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Effects of Life Cycle Cost Information Disclosure on the Purchase Decision of Hybrid and Plug-In Vehicles

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Abstract

Energy-saving technologies have a difficult time being widely accepted and consumed in the marketplace when they have a high initial purchase price and deferred financial benefits. Consumers might not realize that, in the long-run, the financial benefits from reduced energy consumption offset much or all of the initial price premium. One strategy to address consumer misconception of this advantage is to supply information on the "total cost of ownership", a metric which accounts for the purchase price, the cost of the fuel, and other costs over the ownership period. In this article, we investigate how providing information on five-year fuel cost savings and total cost of ownership affects the stated preferences of consumers to purchase a gasoline, hybrid, plug-in hybrid, or battery electric vehicle. Through an online survey with an embedded experimental design using two distinct labels, we find that respondent rankings of vehicles are unaffected by information on five-year fuel cost savings only. However, adding information about total cost of ownership increases the probability that small/mid-sized car consumers express a preference to acquire a hybrid, plug-in hybrid, or a battery-electric vehicle. No such effect is found for consumers of small sport utility vehicles. Our results are consistent with other findings in similar behavioral economics investigations on this topic and suggest that further evaluation of the effects of providing consumers with information on the total cost of ownership is warranted.

Keywords: Rank-ordered logit, life cycle cost, label information, battery electric vehicle

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1. Introduction

Since many green technologies cost more to produce than existing technologies, the initial purchase price disadvantage can discourage consumer adoption. An extreme version of this phenomenon is called the "energy-efficiency paradox" or the "energy-efficiency gap", which refers to situations where consumers decline to purchase an energy-saving technology, even when it promises to be a net cost-saver in the long-run (Gillingham et al., 2009; Gillingham and Palmer, 2013). A related social science literature shows that non-economic factors, such as political ideology or broader societal values, may play a role in consumer evaluation of energy-efficiency opportunities (Axsen and Kurani, 2012; Gromet et al., 2014).

In the United States, the promotion of alternative fuel vehicles (AFV) such as hybrids, plug-in hybrids, and battery electric vehicles is generally motivated by an objective to reduce greenhouse gas emissions

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and increase energy security from reduced gasoline consumption. Significant federal and state resources have been made available to incentivize production and to promote the purchasing of such vehicles among consumers. The federal government provides grants and loans to companies and institutions that develop plug-in electric technology (CBO, 2010; Carley et al., 2013). In addition, car manufacturers are subject to increasingly stringent corporate average fuel economy (CAFE) standards with a target of 54.5 miles per gallon by 2025. The most significant incentive for consumers is a federal income tax credit of up to $7,500 for the purchase of a qualified plug-in electric vehicle. At the state level, monetary incentives such as sales tax exemptions and lower licensing fees are in place. In addition, some states offer non-monetary incentives including access to high occupancy vehicle (HOV) lanes or exemption from public parking meters.

Several motivational factors have been identified in the literature to explain purchasing decisions about alternative fuel vehicles. There is evidence to suggest that fuel economy, government incentives, environmental concerns, and general interest in technological innovations are influential in driving vehicle purchasing decisions (Caulfield et al., 2010; Ozaki and Sevastyanova, 2011). Although Diamond (2009) finds that gasoline prices are a much stronger determinant of hybrid vehicle adoption than policy incentives. Gallagher and Muehlegger (2011) conclude that the type and magnitude of tax incentives as well as the immediacy of the tax policy is also a strong driver. And of these policy incentives, it has been found that a rebate at the point of sale is more effective than an end-of-year tax credit.

Obstacles to the widespread adoption of plug-in electric vehicles are the limited range, the long charging time, the limited availability of recharging stations, and the high purchase price (Nixon and Saphores, 2011; Egbue and Long, 2012; NAS, 2013; Carley et al., 2013). Sales of plug-in electric vehicles are vulnerable to "sticker-price bias" because these vehicles tend to be priced much higher than otherwise similar passenger vehicles. Furthermore, consumers may lack an intuitive understanding for the relative prices of gasoline and electricity as well as the different amounts of these two energy sources that are used by vehicles over their ownership lifetimes. Focus groups with car buyers demonstrate that few engage in any calculations comparing the elevated cost of purchasing the fuel-saving technology with savings in overall fuel expenses over the ownership lifetime. Although consumers might not engage in the calculations, surveys indicate that the vast majority of respondents believe that fuel economy is an important vehicle attribute (Nixon and Saphores, 2011) and is either a major or somewhat of an advantage of battery electric vehicles (Carley et al., 2013).

The literature on behavioral economics leads to the question of whether a greater appreciation of total cost of ownership (TCO) would change the purchasing decisions of consumers. In this context, TCO encompasses information about the initial purchase price, fuel expenses,and other operating cost of the vehicle over the lifetime of ownership. In the industry, TCO information is increasingly used for marketing purposes to compare different vehicles, e.g., for a comparison of different hybrids[1]. TCO information is often expressed on an average monthly basis, taking into account the need for a car loan, the interest rate and payback period of the loan, and a discount rate for future fuel savings over an assumed vehicle ownership lifetime. From a behavioral economics perspective, the TCO information can be seen as a way of doing the calculations for a consumer, so that their decision making is more aligned with a rational choice framework.

