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Barriers to Low-Income Electric Vehicle Adoption in California: An Assessment of Price Discrimination and Vehicle Availability

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Authors

Muehlegger, Erich, PhD
Rapson, David, PhD

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Barriers to Low-Income Electric Vehicle Adoption in California: An Assessment of Price Discrimination and Vehicle Availabiltiy

A Research Report from the University of California Institute of Transportation Studies

Erich Muehlegger, Associate Professor, Department of Economics, UC Davis

David Rapson, Associate Professor, Department of Economics, UC Davis

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16. Abstract

Adoption of alternative fuel vehicles by African-American, Hispanic and low-income consumers has lagged adoption by Asian, White and high-income consumers. Understanding the low-rate of adoption for certain demographic groups is of particular interest to California. In 2015, the Clean Energy and Pollution Reduction Act (SB 350) was signed into law and requires the California Air Resources Board (CARB) to study barriers to zero-emission transportation options faced by low-income consumers. This study analyzes data for over 400,000 California vehicle sales between 2011and 2015, containing information on the price paid by the consumer, the location of dealership, the zip code of the buyer and buyer demographic characteristics (e.g., race, gender, income, age) for each transaction. Researchers test for the presence of two commonly asserted barriers to electric vehicle (EV) adoption: (1) price discrimination against low-income consumers and (2) limited selection of EVs at dealerships proximate to disadvantaged communities, by comparing the prices and distance traveled for buyers of EVs in different demographic groups. As a control, researchers compare EV sales to sales of internal combustion engine (ICE) cars. Researchers find little evidence that price discrimination amongst demographic groups or differences in EV availability explain low rates of EV adoption.

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DISCLAIMER

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UNIVERSITY OF CALIFORNIA INSTITUTE OF TRANSPORTATION STUDIES

June 2017

Erich Muehlegger, Department of Economics, University of California, Davis

David Rapson, Department of Economics, University of California, Davis

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Executive Summary

Policy makers consider alternative fuel vehicles an important element of reducing urban air pollution, lowering carbon emissions and reducing overall petroleum consumption. Federal, state and local governments offer incentives to encourage consumer adoption of these vehicles. However, adoption of these vehicles by African-American, Hispanic and low-income consumers has lagged adoption by Asian, White and high-income consumers (see Figures 1 and 2). As a result, incentives have tended to accrue disproportionately towards high-income households (Borenstein and Davis, 2015).

Understanding the low-rate of adoption for certain demographic groups is of particular interest to California legislators. In 2015, the Clean Energy and Pollution Reduction Act (SB 350) was signed into law and requires the California Air Resources Board (CARB) to study barriers to zero-emission transportation options faced by low-income consumers. The Clean Vehicle Rebate Program (CVRP) and Enhanced Fleet Modernization Program (EMFP) target these groups by offering more lucrative tax incentives to low income consumers or consumers who live in disadvantaged communities.

To better understand potential barriers to electric vehicle (EV) adoption by low-income and minority populations, we analyze data for over 400,000 California vehicle sales between 2011 and 2015, containing information on the price paid by the consumer, the location of dealership, the zip code of the buyer and buyer demographic characteristics (e.g., race, gender, income, age) for each transaction. We test for the presence of two commonly asserted barriers to EV adoption: (1) price discrimination against low-income consumers and (2) limited selection of EVs at dealerships proximate to disadvantaged communities, by comparing the prices and distance traveled for buyers of EVs in different demographic groups. As a control, we compare EV sales to sales of internal combustion engine (ICE) cars. We find little evidence that price discrimination amongst demographic groups or differences in EV availability explain low rates of EV adoption.

Introduction

Policy makers consider alternative fuel vehicles an important strategy to reduce urban air pollution, lower carbon emissions and reduce overall petroleum consumption. Federal, state and local governments offer incentives to encourage consumer adoption of these vehicles. However, adoption of these vehicles by African-American, Hispanic and low-income consumers has lagged adoption by Asian, White and high-income consumers. The incentives for alternative vehicles purchases have accrued disproportionately towards high-income households (Borenstein and Davis, 2015).

