported satisfaction level 3 and below (somewhat satisfied to very dissatisfied), compared with 23.1% of ICE purchasers. In the matched data set, this difference is almost the same; 26.9% of PEV purchasers and 23.3% of ICE purchasers. The Wilcoxon signed rank test on the matched samples indicates that this difference is statistically significant (W = 1,701,600, p = 3.675 x 10^-6), indicating that we should reject the null hypothesis of no difference in satisfaction between similar PEV and ICE purchasers.
Figure 3 illustrates the distribution of level of satisfaction for those who considered but rejected a PEV, and those who considered but rejected an ICE. It shows that PEV considerers reported satisfaction level 3 and below (somewhat satisfied to very dissatisfied) more often than ICE considerers. The Wilcoxon signed rank test on the matched samples indicates that this difference is highly significant ($W = 1,649,700, p = 0.0001284$). As with the purchasers, the difference in satisfaction between PEV and ICE considerers is only slightly smaller in the matched pairs than in the unmatched data. There is a significant difference in satisfaction between those who considered but rejected a PEV and those of the same age, gender, education level, income category, and state who considered but rejected an ICE vehicle.
FIGURE 3 Cumulative frequency of levels of satisfaction for PEV considerers and ICE considerers

Evaluation of Reasons for Rejecting a Vehicle

To test whether consumers rejected PEVs for different reasons than they rejected ICE vehicles, we constructed matched pairs of PEV considerers and ICE considerers. After matching the two samples, we created 2x2 table for each potential reason for rejecting a considered vehicle. Some of the reasons were added to the survey after 2011. For example, environmental friendliness was added to the questionnaire in 2012 and seating capacity, country of manufacturer, and rear leg room were added to the 2014 questionnaire. Therefore, we have different numbers of total responses for them. After creating the 2x2 table for each of the reasons, we conducted the McNemar tests.

Table 5 provides both the p value of the chi-squared test and the mean p-value for 150 runs of the McNemar test. The Bonferroni correction is applied (0.05/27) to establish a critical p-value of 0.00185. Rejection reasons with p-value smaller than 0.00185 are highlighted in table 5.
### TABLE 5 McNemar and Chi-squared Test Result for All the Reasons

<table>
<thead>
<tr>
<th>Reasons</th>
<th>McNemar Result</th>
<th>Chi-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>average p-value</td>
<td>p-value</td>
</tr>
<tr>
<td></td>
<td>(150 repetitions)</td>
<td></td>
</tr>
<tr>
<td>Cargo Capacity</td>
<td>5.18E-03</td>
<td>2.04E-07</td>
</tr>
<tr>
<td>Riding Comfort</td>
<td>9.65E-02</td>
<td>6.50E-03</td>
</tr>
<tr>
<td>Attitude Of Dealer Personnel</td>
<td>1.14E-06</td>
<td>1.56E-08</td>
</tr>
<tr>
<td>Ease Of Handling</td>
<td>5.89E-02</td>
<td>2.21E-03</td>
</tr>
<tr>
<td>Exterior Styling</td>
<td>1.65E-01</td>
<td>4.14E-01</td>
</tr>
<tr>
<td>Interior Roominess</td>
<td>1.26E-01</td>
<td>1.28E-02</td>
</tr>
<tr>
<td>Interior Styling</td>
<td>6.85E-01</td>
<td>5.09E-01</td>
</tr>
<tr>
<td>Lease Option Not Available</td>
<td>3.50E-04</td>
<td>3.10E-09</td>
</tr>
<tr>
<td>Model Not Available At Dealership</td>
<td>4.86E-08</td>
<td>1.21E-21</td>
</tr>
<tr>
<td>Fuel Economy</td>
<td>7.11E-01</td>
<td>7.12E-01</td>
</tr>
<tr>
<td>Available Options/Equipment</td>
<td>6.90E-01</td>
<td>6.65E-01</td>
</tr>
<tr>
<td>Other</td>
<td>2.06E-03</td>
<td>3.11E-06</td>
</tr>
<tr>
<td>Engine Performance/Power</td>
<td>1.96E-01</td>
<td>4.38E-01</td>
</tr>
<tr>
<td>Price/Deal Offered</td>
<td>3.74E-02</td>
<td>1.06E-01</td>
</tr>
<tr>
<td>Overall Quality/Reliability</td>
<td>7.22E-02</td>
<td>2.56E-04</td>
</tr>
<tr>
<td>Financing Terms/Rebate</td>
<td>4.55E-02</td>
<td>2.43E-03</td>
</tr>
<tr>
<td>Manufacturer’s Reputation</td>
<td>4.03E-01</td>
<td>1.30E-01</td>
</tr>
<tr>
<td>Safety Features</td>
<td>4.39E-01</td>
<td>5.80E-01</td>
</tr>
<tr>
<td>Communication System Not</td>
<td>5.01E-01</td>
<td>3.40E-01</td>
</tr>
<tr>
<td>Vehicle Size/Type</td>
<td>4.24E-01</td>
<td>9.22E-02</td>
</tr>
<tr>
<td>Future Trade-in/Resale Value</td>
<td>1.23E-03</td>
<td>1.13E-04</td>
</tr>
<tr>
<td>Value For The Money</td>
<td>2.47E-02</td>
<td>2.60E-05</td>
</tr>
<tr>
<td>Warranty Coverage</td>
<td>2.11E-06</td>
<td>1.30E-09</td>
</tr>
<tr>
<td>Environmental Friendliness</td>
<td>4.25E-04</td>
<td>9.19E-11</td>
</tr>
<tr>
<td>Country Of Manufacturer</td>
<td>5.31E-01</td>
<td>1.05E-01</td>
</tr>
<tr>
<td>Rear Leg Room</td>
<td>4.54E-01</td>
<td>3.29E-03</td>
</tr>
<tr>
<td>Seating Capacity</td>
<td>1.23E-01</td>
<td>1.35E-05</td>
</tr>
</tbody>
</table>