Without providing information about TCO, a recent stated-preference survey found that each $1,000 premium in the purchase price of an AFV must be compensated for by $300 per year (or for each 12,000 miles of travel) savings in fuel costs to the consumer (Nixon and Saphores, 2011). Since a vehicle will typically last 10-15 years (120,000 miles or more), the preferences found in this survey seem quite unfavorable to AFVs that have an advantage in fuel savings. The implication is that it may not be sufficient

[1]See for example the 2013 Hybrid Analysis. http://vincentric.com/Home/IndustryReports/HybridAnalysis.aspx accessed 11 March 2014)

to simply inform consumers about the extent of a vehicle's fuel savings; they need assistance about how to weigh the total amount of money saved in fuel expenses, in conjunction with information about vehicle purchase price. Research also indicates that people apply a high discount rate to future savings associated with lower operating costs, i.e., they value current (e.g., monthly) outlays much more than long term savings (Loewenstein and Thaler, 1989; Frederick et al., 2002; Greene, 2011).

One possibility to address such a characteristic of consumer decision making is to simplify the decision problem through more informative designs of product labels. In the case of household appliances, choice experiments have demonstrated that product labels that focus on the economic value of energy efficiency have a stronger impact on consumer choice than do labels that supply information on energy use in physical units or that emphasize the amount of carbon emissions (Newell and Siikamäki, 2013). Kaenzig and Wüstenhagen (2009) review studies of consumer choice with respect to purchasing decisions of household appliances and cars. They find that in most studies "the purchase likelihood of products with higher initial and lower operating costs increases when life cycle cost comparisons are provided."

In a recent redesign of the fuel economy label for new cars, the United States Environmental Protection Agency (EPA) requires vehicle manufacturers to include financial information on five-year fuel expenditure savings compared to the average passenger vehicle. This information is provided in addition to annual fuel expenditures that were presented on the previous version of the EPA label. The label redesign was supported by focus group research but not any large-sample experiment of different label designs. The federal government did not consider using a metric such as TCO because of a perceived lack of legal authority to move in this direction (EPA, 2011a). The new EPA labels were introduced with the 2013 model year and were implemented to provide "... new ways to compare energy use and cost between new-technology cars that use electricity and conventional cars ... " (EPA, 2011b).

In this analysis, we seek to determine first, when considering which type of new car to purchase, whether an emphasis on only the five-year fuel expenditure savings is likely to enhance consumer interest in hybrids and plug-in electric vehicles. We seek to validate whether the recent label redesign in the U.S. is likely to promote greater interest in lower lifetime fuel costs but higher upfront cost vehicles. One reason to be skeptical is that the new label does not assist the consumer in weighing the accumulated savings in fuel expenses against the premium in the purchase price. Second, we seek to determine whether the metric of TCO has any measurable effect on the stated preferences of new vehicle consumers. By doing the calculations for consumers, one can consider a label with TCO figures as a mechanism for providing information that could further promote the purchase of AFV beyond what the EPA is currently providing on its labels. If providing TCO information can be shown to change the stated preferences of new car consumers, such knowledge could provide policy makers and marketing specialists with a tool to trigger higher penetration of alternative fuel vehicles at a fairly low cost.

For the purpose of examining our research questions, we conducted an online stated preference survey in late 2013. We presented consumers with modified EPA fuel economy labels that were adapted to fit our research goals by showing five-year fuel expenditure savings and TCO. The respondents were asked to rank four types of vehicles according to their preferences if they were to purchase a new vehicle: gasoline, hybrid, plug-in hybrid, and battery electric. The survey focused on two vehicle sizes, depending on a respondent's stated personal interests: small/mid-sized cars and small sport utility vehicles.

The results indicate that the inclusion of the five-year fuel savings information does not exert a statistically significant influence on the ranking of the four vehicle types. For the small/mid-sized car, however, the disclosure of TCO information has a positive effect on the ranking of all AFV vehicle types, i.e., hybrid, plug-in hybrid, and battery electric. That is, the AFVs move up in the rankings and are more likely to be considered as an alternative to gasoline vehicles. This effect was not present for small SUVs.

2. Research Design: Vehicle Technology, Life Cycle Cost, and Label Information

2.1. Vehicle Technology

To assess our research questions, we focus on four vehicle types: gasoline, hybrid, plug-in hybrid, and battery electric vehicles. Gasoline powered vehicles have only an internal combustion engine as a power source. Hybrid vehicles are primarily powered by a gasoline engine but use an electric motor at low speeds. The battery of a conventional hybrid vehicle such as the Toyota Prius is only charged by the gasoline engine and by regenerative braking; there is no plug-in feature. Plug-in hybrid vehicles such as the Chevrolet Volt and the new Prius Plug-In are similar to hybrid vehicles in the sense that they have a gasoline as well as an electric motor onboard. The battery capacity is usually larger and can also be charged by connecting the car to the electrical grid as well as by regenerative braking. With plug-in hybrids, the issue of "range anxiety", i.e., consumers' fear of running out of battery power in a purely electric vehicle, is minimized because the gasoline engine serves as a back-up. Battery electric cars such as the Nissan Leaf or the Tesla Model S only have an electric motor and must be charged using a power outlet, which can take up to 12-15 hours depending upon the speed of the charger.

