Effects of providing total cost of ownership information on consumers' intent to purchase a hybrid or plug-in electric vehicle

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Abstract

Energy-saving technologies have a difficult time being widely accepted 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, conventional hybrid, plug-in hybrid, or battery electric vehicle. Through an online survey with an embedded experimental design using distinct labels, we find that respondent rankings of vehicles are unaffected by information on five-year fuel cost savings. However, adding information about total cost of ownership increases the probability that small/mid-sized car consumers express a preference to acquire a conventional 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 the behavioral economics literature and suggest that further evaluation of the effects of providing consumers with information on the total cost of vehicle ownership is warranted.

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1. Introduction

Conventional hybrid and plug-in vehicles are usually more expensive to purchase because of higher production cost associated with the battery pack and the powertrain. Although energy-saving technologies have lower operating cost and have the potential to be net-cost savers in the long-run, consumers may decline to purchase such technologies, a phenomenon which is referred to as the "energy-efficiency paradox" or the "energy-efficiency gap" (Gillingham et al., 2009; Allcott and Greenstone, 2012; Gillingham and Palmer, 2013). This paper intends to assess the effect of presenting the consumer with monthly cost of ownership in addition to five-year fuel expenditure savings as part of the U.S. Environmental Protection Agency (EPA) fuel economy labels and experimentally assess the impact of this information of stated vehicle purchase choice. Adding the monthly cost of ownership to the label could potentially circumvent the issues arising from the energy-efficiency gap and thus, stimulate the effectiveness of the energy security policies.

As a response to provisions in the Energy Independence and Security Act of 2007, significant federal and state resources have been made available to incentivize production and to promote the purchasing of alternative fuel vehicles among consumers. The federal government provides grants and loans to companies and institutions that develop plug-in electric technology (CBO, 2012; 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 $7500 for the purchase of a qualified plug-in electric vehicle. In some states, additional monetary incentives such as sales tax exemptions and lower licensing fees are in place as well as non-monetary incentives including access to high occupancy vehicle (HOV) lanes or exemption from public parking meters. The policy measures that are of interest to this analysis are related to the fuel economy labels on new cars. The EPA in consultation with the U.S. Department of Transportation (DOT) recently implemented new fuel economy labels to ‘‘help consumers to make more informed vehicle purchase decisions, particularly as the future automotive marketplace provides more diverse vehicle technologies from which consumers may choose.’’ In our research design, we assess the effect of adding a measure of monthly cost of ownership on the fuel economy labels to supplement the current information supplied on the label.

Several motivational factors have been identified in the literature to explain purchasing decisions about conventional hybrid and plug-in vehicles. Research suggests 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, i.e., a rebate at the point of sale is more effective than an end-of-year tax credit. 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; Sexton and Sexton, 2014; Gromet et al., 2014).

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 higher purchase price compared to similar conventional gasoline vehicles (Nixon and Saphores, 2011; Egbue and Long, 2012; NAS, 2013; Carley et al., 2013). 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 lifetimes. For example, Krause et al. (2013) find that 70% of consumers underestimate the fuel savings for a plug-in electric vehicle. 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 (EPA, 2010; Axsen and Kurani, 2012). 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 the vehicle. 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. The TCO information can be seen as providing a heuristic (fast thinking) or as a way of doing the calculations for consumers, thus removing a barrier to rational decision-making.

Without providing information about TCO, a recent stated-preference survey found that each

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

$1000 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 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 outlays much more than long term savings (Loewenstein and Thaler, 1989; Frederick et al., 2002; Greene, 2011).

One possible strategy 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.’’ Providing the live cycle cost or total cost of ownership can hence increase the purchase probability of plug-in vehicles.

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).

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. 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 a tool to trigger higher penetration of conventional hybrid and plug-in vehicles at a fairly low cost of implementation.

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 conventional 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 vehicles with lower lifetime fuel costs but higher upfront cost. Second, we seek to determine whether the metric of TCO has any measurable effect on the stated preferences of new vehicle consumers. For the purpose of examining our research questions, we conducted an online stated preference survey in late 2013.

2. Vehicles and label information

2.1 Vehicle types

To assess our research questions, we focus on four vehicle types: gasoline, conventional hybrid, plug-in hybrid, and battery electric vehicles. Gasoline powered vehicles have only an internal combustion engine as a power source. Conventional 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 conventional 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 partially charged by regenerative breaking and fully charged by connecting the car to the electrical grid through a power outlet (Clement-Nyns et al., 2010). 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 vehicles such as the Nissan Leaf or the Tesla Model S only have an electric motor and must be charged using a power outlet. Charging times vary considerably. A Nissan Leaf can be charged in approximately 5 h using a 240 V home charger. Using a DC Fast Charger, this time can be reduced to 30 min. Tesla Motors provides a charging time calculator on their webpage which indicates times between 5 h and over 92 h depending on whether a 110 V outlet is used or a 240 V, 80 A Wall Connector paired with an 80 A dual charger in the car. A Toyota Rav4 EV can have a full charge in 5–6 h.