With the goal of increasing adoption of alternative fuel vehicles amongst the broader population, the state of California has re-targeted hybrid vehicles incentives towards less advantaged demographic groups.[1] In November 2016, California began means-testing the Clean Vehicle Rebate Program (CVRP), restricting program eligibility to buyers with household incomes below $150,000. In addition, the state amended the Enhanced Fleet Modernization Program (EFMP), to allow for a "Plus-Up" incentive for buyers in disadvantaged communities. As part of the press release of the EFMP Plus-up program, Mary Nichols, Chair of the California Air Resources Board (CARB) announced "What's not to like about a program that cuts greenhouse gases, cleans the air and helps low-income families in the most polluted neighborhoods afford the cleanest, most fuel-efficient cars? And, as icing on the cake, it will put money in their wallets by slashing what they spend at the pump. Thanks to the leadership of Senate Pro Tem Kevin de León, the Plus-Up program is a smart investment in California's hardest hit communities, and fulfills the promise that California's efforts to fight climate change will benefit us all."[2]

The success of targeting incentives towards lower income and minority buyers depends on whether these buyers will switch from traditional vehicles powered by internal combustion engines (ICEs) towards alternative fuel vehicles, or whether impediments might limit substitution. In this paper, we examine two possible barriers during the car buying process that might impede the adoption of alternative fuel vehicles amongst low income and minority car buyers.

First, we consider availability of alternative fuel vehicles. If few low income or minority buyers purchase alternative fuel vehicles, car dealerships near low income or minority communities might be unwilling to carry a large stock. As a result, a potential car buyer might be less inclined to choose an alternative fuel vehicle as opposed to a vehicle powered by an ICE. Put differently, an individual who wants to purchase an alternative fuel vehicle might have to travel to a

[1] Nikolewski, R., "California's electric car rebates jump for lower-income buyers and vanish for more high earners." Los Angeles Times, October 31, 2016. http://www.latimes.com/business/autos/la-fi-hy-electric-car-rebates-20161031-story.html

[2] Mary Nichols, ARB News Release, 5/27/2015. https://www.arb.ca.gov/newsrel/newsrelease.php?id=730

dealership far from their home, if dealerships in their community do not carry a wide selection of alternative fuel vehicles.

Second, the decision to purchase a vehicle depends on the price a potential buyer is able to negotiate. Car dealerships price-discriminate between customers – if a particular consumer has a strong preference for a particular vehicle, the car dealership may be able to negotiate a higher price than if a consumer is indifferent between different vehicles. Even if alternative fuel vehicles are available, low income or minority buyers might pay different prices as a result of the negotiation with dealerships.

To test for both of these possible barriers to adoption, we analyze data on approximately 400,000 vehicle purchases in California from a third-party data vendor. Our data contain all California sales of plug-in electric vehicles (PEVs) as classified by the CARB from 2011 through December 2015. In total, approximately 200,000 PEVs were sold during this period, including approximate 38,000 Chevy Volts, 35,000 Nissan Leafs and 27,000 Tesla Model S. In what follows, we distinguish between battery electric vehicles ("BEVs") and plug-in hybrid electric vehicles ("PHEVs"). In addition, we have a similarly sized, representative random sample of the sales of select "comparable" vehicles. The select "comparable" vehicles consist of the passenger vehicles most similar to PEV models, and include both hybrid electric vehicles (HEVs) and ICE models such as the Toyota Prius, Honda Civic, Honda Accord and the Ford Focus.[3]

For each transaction, we observe information about: (1) the vehicle purchased (e.g., make, model and model year), (2) the transaction (e.g., date of the transaction and the price paid), (3) the dealer (e.g., name and zip code of the dealership), and (4) the buyer (e.g., the zip code of the buyer and select demographics). Although the data does not report buyer name, the market research firm does report an estimate of the buyer's income, their ethnicity, their age and their gender. These characteristics are the results of an algorithm that uses publicly available data such as address, tax records, credit reports, magazine subscriptions, to predict attributes of the buyer.