The choice to include these three AFVs in the present analysis was determined by their projected growth potential. According to the United States Energy Information Administration (EIA), the AFVs that are projected to grow the fastest all use a battery pack to do part or all of the propulsion (EIA, 2013). Plug-in hybrid vehicles are estimated to have the highest average annual growth rate at 23.2% between 2011 and 2040 followed by battery electric vehicles (17.9%) and hybrid vehicles (5.8%) (EIA, 2013). Hybrid vehicles have been increasing their market share since 2004 with the Toyota Prius being responsible for the majority of sales (Jenn et al., 2013). Plug-in hybrid and battery electric vehicles were introduced to the market in 2011 but are forecasted to grow in the future (EIA, 2013).

We limited the sample of respondents to those who are considering vehicle sizes for which all three ATVs are a practical option. Thus, consumers of large and heavy passenger vehicles such as pick-up trucks, vans, and large SUVs are excluded because the three new technologies are not available for these vehicles in model year 2013 (DOE, 2013). Battery electric vehicles are available in most EPA size categories except mid-sized and large station wagons, vans, trucks, and large SUVs. Plug-in hybrid vehicles are only available in the size category compact (Chevrolet Volt) and mid-sized (Ford C-Max Energi Plug-in Hybrid, Ford Fusion Energi Plug-in Hybrid, and Toyota Prius Plug-In Hybrid). In some markets, i.e., Japan and Europe, the Mitsubishi Outlander Plug-in Hybrid is offered as the only plug-in hybrid SUV. Thus our decision as to which vehicle options to offer in the experiment was determined by the availability in the plug-in hybrid vehicle market.

2.2. TCO and Label Information

To determine the effect of five-year fuel expenditure savings and TCO information on consumers' ranking of new cars, we generated "EPA labels" populated with information of generic vehicles for the technology types and vehicle sizes mentioned before. There are a multitude of gasoline, hybrid, plug-in hybrid, and battery electric vehicles on the market with differences in terms of price, fuel economy, equipment, range, battery capacity, among other attributes. To make the vehicles in our study comparable in terms of equipment, we portrayed "generic" cars and base our assumptions on incremental costs and prices compared to generic gasoline vehicles. Incremental cost calculations rely on the concept that a given type of vehicle, e.g., a mid-sized sedan, only differs in terms of the propulsion system and drive train. For example, the incremental cost of a battery electric mid-sized sedan is the cost premium associated with the battery pack, electric motor, and the electrical equipment associated with the plug-in technology when compared to an

	Mid-Sized Car				Mid-Sized SUV			
	GAS	HYB	PHV	BEV	GAS	HYB	PHV	BEV
MPG city	23.20	40.60	41.65	-	18.40	30.60	32.95	-
MPG highway	41.40	43.70	48.40	-	29.70	36.50	38.35	-
MPG combined	30.60	42.25	45.11	-	23.27	33.59	35.72	-
FE City (kWh/mile)	-	-	0.285	0.261	-	-	0.339	0.430
FE Highway (kWh/mile)	-	-	0.293	0.329	-	-	0.340	0.458
Utility Factor City	-	-	0.79	-	-	-	0.79	-
Utility Factor Highway	-	-	0.41	-	-	-	0.41	-

Table 1: Parameters for TCO calculations. The fuel economy (FE) parameters for the gasoline (GAS), hybrid (HYB), and plug-in hybrid vehicles (PHV) are taken from Al-Alawi and Bradley (2013). The fuel economy parameters for the battery electric vehicle (BEV) are assumed to be the same as the Nissan Leaf and the Toyota RAV4 EV.