The choice to include hybrid and plug-in vehicles in the present analysis was determined by their projected growth potential. According to the United States Energy Information Administration (EIA), the vehicles that are projected to grow the fastest all use a battery pack to do part or all of the propulsion. The 2013 sales data shows that almost 49,000 plug-in hybrid and over 46,000 battery electric vehicles were sold in the United States.[2] In 2013, California alone has paid Clean Vehicle Rebates for 14,676 qualifying battery electric vehicles and 12,865 plug-in hybrid electric vehicles.[3] Hybrid vehicle sales are an order of magnitude larger in the U.S. with almost 380,000 hybrids sold in 2012 (EIA, 2014). Their market share has been growing since 2004, with the Toyota Prius responsible for the majority of sales (Jenn et al., 2013). Those numbers result in a market shares of 1.9% (conventional hybrid), 0.08% (plug-in hybrid), and 0.04% (battery electric). Plug-in hybrid and battery electric vehicles were not introduced until 2011 but are forecasted to grow in the future (EIA, 2014). The most recent full-year data (2013) reveal that the Chevrolet Volt, Nissan Leaf, and Tesla Model S are the largest selling plug-in vehicles in the U.S., each with sales volumes on the order of 20,000. According to EIA (2014), the projected 2040 market shares for conventional hybrids, plug-in hybrids, and battery electric vehicles are 7.1%, 1.63%, and 0.71%, respectively. For light-duty vehicles, plug-in hybrid vehicles are estimated to have the highest average annual growth rate of 14.91% between 2012 and 2040, followed by battery electric vehicles (13%) and conventional hybrid vehicles (6.2%) (EIA, 2014).

2.2Vehicle sizes

We limited the sample of respondents to those who are considering vehicle sizes for which the conventional hybrid and the plug-in vehicles are a practical option. 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 a conventional hybrid and plug-in vehicle for their next vehicle purchase (Nixon and Saphores, 2011). Thus, consumers of large and heavy passenger vehicles such as pick-up trucks, vans, sports cars, 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

[2] http://evobsession.com/electric-car-sales-increased-228-88-2013/ accessed 4 December 2014.
[3] https://energycenter.org/clean-vehicle-rebate-project/rebate-statistics accessed 4 December 2014.

offer in the experiment was determined by the availability in the plug-in hybrid vehicle market. Thus, the survey focused on two vehicle sizes, depending on a respondent's stated personal interests: small/mid-sized cars and small sport utility vehicles.

2.3 Generic cars and incremental cost

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, conventional 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. Using a generic model also avoids the problem that respondents are influenced by loyalty to a particular brand or model. Most engineering-economic analysis including the work by Al-Alawi and Bradley (2013) base their generic vehicle on models from EPRI (2001, 2004), Simpson (2006) and Lemoine et al. (2008). These models, which we follow, start with a conventional vehicle powered only by an internal combustion engine. The conventional hybrid as well as the plug-in vehicles are modeled as closely as possible to have the same size and performance characteristics as the baseline vehicle (EPRI, 2001). Those characteristics include speed, grade-ability, passing performance, standing acceleration, and towing capacity. Simpson (2006) outlines the assumption of the generic model in terms of parameters such as vehicle mass, drag coefficient, frontal area, and rolling resistance, thereby achieving comparability to either a Toyota Camry or a Chevrolet Malibu. Al-Alawi and Bradley (2013) includes vehicles of similar functionality, size, and interior volume. 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 midsized 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 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. The information about the fuel savings is calculated over 5 years which is the time period chosen by the EPA in their final rulemaking.[4] For the total cost of ownership, we used a lifetime of 10 years which is consistent with EPRI (2004) and Huang et al. (2011). Currently, the average age of a car on U.S. roads is 11.4 years.[5] This value is the highest since 2004–2005 and is mainly due to the recession. Fig. 1 displays all the information used in the survey for the two sizes of cars and the four vehicle technologies. The exact labels for the three treatment groups are found in Appendix A. All prices and cost in this study were adjusted to 2013 U.S. Dollars using the Consumer Price Index (CPI).

2.4 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. 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.

2.5 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

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[4] Federal Register Vol. 76, No. 129, Part II, 49 CFR Part 575 Revisions and Additions to Motor Vehicle Fuel Economy Label; Final Rule.

[5] ‘‘253 million cars and trucks on U.S. roads; average age is 11.4 years,’’ LA Times, 9 June 2014, http://www.latimes.com/business/autos/la-fi-hy-ihs-automotive-average-age-car-20140609-story.html accessed on 3 August 2014.

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.

On the actual EPA labels, some vehicle labels will display the word ‘‘save’’ whereas other labels will use ‘‘spend’’. This is consistent with the EPA’s approach to compare fuel savings to the average car, i.e., the vehicles indicated on the label as ‘‘you save’’ in fuel costs over five years will have a fuel economy that is better than the projected average level for the fleet for that model year, while those indicating ‘‘you spend’’ will be below the projected average (Federal Register, 2011). The same problem does not exist for TCO information because TCO is not compared to the average passenger vehicle. Changing the reference from comparing the 5-year fuel expenditure information to the ‘‘average car’’ to comparing the TCO across different vehicle types might serve as an explanation for the finding 5-year fuel expenditure information does not affect vehicle rankings.

2.6 Total cost of ownership

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) which is written as $V(t) = e^{-rt} V(0)$. We assume a sales tax of 6% which representative of the predominate rates in the cities selected for our survey. For the plug-in hybrid as well as the battery electric vehicle, we assume that the home charging station costs $2000 and that the tax credit received is $7500. For the total cost of ownership calculations, we make the implicit assumption that the consumer is indifferent between receiving the tax credit at the point of sale or the end of the year. Although Gallagher and Muehlegger (2011) find that the immediacy of the tax credit has an influence on consumers, our approach is consistent with the total cost of ownership calculations. 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.