We begin by verifying the popular assumption that initial adoption of alternative fuel vehicles has been concentrated amongst high income individuals and particular demographic groups. In Figures 1 and 2, we graph the fraction of ICE, HEV and alternative fuel vehiclesales in our data purchased by different demographic groups. In Figure 1, we group buyers into one of four income brackets: less than \$50k, \$50k - \$100k, \$100k - \$150k and more than \$150k. The first two pie charts in Figure 1 show the fraction of comparable ICEs and HEVs purchased by each income bracket. For ICE and HEVs, buyers with incomes below \$100k account for 72% and 63% of purchases respectively. These income brackets include for the majority of Californians, hence, it is unsurprising that they also account for the majority of ICE and HEV purchases. In contrast, the majority of alternative fuel vehicles are purchased by buyers with incomes above \$100k. The

[3] It is important to note that the sample is select, and thus, it is inappropriate to draw conclusions about all ICE and HEV purchases. But, conditional on a buyer purchasing a "comparable" vehicle to a PEV, the sample is randomly drawn and thus appropriate for inference.

market shares presented in the pie charts confirm the conventional wisdom – high income buyers account for a disproportionately high fraction of alternative fuel vehicle purchases.

Figure 1: Fraction of Sales by Income Bracket

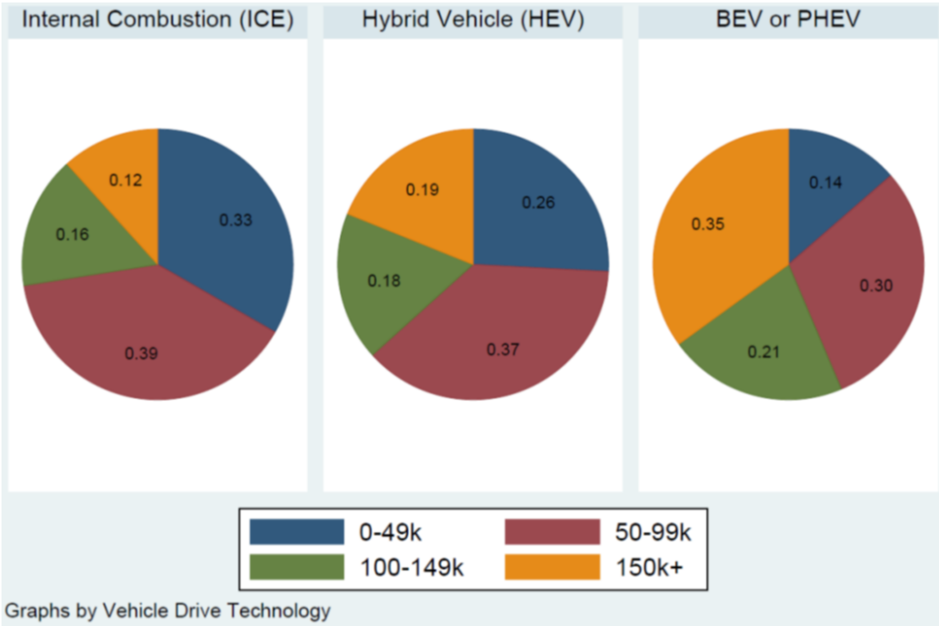
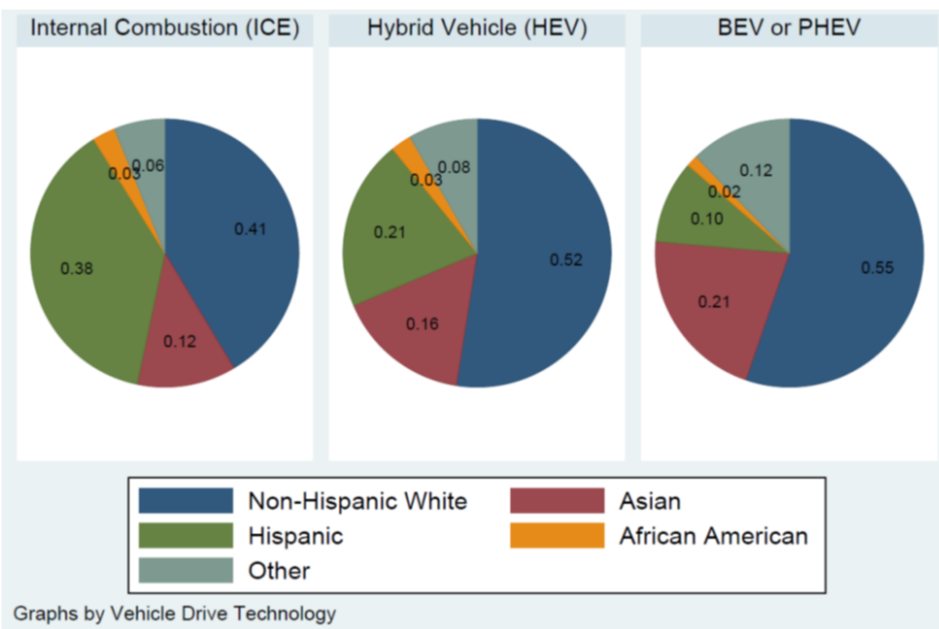