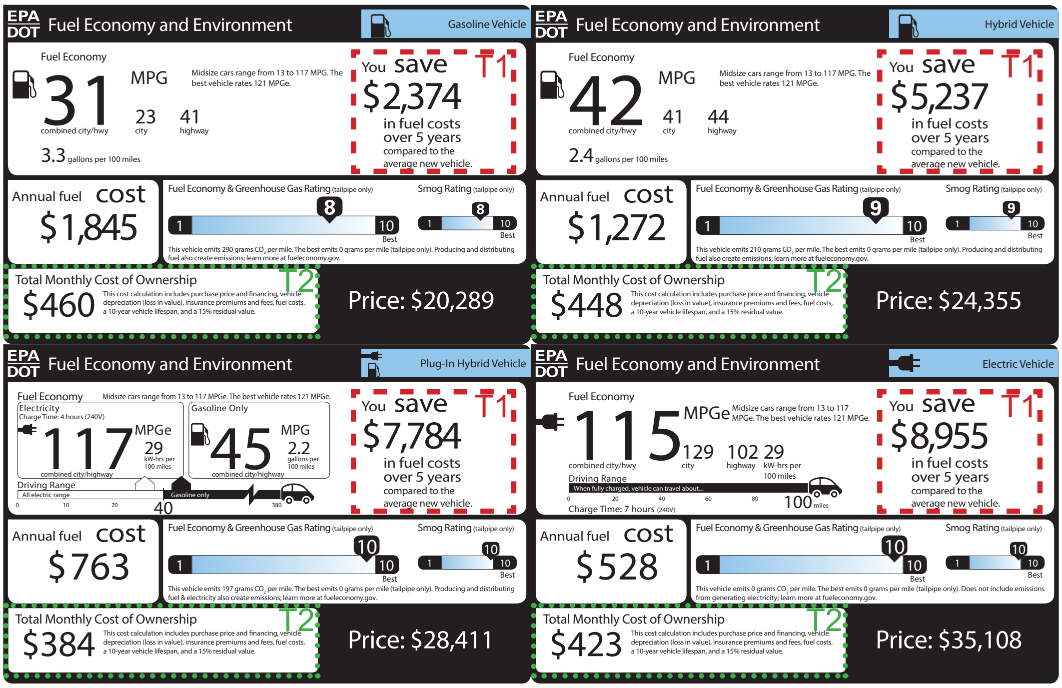
identically equipped and sized gasoline vehicle. Current prices for plug-in vehicles reflect near-term marketing considerations and may not be sustainable in the long-run. Thus, we rely on the concept of incremental cost of production for all cost calculations. The following sections describe the approach used to calculate the purchase price, five-year fuel expenditure and cost savings, and monthly TCO. Figure 1 displays all the information used in the survey for the two sizes of cars and the four vehicle technologies.

2.2.1. Purchase Price

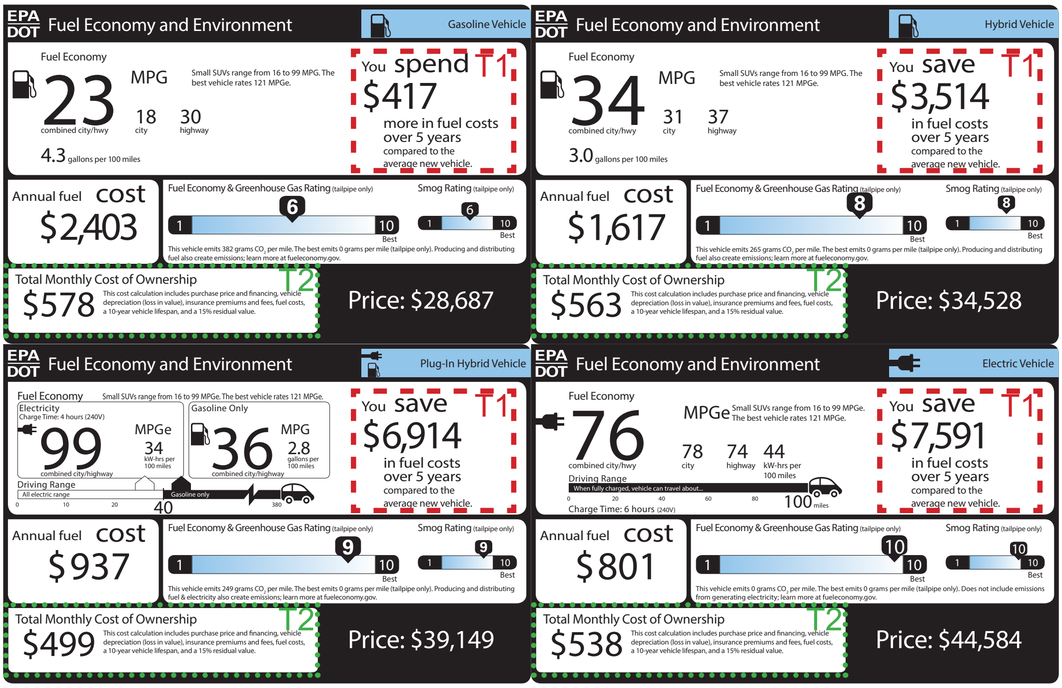
The purchase prices on the labels are taken from Al-Alawi and Bradley (2013) who provide manufacturer suggested retail price (MSRP) for mid-sized cars and mid-sized SUVs. All prices and cost in this study were adjusted to 2013 U.S. Dollars using the Consumer Price Index (CPI). For the plug-in hybrid, we chose a vehicle that has a range of 40 miles before recharging of the battery or switch to the internal combustion engine is necessary. This is referred to as a PHEV40 where "40" refers to the all electric range in miles. This is closest to the 38 miles of all electric range of the Chevrolet Volt but more than the 21 miles of the Ford plug-in hybrid models and much more than the Toyota Plug-In Prius. For the battery electric vehicle, we chose a car that has a 100 mile all electric range, which is usually referred to as a BEV100. The range of 100 miles is higher than the 75 and 76 miles electric range of the Nissan Leaf and the Ford Focus Electric but on par with the 103-mile range of the Toyota RAV4 Electric.