2.7 Comparison of actual vehicles to generic vehicles

To compare the label information used in our analysis to attributes from actual cars, we compile information from the 2013 EPA fuel economy guide and summarize the information in Tables 2 and 3. Due to the large number of gasoline vehicles available, we focus on cars that are in the top twenty models sold in the U.S. and that are comparable in size to the vehicles presented in our survey.[6] For the conventional hybrid and plug-in hybrid vehicles, we summarize all vehicles available in those categories according to the 2013 EPA fuel economy guide. The price, the annual fuel cost, and the ‘‘You save (spend)’’ was taken from the 2013 EPA fuel economy guide as well. If multiple prices and models were available, we took the lower and upper values in each category to determine minimum and maximum bounds. Note that the minimum and maximum values for the conventional hybrid and plug-in hybrid vehicles are based on a small number of available vehicles on the market. This is one of the reasons why we focused on generic vehicles. Basing our cost information on the vehicles available would compromise our comparison due to size and equipment differences. For the plug-in hybrid vehicles, the only 40-mile electric-only hybrid available on the market at the time of our study was the Chevrolet Volt. It seemed an appropriate choice since, in 2013, it was the largest selling plug-in vehicle in the United States. The Nissan Leaf was the second leading plug-in vehicle by sales in 2013. We take the data from the 2012 Ford Escape Hybrid for the conventional hybrid SUV. Other vehicles included in this category such as the Toyota Prius Plug-in or the Ford Fusion Plug-in Hybrid have a range of 11–20 miles on electricity before they switch to gasoline. For the mid-sized SUV, only the Mitsubishi Outlander is available in that category, and only in Japan and Europe (i.e., the date for the Outlander's introduction into the United States market is not yet available). The Toyota RAV4 EV is the only SUV available on the U.S. market at the time of our survey.

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, pick-up truck, or sports car. Research suggests that car buyers first chose the type of car, e.g., sedan, minivan, SUV, and then the size of the car, e.g., small, medium, large (Lave and Train, 1979; Berkovec, 1985; Mannering et al., 2002; Kleit, 2004). The U.S. Environmental Protection Agency also uses a consumer choice model which assumes that new car buyers first decide about the type of the car, i.e.,

[6] The top twenty cars marked with (*) were included in the summary table for gasoline vehicles. We only included the 4 cylinder, gasoline, front-wheel drive versions: Ford F-Series, Chevrolet Silverado, Toyota Camry, Dodge Ram, Honda Civic*, Honda Accord, Toyota Corolla/Matrix*, Ford Fusion*, Ford Focus*, Honda CR-V*, Nissan Altima, Chevrolet Cruze*, Hyundai Sonata, Ford Escape*, Chevrolet Equinox*, Toyota RAV4*, Toyota Prius*, Ford Explorer*, Hyundai Elantra, Nissan Sentra.

standard car versus standard SUV and then the size of the car (EPA, 2012).

For our research design, we chose a classical experimental design because it has the advantage that all internal threats to the experiment are controlled for (Giannatasio, 2008). Using a one-group pre-test post-test design does not allow us to control for events such as history, testing, learning, and fatigue between the rankings. 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 Fig. 1. In the control group, the respondents received all the information displayed on the labels depicted in Fig. 1 except ‘‘You save (spend) 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.’’ The label that corresponds closest to the actual EPA label is displayed for treatment group 1. The only difference between our label displayed for treatment group 1 and the actual EPA label is the information at the bottom of the label. Whereas the actual EPA label contains information about the cost and driving assumptions, information about the fuel economy webpage and a QR code, our label reserves this space for the cost of ownership information for treatment group 3. The information about the cost and driving assumptions is presented to the respondent at the beginning of each set of labels. The reason for this being the need for some space at the bottom of our label to add the cost of ownership information on the label for treatment group 3. 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, conventional 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 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 (Fig. 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). The advantage of using a rank-ordered logit is the additional information contained in such models. A multinomial logit provides information about the most preferred item but does not offer any information about the ordinal rank of the remaining items (Beggs et al., 1981; Fok et al., 2012). The rank-ordered logit is preferred because it uses the information contained in the ordinal ranking of all items in the choice set to estimate the parameters. For completeness, the results section presents the estimates for the multinomial logit as well as the rank-ordered logit.

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 $j=1;\dots;J$ alternatives and $i=1;\dots;N$ 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 Vj . Let r_i be a vector whose elements r^j_i denote the ranking received of alternative j by respondent i, i.e., $r_i = (r^1{}_i, \ldots r^J{}_i)$. Then the probability to observe a particular ranking is written as (Borzekowski and Kiser, 2008; Fok et al., 2012; Lee and Yu, 2013)

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

There are similarities between the multinomial logit (MNL) and the rank-ordered logit presented in Eq. (1). The rank-ordered logit can be thought of a sequence MNL model in which the pool of alternatives diminishes 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 3199 responses were collected from 32 U.S. metropolitan areas.[7] Table 3 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 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 2759 individuals, 1499 of which ranked mid-sized vehicles and 1260 of which mid-sized SUVs.

We include several control variables in the models as displayed in Table 3. We control for whether a respondent has at any point previously owned a conventional hybrid and plug-in vehicle since previous studies have shown that those interested in conventional hybrid and plug-in vehicles have likely already owned one. Previous research analyzes the purchase behavior of innovators and early adopters of conventional hybrids and plug-in vehicles (Struben and Sterman, 2008; Gallagher and Muehlegger, 2011). Controlling for respondents that are ‘‘innovators’’ or ‘‘early adopters’’, which represent around 16% of consumers (Rogers, 2003), with the variable ‘‘Own’’ allows for generalization to mainstream buyers of new cars of our results. This variable is alternative specific. Electric vehicle owners, for example, are likely to have previously owned a conventional hybrid

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

(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.