Figure 4 shows the mean of the fraction of the respondents in matched samples who cited each reason for rejecting a considered vehicle. They are separated by type of powertrain considered. We report the mean of the 150 runs because the control group varies as a result of the random selection during matching step. The grey columns are the percentage of all the pairs that a PEV considerer chose that reason, and black columns are percentage of all the pairs that an ICE considerer chose that reason.

By looking at figure 4 and 5 we find out which reasons are important for each group in general based on frequency of citation.
FIGURE 4 Fraction of respondents who chose each reason in paired matched samples (1 ICE considerer matched to each PEV considerer)
There were 6 rejection reasons that were identified as significantly different for PEV and ICE considerers, based on both the chi-squared and McNemar test. In addition, based on the chi-squared test on the unbalanced data, there were 5 further reasons that were identified as significantly different for PEV and ICE considerers.
DISCUSSION AND CONCLUSIONS

There is a small but statistically significant difference in satisfaction between all PEV buyers and all ICE buyers in the sample. This could be due to differences in dealership experience, or to differences in PEV and ICE buyers’ general propensities to be satisfied or not (20). Because the samples were matched on covariates this suggests that the difference in satisfaction is indeed due to differences in the vehicle purchasing experience – although the difference appears to be small in practical terms, and might be attributable to other factors not tested, such as brand experience.

Since it is possible that a poor dealership experience could actually be turning people off from buying PEVs, we also examined buyers who considered but ultimately rejected a PEV, to see if they reported a lower level of satisfaction. The pattern of the consider-but-reject group was similar to the purchasers: those who considered but rejected a PEV were slightly but significantly less satisfied than those who had considered but rejected an ICE, and most of this difference persisted even after constructing matched pairs.

Also, from comparing figure 2 and figure 3 we can see that buyers who considered but rejected a PEV were not less satisfied (in a practical sense) than those who bought a PEV. Overall, these results suggest that PEV buyers are slightly less satisfied than comparable ICE buyers, but the difference is very small in practical terms, and it is unlikely that an unsatisfactory dealership experience is turning off potential PEV buyers.

The result of the McNemar and Chi-squared tests indicates 6 reasons that are significantly different between ICE and PEV considerers, and 5 that may be significantly different based only on the Chi-squared test. Out of these 11 reasons “attitude of dealer personnel” and “value for the money” are among important rejection reasons for ICE considerers and they cited these reasons more often than PEV considerers. Even though both PEV considerers and purchasers are less satisfied with their overall purchasing experience at the dealership, “attitude of dealer personnel” was reported significantly more often by similar ICE considerers as an actual reason of rejecting a vehicle.

“Price/deal offered” is cited most often as a reason for rejecting a vehicle for both groups. Based on this, price does not appear to be a disproportionately important barrier for those who reported seriously considering a PEV between 2011 and 2015. However, it is possible that perceptions of high prices or poor relative value for PEVs precluded some consumers from seriously considering a PEV in the first place. In other words, price and value could be an important barrier, especially for the general vehicle consumer who, as shown in figure 1 has a lower income and in general is more price sensitive. This will be a bigger problem long-term if price reductions do not exceed the lost value from depleted financial subsidies or other incentives such as HOV lane access that improve the value of a PEV.