2.2.2. Fuel Expenditure and Fuel Savings

We assume that the vehicles travel 15,000 miles per year over a 10 year period (EPA, 2011a). The gasoline and electricity price at the beginning of the 10 year period are assumed to be \$3.50 per gallon and \$0.12 per kWh, respectively. We also assume 55% city and 45% highway driving which is consistent with the EPA method. The 2013 Annual Energy Outlook by the EIA estimates an average annual long-term increase in real gasoline prices of 0.8% and in real electricity prices of 0.3% (EIA, 2013). To calculate the annual fuel expenditures of a plug-in hybrid vehicle, a multi-day utility factor is used, which is vehicle specific. The utility factor calculates a weighted average of charge depleting and charge sustaining driving. Put differently, utility factors are a weighted average of the percentage of miles that a vehicle is expected to be operated in charge depleting mode (see Table 1 for details). As with the fuel economy calculations for conventional gasoline vehicles, the utility factors are specified for city and highway.



(a) Labels for small/medium-sized car



(b) Labels for small SUVs

Figure 1: Labels used in the survey: The control group received the label except the information shown in boxes "T1" and "T2". Treatment group 1 were provided the same label as the control group except box "T2". Treatment group 2 received full information.

2.2.3. Monthly TCO Information

The metric TCO is composed of dollar value for purchase price (depreciated over 10 years), along with fuel, financing, maintenance, insurance, and registration costs over the same time period. As in Alshamary and Calin (2013), we adopt the logarithmic depreciation of the car with a residual value of 15% and a lifetime of 10 years (Huang et al., 2011):

$$V(t) = e^{-rt}V(0)$$

We assume a sales tax of 6%. For the plug-in hybrid as well as the battery electric vehicle, we assume that the home charging station costs $2,000 and that the tax credit received is $7,500. We make the assumption that the tax credit is received at the point of sale, which is not current practice but has been recommended by the Obama administration based on previous research. For insurance and maintenance, we adopt the values used in Al-Alawi and Bradley (2013). For financing, we assume a down payment of 10%, a loan period of 60 months, and an interest rate of 5%. Based on the aforementioned data, we calculated TCO on an average monthly basis for presentation on the labels and consideration by the survey respondents.

3. Survey Design

The initial screening criteria to participate in the survey were fourfold. Respondents had to (1) be 18 years of age or older; (2) have a valid driver's license; (3) intend to purchase a new vehicle within the next two years; and (4) intend to purchase specifically either a small/mid-sized vehicle (e.g., Honda Civic, Chevrolet Malibu) or a small SUV/cross-over (e.g., Ford Escape, Toyota RAV4). The last screening criteria was implemented to screen out respondents who intend to buy a large SUV, van, or a pick-up truck.

Respondents were randomly assigned into three groups: control group, treatment group 1, and treatment group 2. The three groups were identical with the exception of the labels presented to the respondent. In the control group, the respondents received all the information displayed on the labels depicted in figure 1 except "You save X in fuel expenditures over 5 years compared to the average new vehicle" and the box "Total Monthly Cost of Ownership". Treatment group 1 received the five-year fuel savings plus all the information given to the control group. Comparing the control group with the treatment group 1 allows us to assess our first research question about whether the inclusion of information on the five-year fuel expenditures influences the stated purchase preferences of respondents. For treatment group 2, we added the TCO information, expressed on the label as "Total Monthly Cost of Ownership". Comparing treatment group 1 to treatment group 2 enables the second research question to be addressed, whether providing the potential buyer the TCO information changes rankings of the preferred vehicles for purchase in addition to the information on five-year fuel savings.

In a first step, respondents had to choose between a small/midsized car or a small SUV/cross- over, whichever size range is closest to what they were considering for purchase or lease. Adding this choice of vehicle type to the other information allows for the results differentiate and compare the effects of the labels relative to two different car sizes. Note that once the respondents chose the vehicle size, the information given in terms of vehicles and the labels were specific to the vehicle size chosen. Following the choice of vehicle size, the characteristics of gasoline, hybrid, plug-in hybrid, and battery electric vehicle were explained to ensure that all respondents have comparable information about the four vehicle types and understand the differences between the various technologies. Differences in battery sizes and charging technologies were also explained. The respondents were made aware of the availability of the federal tax credit. We also included information about level 2 chargers, since chargers are also important to consider when one is interested in purchasing a battery electric vehicle.

Following the presentation of basic vehicle information, but just before respondents were shown the labels, we explained the assumptions behind the labels in terms of miles driven per year and gasoline/electricity prices. We use the EPA labels that are displayed on new cars as a template to modify because they mimic closely what customers are used to seeing in the dealer showroom (Figure 1). The labels for the four types of vehicles were presented in a random order to purge any anchoring effects in the data. Immediately following the presentation of the labels, the respondents had to pick their first choice of vehicle for possible purchase and then rank the remaining three vehicles in descending order of preference. In the remaining sections of the survey, respondents were asked a variety of questions relating to their preference of various vehicle attributes, travel behavior, and demographics, among others.