6. Results and discussion

The results of the multinomial logit model and the rank-ordered logit model are presented in Tables 4 and 5, respectively. Although comparable in results, our second research question is answered more completely by the rank-ordered logit. 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 5) 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., 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. If you want to make buyers of large cars aware of the high fuel cost associated with their car choice, then the use of the average car across all choices is appropriate. If you want to inform consumers about the fuel cost associated with a car compared to other cars in the same class, then the average car in the size class is more appropriate. If the policy goal is to steer buyers of large cars away from cars with high fuel consumption, then the last approach might not be optimal and we should stay with the average car.

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. Although the results of the multinomial logit and the rank-ordered logit models are similar, there is a difference in the results for the ‘‘CAR’’ in ‘‘Treatment Group 1 vs. Treatment Group 2.’’ The multinomial logit detects a statistically significant effect only for the plug-in hybrid electric vehicle, not for the other vehicles, i.e., conventional hybrid and battery electric vehicle. The rank-ordered logit uses all the information contained in the data set and detects significant effects for conventional hybrid and battery electric vehicles as well. We are not testing whether respondents rank the vehicles correctly based on total cost of ownership or the calculation thereof. We are interested in determining the effect of TCO information on people who might consider buying a plug-in hybrid or battery electric car but are ultimately dissuaded by the high capital expense. If those potential buyers are made aware that the total cost of ownership is comparable (not necessarily lower) to a gasoline vehicle, then there is the possibility that those potential buyers might switch to either a conventional hybrid or a plug-in vehicle. Our results indicate that this is the case when comparing treatment group 1 to treatment group 2. 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. When we compare the control group to treatment group 1 by including the 5-year fuel expenditure information, the EPA label requires the respondent to process the information in relation to the average car. This comparison to the average car is not present when the total cost of ownership is included for treatment group 2. In treatment group 2, respondents compare cars across the different labels and do not need to engage in implicit comparisons to the average car. This might be an additional explanation why 5-year fuel expenditure information, as presented on the EPA label, does not affect vehicle rankings.

The fact that the TCO information is not statistically significant for the small SUV category may have a variety of possible explanations that go beyond the scope of our experiment. The question is whether SUV buyers value other attributes more than they value fuel economy (relative to small car buyers). Any other attributes that mid-sized car or small SUV buyers think are different between vehicle types is controlled for by the vehicle-specific intercepts. The total cost of ownership information is mainly driven by differences in purchase price and fuel costs. And thus, it is possible that small SUV buyers do not put a high weight on fuel economy and the resulting total cost of ownership. As mentioned before, buyers of large vehicles might not be interested in fuel economy (Nixon and Saphores, 2011).

The socio-demographic variables reveal that increasing age decreases the probability of ranking a plug-in hybrid or a battery electric vehicle over a gasoline vehicle. This relationship is also statistically significant for the conventional 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 a conventional hybrid and plug-in 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.

There are several other non-economic factors that might influence the purchase decision of buying a hybrid or plug-in vehicle. Range anxiety or issues related to charging time, infrastructure, or accessibility can explain consumer's hesitation to buy a battery electric vehicle. There are several differences between the vehicles that are not directly covered. Real or perceived differences between the vehicles are range, appearance, safety, space, or charge time. Also, range anxiety, environmental benefits, or the belief that plug-in vehicles are at the cutting edge of technology are differentiating factors as well. Those factors are summarized in the alternative specific constants. Given the sample size, we do not believe that there are any significant differences across the groups that would not make them comparable. For example, we do not believe that range anxiety in the control group is different from treatment group 1. So it is possible to isolate the effect of providing TCO information, which is the primary objective. We randomized the assignment of respondents to the different groups to ensure that roughly equal numbers of respondents with specific concerns (e.g., range anxiety) are within the three groups. Research has shown that there exists, for some early adopters, conspicuous consumption with respect to hybrid vehicles to display environmental concerns to peers (Sexton and Sexton, 2014). Although those factors contribute to the purchase decision, we do not have reason to believe that those factors are different across groups given the randomization and sample sizes in our experiment. Our research looks at the role of the information as a whole by using a 0/1 dummy variable but future research might consider decomposing the information on the label to assess the influence of the different components of the EPA label on consumer decision-making.

7. Conclusion

Conventional hybrid and plug-in 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 hybrid and plug-in 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 conventional hybrid and plug-in vehicles.

We find that the five-year fuel expenditure savings information has no effect on consumers' ranking of gasoline, conventional hybrid, plug-in hybrid, and battery electric vehicles. The five-year fuel expenditure savings are large for the conventional 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 conventional hybrid and plug-in 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 conventional 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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Tables

Table 1

Parameters for TCO calculations. The fuel economy (FE) parameters for the gasoline (GAS), conventional 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.

	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 2

Comparison of generic cars to actual cars. The value in parenthesis represents the amount spend over 5 years. There is no SUV PHV available in the 2013 EPA fuel economy guide. The only available model in this category is the Mitsubishi Outlander which is not yet sold in the United States.

	Mid-sized car				Mid-sized SUV			
	GAS	HYB	PHV	BEV	GAS	HYB	PHV	BEV
Price								
This study	20,289	24,355	28,411	35,108	28,687	34,528	39,149	44,584
Min.	16,200	19,080	32,000	22,995	22,470	30,570		49,800
Max	30,200	32,100	40,100	39,200	38,100	33,080		49,800
Annual fuel cost								
This study	1845	1272	763	528	2403	1617	937	801
Min.	1550	1050	950	500	2050	1732		800
Max	2300	1250	1100	600	2350	1732		800
You save (spend)								
This study	2374	5237	7784	8955	(417)	3514	6914	7591
Min.	100	5350	6250	8600	–	1732		7600
Max	3850	6350	7000	9100	1350	1732		7600
Monthly total cost of ownership over 10 years								
This study	460	448	384	423	578	563	499	538
Min.	391	365	446	302	467	498		537
Max	533	479	522	428	613	501		537
Monthly total cost of ownership over 11 years								
Min.	380	353	427	291	456	483		513
Max	515	460	499	409	594	501		513
Monthly total cost of ownership over 12 years								
Min.	373	344	413	284	445	468		493
Max	502	446	481	396	576	485		493
Monthly total cost of ownership over 13 years								
Min.	363	334	400	278	435	468		474
Max	487	430	465	383	560	471		474

Table 3

Descriptive statistics with standard deviation in parenthesis.