Among the top 5 rejection reasons cited by ICE considerers, “other” is the only one to be cited more often by PEV considerers. Reviewing the “other” reasons written by consumers, limited range is commonly listed among them. Although we don’t know whether it is significantly more important than other mentioned reasons based on our data, previous research confirms that range anxiety can be a major concern of consumers about electric vehicles (35,36).
PEV considerers were significantly more likely than ICE considerers to cite “model not available at dealership” as a reason for rejecting a vehicle. This is surprising, since dealers are generally willing and able to order a vehicle from another nearby dealership, even if it is not available on the same dealer’s lot. Nevertheless, it may be important, though we should be careful about what this does and does not tell us. One possible explanation is that consumers may consider a test drive to be more important for PEVs than for ICEs, due to the novelty of the powertrain. Even if PEVs are just as common on dealer lots (or more so) as ICEs, consumers may be more inclined to stop considering the PEV in those cases when the PEV is not available. Another explanation is that, to the extent that PEV sales volumes are lower than conventional vehicle volumes, this would tend to increase the inventory costs of keeping PEVs on the lot. As sales volumes for PEVs increase, we expect it to become easier for dealerships to make sure they have at least one or two PEVs on the lot at all times. Either of the above reasons would be expected to resolve itself in the future, as familiarity with the technology increases and the market grows. However, for now it could negatively affect PEV considerers’ perceptions of the vehicles and market growth, but the extent needs further evaluation.

Interpreting table 5, figure 4 and figure 5, PEVs’ models and styles, the availability of models and lease option, and “other” reasons are issues that PEV considerers are concerned with more often than ICE considerers. We conclude that other main barriers to converting PEV considerers into purchasers are limitations in the vehicle attributes such as variety and availability of models, and “other” reasons including range limitations.

It is surprising to see “Environmental friendliness” cited more often as a reason for rejecting PEVs than for rejecting ICEs. One possible explanation is that consumers who are considering a PEV may initially expect it to be cleaner and greener than it is. Another possibility is that these are consumers who rejected a PHEV in favor of a BEV. Finally, some respondents may simply cite this as an excuse for not purchasing the vehicle. Regardless, we note that the overall importance of this reason is fairly low (cited by less than 5% of respondents), which is consistent with prior research (35) finding that a history of pro-environmental behavior was less important than fuel savings in determining choices of PEVs.

This analysis has provided a new perspective on the PEV purchasing experience. Our results suggest that current PEV purchasers are less satisfied with the dealership experience than similar ICE purchasers, by an amount that is statistically significant but likely of little practical consequence. This result is consistent with findings of prior research (18), although our methods differ (matching vs. regression). We also go further than prior work, finding a similar gap in satisfaction between those who considered but ultimately rejected a PEV, and those who considered but rejected a conventional vehicle. We believe the latter comparison is more relevant to the question of whether a poor dealership experience is turning customers off of PEVs. Our analysis of consumers’ reasons for rejecting PEVs and conventional vehicles suggests that attitude of dealer personnel is not an important determinant of the decision to reject a PEV. Therefore, policy specifically targeting dealer education may not be effective, as the underlying reasons have more to do with the overall value proposition as determined by the attributes, price, and availability of PEV models.
LIMITATIONS AND FUTURE RESEARCH

The application of matching methods to our large data set provides excellent internal validity, but the early stage of the PEV market limits this study’s external validity (i.e. its generalizability to a constantly-evolving PEV market). The data include automotive sales from 2011-2015. Even though the PEV data is skewed towards the later years (table 1) at the beginning of this period both technology and variety of PEVs were limited and through these years many improvements in PEV technologies and accessibility of charging facilities occurred while regulators were working toward incentivizing PEV purchasing. Therefore, it may be worthwhile to do a similar analysis in several years to explore the impacts of the next generation of PEVs and fuel cell vehicles.

While this work has addressed both dealership satisfaction and reasons for rejecting a considered vehicle, it has not done so in a unified fashion. In the future, methods such as hybrid choice modeling (37) might allow us to understand how satisfaction, rejection reasons, and observable vehicle attributes interact to shape choices, particularly as the PEV market matures and the repurchasing patterns of PEV buyers become available. In particular, this would allow us to test quantitatively our judgment that the difference in satisfaction between PEV and ICE considerers is of little practical importance.

There are additional aspects of the dealership experience that may affect consumers’ satisfaction and their selection or rejection of a PEV. Our data set included “attitude of dealer personnel” and “model not available at dealership” as potential rejection reasons. However, other relevant factors might include things like “sales staff knowledge of product” or “availability of product information.”

The need for statistical robustness limited cutting the data in additional ways, but this may be possible in the future as cumulative and annual PEV sales grow. For example, in this analysis we did not match using premium vehicles vs. non-premium, or by brand. This may influence the level of satisfaction of consumers since premium vehicles’ dealerships and brands provide different purchasing experience for the customers, but most of the PEVs in the study were purchased through a few non-premium brands. The next step would be to match the consumers based on whether they purchased a premium vehicle or not, or by specific brand. Additionally, while income was used for matching, the value of that income does vary by geographic location within state based on cost of living. This affects ability or willingness to spend on a vehicle.

This research specifically evaluated the decision factors after a consumer has put a PEV in their consideration set. It would be valuable to conduct a parallel analysis of potential consumers who are familiar with the technology to determine if the same reasons for rejection also are important influencers in moving consumers from being merely familiar to actually considering a PEV.
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