4. Model

To assess the research question, the data are analyzed using a rank-ordered logit model. One of the first applications of a rank-ordered logit was to estimate the demand for electric cars given different attributes (range, price, fuel expenditure, etc.) by Beggs et al. (1981). In our case, the ranking is among the different vehicle types. In each treatment group, respondents were asked to pick their most preferred vehicle and then rank the remaining three. This is equivalent to require a ranking of the four cars by the respondents (Train, 2003). We are going to use a random utility framework assuming that there are $j = 1, \ldots, J$ alternatives and $i = 1, \ldots, N$ individuals. For individual i, the utility of alternative j is given by U_{ij} (Fok et al., 2012). In the random utility framework, it is assumed that the researcher does not directly observe U_{ij}. Instead, the researcher constructs a random utility model of the form $U_{ij} = V_{ij} + \epsilon_{ij}$ where V_{ij} is the deterministic component of the utility that is observed by the researcher and ϵ_{ij} is independent and identically distributed extreme value. The specification of V_{ij} is written as $V_{ij} = \beta X$ where β is a vector of coefficients and X are the covariates that can be either alternative specific or individual specific.

The alternatives are the four cars, i.e., $J = 4$ and the probability of choosing alternative j is increasing in V_j. Let r_i be a vector whose elements r_i^j denote the ranking received of alternative j by respondent i, i.e., $r_i = (r_i^1, \ldots r_i^J)$. Then the probability to observe a particular ranking is written as (Borzekowski and Kiser, 2008; Fok et al., 2012; Lee and Yu, 2013)

$$P(r_i|\beta) = P(U_{r_i^1} > \cdots > U_{r_i^J}) = \prod_{j=1}^{J-1} \frac{\exp(V_{ir_i^j})}{\sum_{l=j}^{J} \exp(V_{ir_i^l})} \tag{1}$$

There are similarities between the multinomial logit (MNL) and the the rank-ordered logit presented in equation 1. The rank-ordered logit can be thought of a sequence MNL model in which the pool of alternatives diminshes with each alternative receiving a ranking.

5. Data

The data was collected in late October and early November 2013 through an online survey administered by Qualtrics. A total of 3,199 responses were collected from 32 U.S. metropolitan areas[2]. Table 2 summarizes the characteristics of each group in the experiment. Some respondents were dropped from the survey because they did not indicate a ranking that could be considered complete. Some respondents only ranked

[2]Austin, Boston, Bridgeport, Chicago, Dallas, Denver, Detroit, Houston, Indianapolis, Los Angeles, Nashville, New York, Orlando, Phoenix, Portland, Raleigh, Richmond, Sacramento, San Diego, San Francisco, Seattle, Sonoma County, Tucson, Washington, El Paso, Charlotte, Philadelphia, Baltimore, Jacksonville, Memphis, San Antonio, and Atlanta

Variable	Control Group		Treatment Group 1		Treatment Group 1	
Variable	CAR	SUV	CAR	SUV	CAR	SUV
Observations	498	409	507	433	494	418
Respondents Characteristics						
Age	40.22	43.41	40.69	43.29	41.87	42.71
	14.98	13.99	14.66	14.41	15.41	14.12
Level 2	25.46%	30.62%	30.40%	25.64%	30.60%	29.88%
	0.44	0.46	0.46	0.44	0.46	0.46
Number of cars	1.86	2.01	1.80	1.96	1.85	1.91
	1.02	1.07	0.88	0.98	1.11	0.93
Gender	63.77%	65.84%	57.82%	63.21%	59.22%	64.71%
	0.48	0.47	0.49	0.48	0.49	0.48
Education	46.79%	52.70%	47.14%	50.35%	49.19%	52.87%
	0.4991	0.4994	0.4993	0.5001	0.5001	0.4993
Income	22.42%	26.04%	20.00%	28.47%	22.92%	25.90%
	0.4172	0.439	0.4001	0.4514	0.4204	0.4382
Previous vehicle ownership						
Gasoline	93.17%	97.31%	94.67%	96.07%	94.13%	95.22%
	0.25	0.16	0.22	0.19	0.24	0.21
Hybrid	5.42%	7.33%	8.88%	3.70%	7.09%	5.02%
	0.23	0.26	0.28	0.19	0.26	0.22
Plug-in Hybrid	0.60%	0.98%	1.58%	1.39%	1.42%	0.96%
	0.08	0.10	0.12	0.12	0.12	0.10
Battery Electric	1.20%	0.73%	0.59%	0.46%	1.21%	0.48%
	0.11	0.09	0.08	0.07	0.11	0.07
Gasoline	2.14	2.20	2.11	2.20	2.29	2.18
	1.15	1.14	1.15	1.15	1.18	1.14
Hybrid	2.09	1.99	2.12	1.94	2.11	1.97
	0.89	0.88	0.89	0.83	0.90	0.88
Plug-in Hybrid	2.48	2.47	2.45	2.45	2.38	2.45
	1.02	0.99	0.99	0.98	1.00	0.96
Battery Electric	3.29	3.34	3.31	3.41	3.22	3.40
	0.96	0.94	0.98	0.90	1.04	0.90