Variable	Control group		Treatment group 1		Treatment group 2	
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%
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Income	22.42%	26.04%	20.00%	28.47%	22.92%	25.90%
	(0.42)	(0.44)	(0.40)	(0.45)	(0.42)	(0.44)
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)
Conventional 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)
Average rank						
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 4

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

	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
Intercept								
BEV	1.14**	0.58	−1.34*	0.77	0.31	0.55	−0.77	0.79
HYB	0.69*	0.42	0.41	0.48	0.56	0.41	0.47	0.49
PHV	1.51***	0.43	1.05**	0.52	1.36***	0.41	1.1**	0.54
Own (equal to 1 if previous ownership of a new technology car)								
own	0.77***	0.22	0.21	0.27	0.69***	0.21	0.61**	0.29
Age of the respondent								
BEV	−0.02***	0.01	−0.01	0.01	−0.02**	0.01	−0.01	0.01
HYB	−0.02***	0.01	−0.01**	0.01	−0.01**	0.01	−0.01**	0.01
PHV	−0.04***	0.01	−0.03***	0.01	−0.04***	0.01	−0.03***	0.01
Level 2 (equal to 1 if awareness public level 2 charging stations in respondent's community)								
BEV	0.9***	0.28	0.75**	0.35	1.08***	0.26	1.22***	0.33
HYB	0.41**	0.20	0.51**	0.21	−0.14	0.20	0.47**	0.21
PHV	0.93***	0.20	0.97***	0.22	0.47*	0.19	0.74***	0.22
Number of cars currently owned or leased by the household								
BEV	−0.69***	0.19	−0.08	0.16	−0.3*	0.15	−0.06	0.18
HYB	−0.02	0.09	0.04	0.09	0.02	0.09	0.17*	0.09
PHV	−0.07	0.09	−0.11	0.10	0.01	0.09	0.06	0.11
Gender (equal to 1 if female)								
BEV	−0.22	0.26	0.45	0.34	−0.03	0.25	0.17	0.34
HYB	0.21	0.17	0.19	0.19	0.28	0.17	0.18	0.19
PHV	0.03	0.18	0.14	0.21	0.03	0.18	0.05	0.21
Education (equal to 1 if 4-year college degree or higher)								
BEV	−0.1	0.27	−0.33	0.33	−0.27	0.26	−0.1	0.33
HYB	0.08	0.18	0.14	0.18	0.13	0.18	0.15	0.18
PHV	0.3*	0.18	0.02	0.20	0.34*	0.18	0	0.20
Income (equal to 1 if annual household income is $100,000 or higher)								
BEV	0.03	0.35	0.18	0.36	−0.35	0.35	−0.13	0.37
HYB	0.18	0.21	−0.23	0.21	−0.02	0.21	−0.22	0.21
PHV	−0.25	0.24	0.02	0.23	−0.36	0.23	−0.14	0.23
Group (1 if more information was disclosed to consumer)								
BEV	0.02	0.26	0.03	0.31	0.36	0.25	−0.23	0.31
HYB	−0.05	0.17	−0.05	0.18	0.19	0.17	−0.02	0.17
PHV	−0.11	0.18	−0.11	0.19	0.39**	0.18	−0.09	0.19

Table 5

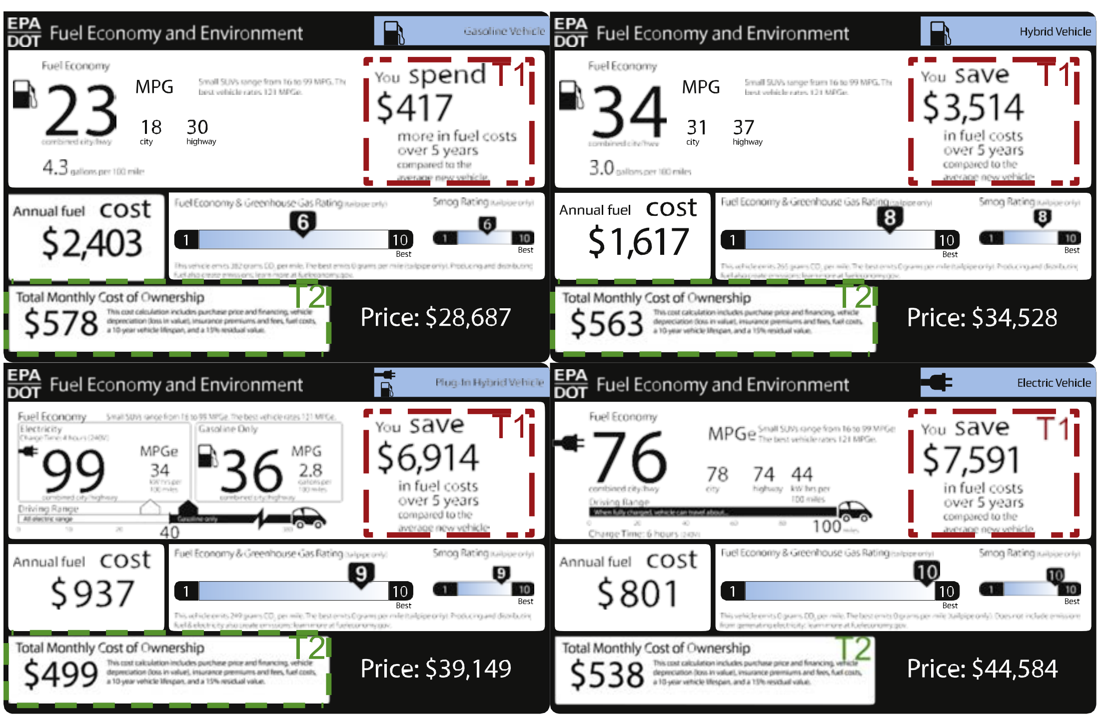
Results of the rank-ordered logit model: The gasoline vehicle is used as the base case when compared to conventional hybrid (HYB), plug-in hybrid (PHV), and battery electric vehicles (BEV).