Figure 2: Fraction of Sales by Ethnicity



In a similar fashion, in Figure 2 we split the vehicle purchases by demographic group, and again confirm the conventional wisdom surrounding alternative fuel vehicles. Hispanic and non-Hispanic whites comprise roughly equal fractions of ICE buyers in our data at 38% and 41% respectively. But non-Hispanic whites purchase 55% of the alternative fuel vehicles, compared to 10% of purchases by Hispanics. Asian buyers show similar patterns to non-Hispanic whites, accounting for a relatively high fraction of alternative technology vehicle purchases relative to their share of traditional vehicle purchases.

Empirical Methodology

The empirical objective is to estimate the magnitude of barriers that make it difficult for certain demographic groups to access EV technology. We assert that there is a baseline level of "access" to technology for each subpopulation, and that the root causes of differences in baseline levels are largely predetermined. For example, historical conditions and decisions may influence where people live relative to the availability of PEV supply and other transportation resources, and institutions may create differential ease of access to different people. What we seek to identify at present is thus not whether there are *absolute* differences in access to EVs across subpopulations, but whether access to EVs is relatively more restricted to some subpopulations *when compared to that subpopulation's baseline level of access.* Our empirical approach thus requires clarity about what baseline comparison group is appropriate, a definition of "access" that is measurable, and data that includes measures of access for each subpopulation in the EV and comparison group.

Our preferred comparison group is ICE vehicles and HEVs. There is abundant data on adoption patterns of these vehicles, and it is straightforward to compare these to adoption patterns of PEVs. We do so using two measures of "access": purchase price and the distance between the customer's home and the dealer. All else equal, if one group faces a higher purchase price than another group, we interpret that as being a barrier to adoption. Similarly, customers having to travel shorter distances can be thought to have more access.

As discussed above, our dataset contains vehicle make, model, and model year as descriptive vehicle attributes, in addition to demographic characteristics of the buyer. There is substantial heterogeneity in the prices across trim levels within make-model-model year combinations. To account for this trim-level heterogeneity, we often include fixed effects for each unique combination of the manufacturer identifier and "vehicle descriptor section" (VDS) of the VIN.4 This section of the VIN encodes information such as body style, engine, and transmission information for the vehicle.