Table 2: Descriptive statistics with standard deviation in parenthesis

Variable	Description
Own	=1 if previous ownership of a new technology car
Age	Age of the respondent
Level 2	=1 if awareness of any public Level 2 charging stations in respondent's community
# of cars	Number of cars currently owned or leased by the household
Gender	=1 if female
Education	=1 if 4-year college degree or higher
Income	=1 if annual household income is $100,000 or higher
Group	=1 if more information was disclosed to consumer

Table 3: Variables included in the analysis

three vehicles and thus, we assigned the value of 4 to the no-rank vehicles (Allison and Christakis, 1994). The implicit assumption is that the vehicle not ranked is the least desirable, just as those that are ranked last are the least desirable. This procedure was done for 38 respondents, leaving us with complete rankings for 2,759 individuals, 1,499 of which ranked mid-sized vehicles and 1,260 of which mid-sized SUVs.

We include several control variables in the models as displayed in Table 2. We control for whether a respondent has at any point previously owned an alternative fuel vehicle since previous studies have shown that those interested in alternative fuel vehicle have likely already owned one. This variable is alternative specific. Electric vehicle owners, for example, are likely to have previously owned a conventional hybrid (Carley et al., 2013). We also control for whether a respondent has seen a level 2 charger in their community, since knowledge of where chargers exist may increase the interest in an electric vehicle. We additionally include the number of vehicles a respondent owns as well as a number of demographic characteristics. For our analysis, we transformed the variables education and income into dummy variables based on having completed a four-year college education and having an income of $100,000 or above (Table 3).

6. Results and Discussion

The results of the rank-ordered logit model are presented in Table 4. A positive coefficient indicates an increase in the probability of ranking the car in question more favorably compared to a gasoline vehicle which serves as the base case.

Our first research question is designed to assess the potential influence of including five-year fuel expenditure savings on the EPA labels on purchasing preferences. The variable "Group" in the column "Control Group vs. Treatment Group 1" (Table 4) indicates the influence of this information. The rank-ordered logit model reveals that the provisioning of the five-year fuel expenditure savings information is not statistically significant for any vehicle. The result suggests that consumers may have difficulties comparing the value of the five-year fuel expenditure savings to the vehicle price in a meaningful way. Our finding is not consistent with a European study by Nixon and Saphores (2011) who found that five-year savings information did influence stated preferences. However, fuel prices in Europe are roughly double the U.S. average and thus, European respondents may be more sensitive to information about savings in fuel expenditures. Another possible explanation for the finding is that consumers are not considering the "average" passenger car or do not know what the average passenger car is. Thus, they dismiss the five-year fuel expenditure savings as irrelevant to their personal decision. A person buying a small/midsized car or a small SUV might be more interested in how the vehicle of his/her choice compares to the average vehicle in the same class, i.e.,

		Control Group vs. Treatment Group 1				Treatment Group 1 vs. Treatment Group 2			
		CAR		SUV		CAR		SUV	
		Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Intercepts	BEV	0.46	0.32	0.05	0.40	0.37	0.31	-0.03	0.41
	HYB	0.6**	0.28	0.59.	0.34	0.71***	0.28	0.69*	0.36
	PHV	0.94***	0.30	0.49	0.36	1.18***	0.29	0.51	0.38
Own	own	0.47***	0.15	0.27	0.19	0.5***	0.14	0.45**	0.21
Age	BEV	-0.03***	0.00	-0.03***	0.01	-0.03***	0.00	-0.03***	0.01
	HYB	-0.01*	0.00	-0.01	0.00	-0.01*	0.00	-0.01	0.00
	PHV	-0.02***	0.00	-0.02***	0.01	-0.03***	0.00	-0.02***	0.01
Level 2	BEV	0.83***	0.15	0.92***	0.17	0.8***	0.15	0.88***	0.17
	HYB	0.33**	0.13	0.49***	0.15	0.1	0.13	0.35**	0.15
	PHV	0.86***	0.14	0.92***	0.15	0.47***	0.14	0.65***	0.15
# of cars	BEV	-0.08	0.07	-0.12	0.08	-0.06	0.07	0.03	0.08
	HYB	0	0.06	0.03	0.07	-0.01	0.06	0.08	0.07
	PHV	-0.12*	0.07	-0.03	0.07	-0.06	0.06	0.04	0.07
Gender	BEV	-0.05	0.14	0.16	0.17	-0.08	0.14	0.09	0.17
	HYB	0.11	0.12	0.02	0.14	0.11	0.12	0.13	0.14
	PHV	-0.01	0.13	0.17	0.15	-0.15	0.13	0.04	0.15
Education	BEV	-0.2	0.15	-0.25	0.16	0.12	0.15	-0.29*	0.16
	HYB	0.22*	0.12	0.05	0.14	0.13	0.12	0.15	0.14
	PHV	0.11	0.13	-0.14	0.14	0.21	0.13	0.03	0.14
Income	BEV	0.13	0.18	0.4**	0.18	-0.26	0.18	0.09	0.18
	HYB	-0.02	0.15	-0.25	0.15	-0.09	0.15	-0.28*	0.15
	PHV	-0.03	0.16	0.15	0.16	-0.39**	0.16	-0.08	0.16
Group	BEV	-0.13	0.14	-0.09	0.15	0.36**	0.14	-0.03	0.15
	HYB	-0.05	0.12	0.09	0.13	0.2*	0.12	-0.08	0.13
	PHV	-0.02	0.13	-0.04	0.14	0.36***	0.12	0.03	0.14