	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
Intercept								
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 (equal to 1 if previous ownership of a new technology car)								
Own	0.47***	0.15	0.27	0.19	0.5***	0.14	0.45**	0.21
Age of the respondent								
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 (equal to 1 if awareness public level 2 charging stations in respondent's community)								
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
Number of cars currently owned or leased by the household								
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 (equal to 1 if female)								
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 (equal to 1 if 4-year college degree or higher)								
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 (equal to 1 if annual household income is $100,000 or higher)								
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 (1 if more information was disclosed to consumer)								
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

Figures

Fig. 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.

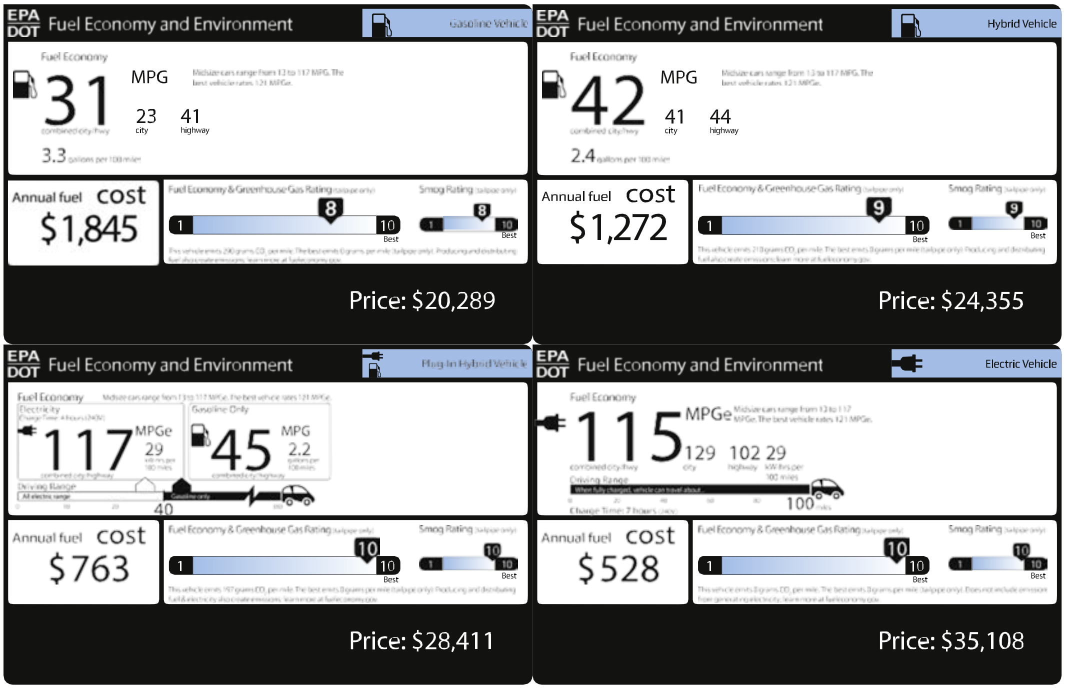
(a) Labels for small/medium-sized car



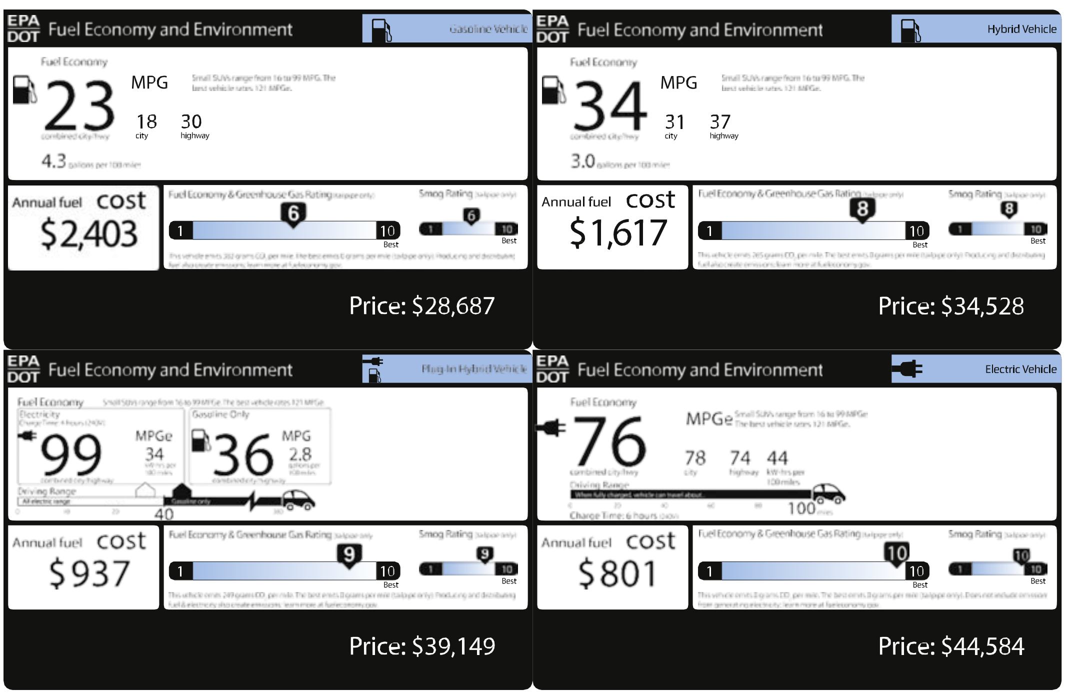
(b) Labels for small SUVs

Appendix A. Control group labels

See Fig. A.2.



(a) Labels for small/medium-sized car

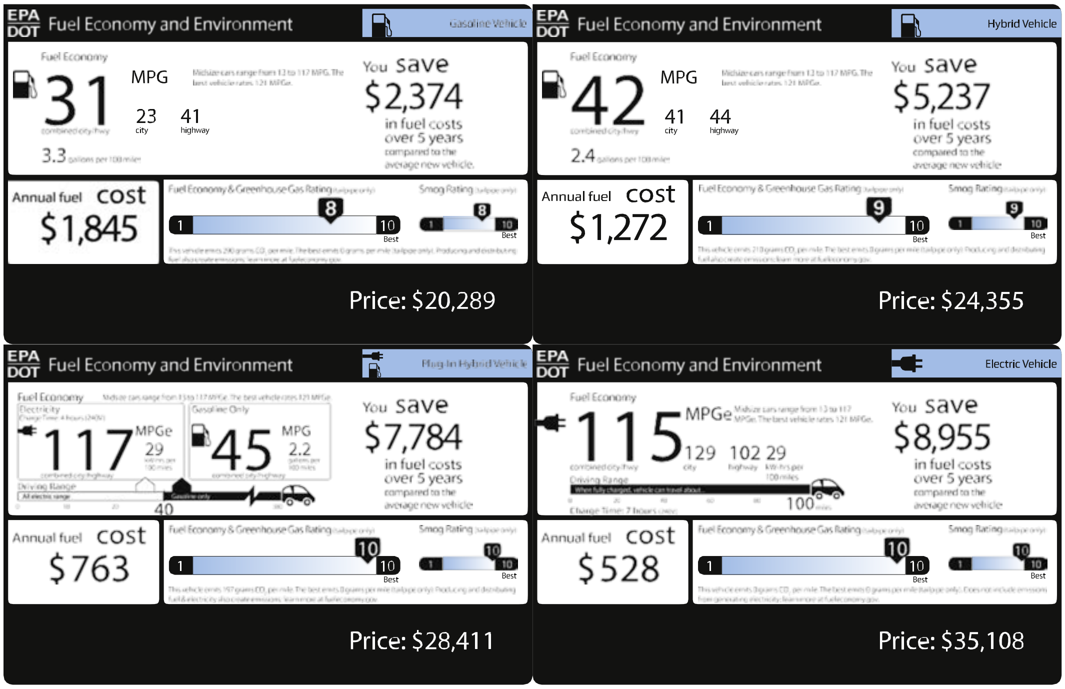


(b) Labels for small SUV

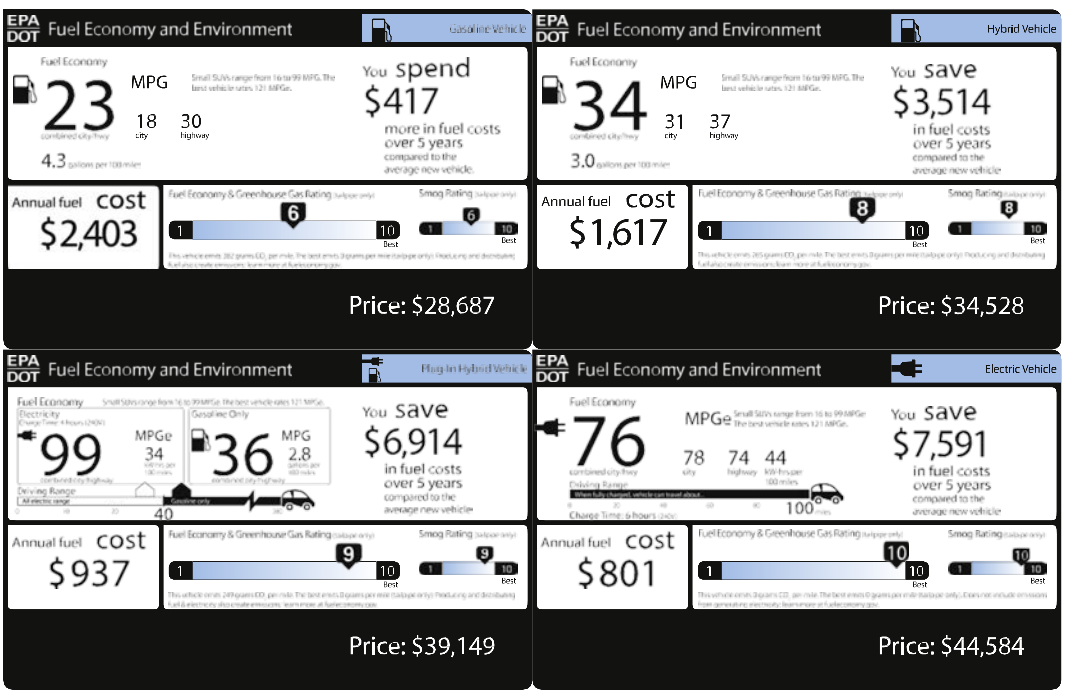
Fig. A.2. Survey labels presented to the control group.