Our baseline specification regresses vehicle price on income (*Inc*) by ethnicity (k), drive-type (HEV, BEV and PHEV), and drive-type interacted with income. Specifically, for buyer *i* given drive-type $j \in \{HEV, BEV, PHEV\}$, vehicle of model type *m*, at time (in months) *t.* We estimate the following linear model:

[4] The manufacturer identifier consists of the first three characters of the VIN and denote the manufacturer and country of origin. The VDS consists of digits four through eight and denote details about the vehicle. The combination of these sections are used to identify trim-level fixed effects.

$$P_{imzt} = \alpha_0 + \sum_{k\in\{ethn\}} \beta_k * I_{i\in k} + \sum_{k\in\{ethn\}} \gamma_k * I_{i\in k} * Inc_i + \sum_{k\in\{ethn\}} \sum_{j\in\{type\}} \delta_{kj} * I_{i\in k} * I_{j=m}$$
$$+ \sum_{k\in\{ethn\}} \sum_{j\in\{type\}} \mu_{kj} * I_{i\in k} * I_{j=m} * Inc_i + \theta * X_{imzt} + \varepsilon_{imzt}$$

Results

Tables 1 (price) and Table 2 (distance) display results from our main specifications estimated on the population of new cars. Note that all entries in the tables arise from a single pooled regression. Coefficients reported under each ethnicity column header should be interpreted as differential with respect to ICEs purchased by non-Hispanic whites (NHWs).

The baseline price relationships in Table 1 show that the average price of a car purchased in our sample by NHWs is $34,011. On average, African Americans purchase ICEs that are of statistically similar price as NHWs, whereas Asians and other ethnicities spend slightly less while Hispanics spend slightly more. As income increases, Asians and Hispanics tend to spend less on ICEs (all else equal) while other ethnicities spend more relative to NHWs. Since all ICEs included in our sample are comparable in attributes to the HEVs and PEVs, they are generally smaller and less expensive relative to the full distribution of ICEs. It would therefore be incorrect to interpret the ICE baseline estimates as representative of ICEs in general.

The coefficients of interest in Table 1 are in the "BEV/PHEV" and "PEV/PHEV x Income" rows. To the extent that the BEV/PHEV coefficients are positive, it reflects a higher price paid in general by consumers of the relevant ethnic group. These coefficients will reflect two key elements of the relationship between ethnicity and price concurrently: the selection of vehicles within the BEV/PHEV class *and* any price premium that is charged to members of that group due to price discrimination. While we are controlling for observable vehicle attributes like age, odometer, and average model-year unobservables, there remains significant variation within similar model-year cars due to differences in trim and optional features. As such, a positive coefficient is neither necessary nor sufficient for the presence of discrimination, just as a negative coefficient does not necessarily or sufficiently signify its absence. The coefficients on "BEV/PHEV x Income" will be positive if the price paid for BEVs/PHEVs increases with income.

African Americans and "Other" ethnicities tend to purchase PEVs that are $2,854 to $4,311 less expensive than those purchased by NHWs. As incomes increase among African Americans and other ethnicities, buyers tend to spend more on their PHEVs. For example, for each additional $10,000 in income, an African American spends on average $263 more for PHEVs. No income effects are seen for BEV purchases or Asian and Hispanic PHEV purchases

Table 1: Vehicle Price by Ethnicity and Income

	Base Effect	African American	Asian	Hispanic	Other
Intercept	34,011.06	-75.59	-527.52	169.69	-589.17
	(1,838.33)***	(188.65)	(89.29)***	(84.39)**	(228.11)**
Income (USD 1000s)	1.62	-1.20	-1.65	-1.56	1.67
	(0.90)*	(1.73)	(0.63)***	(0.85)*	(1.64)
HEV	1,878.38	-336.79	142.05	-220.12	-179.65
	(242.09)***	(586.64)	(151.92)	(206.63)	(720.98)
HEV $\times$ Income	-1.14	2.67	1.58	2.46	1.81
	(1.01)	(3.91)	(0.93)*	(2.10)	(4.20)
PHEV	6,328.21	-4,311.78	63.29	-213.81	-4,412.02
	(339.50)***	(1,451.43)***	(149.98)	(152.02)	(1,000.60)***
PHEV $\times$ Income	-0.20	26.30	1.22	0.74	22.25
	(1.12)	(8.89)***	(1.01)	(1.58)	(4.88)***
BEV	4,902.43	-2,853.97	-684.96	-1,041.34	-2,646.26
	(1,565.94)***	(2,886.09)	(427.32)	(432.35)**	(2,005.70)
BEV $\times$ Income	1.70	15.91	-1.58	2.99	14.10
	(1.85)	(15.34)	(2.75)	(4.66)	(9.50)
N	133,649	2,238	25,788	26,779	13,239