Table 4: Results of the rank-ordered logit model: The gasoline vehicle is used as the base case when compared to hybrid (HYB), plug-in hybrid (PHV), and battery electric vehicles (BEV).

the average small/midsized car or the average small SUV. The EPA already classifies cars in different size categories in their fuel economy guide but does not utilize a category-specific approach on the labels. Still another possible explanation is that consumers are not sure how long they will use the car and thus, are not sure whether the five-year time frame is relevant to their situation.

Our second research question aims to analyze the effects of providing information about TCO in addition to five-year fuel expenditure savings on vehicle preferences. We find that the "Group" variable for the small/mid-sized car is statistically significant for all new technology vehicles in our analysis, especially the plug-in hybrid and the battery electric vehicles. The plug-in vehicles show a significant increase in ranking compared to the gasoline vehicle. The same result is not present for the small SUVs. The result for the small/mid-sized car is consistent with our behavioral economics hypothesis that providing TCO information helps consumers to choose by doing the calculations that are required to weigh the purchase price against the lower operating costs.

The fact that the TCO information is not statistically significant for the small SUV category can have different explanations. A recent survey found that consumers of large vehicles are generally less interested in fuel economy as a vehicle attribute and are less like to consider an alternative fuel vehicle for their next vehicle purchase Nixon and Saphores (2011). Moreover, consumers choosing SUVs may focus on more high-priority vehicle attributes such as seating capacity, cargo capacity, ride height, and engine performance. Those consumers may value fuel savings to some extent but it may be difficult to detect the effect of TCO information in a population of consumers who are focused more strongly on other vehicle attributes.

The socio-demographic variables reveal that increasing age decreases the probability of choosing a plug-in hybrid or a battery electric vehicle. This relationship is also statistically significant for the hybrid vehicle in the small/mid-sized car category. Respondents who are aware of a public level 2 charger in their community are more likely to rank an alternative fuel vehicle higher. It is possible that the knowledge of a level 2 charger made respondents aware of the presence of plug-in vehicles in their community. It could also be an indication that respondents would purchase or lease a plug-in electric vehicle with more confidence because a level 2 charger is present and they know that the vehicle can be readily re-charged.

7. Conclusion

Alternative fuel vehicles such as hybrid, plug-in hybrid, and battery electric vehicles have a difficult time penetrating the car market which is currently dominated by gasoline vehicles. In this analysis, we hypothesize that the provision of total cost of ownership information on fuel economy labels could increase stated consumer demand for alternative fuel vehicles. We also suggest that the EPA information on five-year fuel expenditure savings may not be effective because consumers do not know how to relate this information to the salient purchase price premium of alternative fuel vehicles. The latter issue addresses the effectiveness of the recent redesign of the EPA fuel economy label whereas the former issue considers a potential reform of the EPA label that might be effective at increasing interest in alternative fuel vehicles.

We find that the five-year fuel expenditure savings information has no effect on consumers' ranking of gasoline, hybrid, plug-in hybrid, and battery electric vehicles. The five-year fuel expenditure savings are large for the hybrid, plug-in hybrid, and battery electric vehicles but consumers do not appear to respond to the information in their preference rankings. Possible explanations for this result are worthy of further inquiry since the five-year fuel expenditure savings information is already implemented on the EPA labels. The information of total cost of ownership is not yet included on the EPA fuel economy labels but seems to trigger consumer interest in alternative fuel vehicles based on our analysis. We find that when total cost of ownership information is disclosed to respondents interested in small/midsized cars, the likelihood of ranking a hybrid, plug-in hybrid, and battery electric vehicle more favorably increases and is statistically significant. Similar results for the total cost of ownership information are not obtained for small SUVs.

Future research on the impact of total cost of ownership information on consumers is warranted. Recent research suggests that fuel savings information may have a greater impact on consumers when presented in promotional materials than when put on standard car labels (Codagnone et al., 2013). The same may be true for total cost of ownership information but that hypothesis needs to be tested directly in an experiment. Since vehicle prices vary considerably by car dealer, it may be reasonable to incorporate total cost of ownership information in promotional materials than on EPA label which cannot be varied across dealers. Future research of total cost of ownership information should examine a richer array of vehicle categories such as pick-up trucks and large SUVs which are not included in our analysis.

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