Standard errors are in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

There are some interesting differences between price effects and our second measure of access: the distance people drive to make their purchases. These are displayed in Table 2. On average, NHWs live 8.7 miles away from their dealership of purchase. Wealthier NHW households travel farther: for every $10,000 in additional income, NHWs travel an extra 0.1 miles on average. In contrast, wealthier Hispanics purchase cars that are closer to their home address.

On average, all ethnicities travel significantly farther to buy BEVs (7.5 miles) and PHEVs (4.6 miles) than they do to buy ICEs. Relative to NHWs, non-white ethnicities do not travel incrementally farther distances. An (untestable) explanation that unifies this result and the price effects is that PEV buyers are willing to search for better deals or for cars with attributes that better match their preferences. This causes them to travel farther but, in some cases, to ultimately pay a lower price for PEVs than ICEs (e.g. African American PHEV buyers or Hispanic BEV buyers). There are few effects of income on distance travelled by car type. While Hispanics travel 0.2 miles farther to purchase BEVs for every $10,000 in additional income, and other ethnicities travel 0.2 miles farther for PHEVs, there are otherwise no statistically significant differences in distance relating to increases in income of PEV buyers.

Table 2: Buyer Distance from Dealer by Ethnicity and Income

	Base Effect	African American	Asian	Hispanic	Other
Intercept	8.6881	2.9761	3.3959	0.8176	2.4263
	(6.0576)	(0.9538)***	(0.5741)***	(0.4154)*	(0.6765)***
Income (USD 1000s)	0.0110	-0.0126	-0.0040	-0.0070	-0.0056
	(0.0030)***	(0.0099)	(0.0040)	(0.0032)**	(0.0056)
HEV	1.6928	-1.0607	0.5021	1.2192	0.1242
	(0.7203)**	(2.4603)	(0.9933)	(1.1078)	(1.4162)
HEV × Income	-0.0016	-0.0083	-0.0069	-0.0010	-0.0037
	(0.0046)	(0.0195)	(0.0073)	(0.0087)	(0.0115)
PHEV	4.5814	0.3214	-1.0451	-0.4445	2.4177
	(0.7025)***	(2.5047)	(0.6870)	(0.6678)	(1.5987)
PHEV × Income	-0.0059	-0.0088	0.0036	0.0014	-0.0177
	(0.0037)	(0.0181)	(0.0050)	(0.0055)	(0.0105)*
BEV	7.4807	6.8096	-3.6555	-1.4519	-3.2440
	(1.8743)***	(5.7662)	(2.5883)	(1.3362)	(2.2683)
BEV × Income	-0.0241	-0.0373	-0.0062	0.0169	0.0061
	(0.0073)***	(0.0292)	(0.0080)	(0.0101)*	(0.0121)
N	132,299	2,212	25,592	28,083	12,344

Standard errors are in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Discussion

The results of our work suggest that price discrimination and market access are likely not impediments to adoption amongst low-income and minority groups. Comparing purchases of alternative fuel vehicles with those of comparable ICEs and HEVs, we find little evidence that low-income or minority buyers have to travel further or pay higher prices to acquire alternative fuel vehicles.

Our results suggest that the low rates of adoption that we observe may be the result of differences in preferences for ICEs, HEVs and alternative fuel vehicles. Investments through the Low Carbon Transportation funds, including the CVRP and the EFMP, may help to increase adoption levels, if the increased incentive is sufficient to shift consumers in these demographic groups toward alternative fuel vehicles. But, our analysis cannot provide direct evidence on whether the proposed changes to alternative fuel vehicle incentives will be sufficient to reach planned levels of adoption. Evaluating the effects of the new incentives targeting disadvantaged communities and the demand elasticity of alternative fuel vehicle purchases for these demographic groups is an important area of future research.

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