Appendix B. Treatment group 1 labels

See Fig. B.3.



(a) Labels for small/medium-sized car

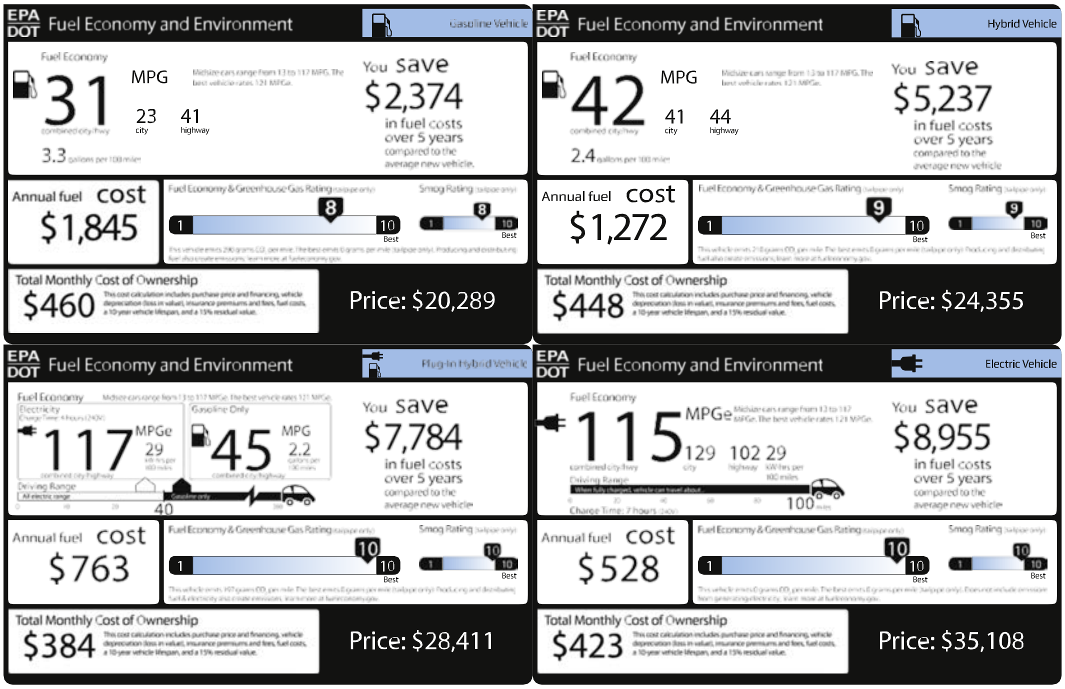


(b) Labels for small SUV

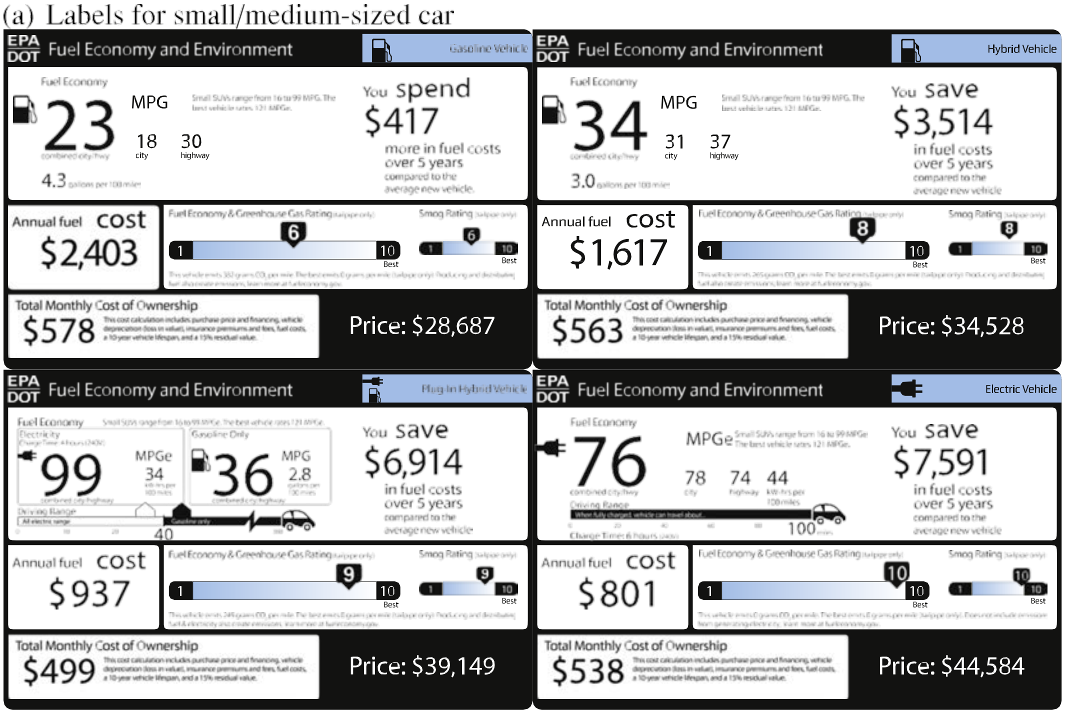
Fig. B.3. Survey labels presented to treatment group 1.

Appendix C. Treatment group 2 labels

See Fig. C.4.



(a) Labels for small/medium-sized car



(b) Labels for small SUV

Fig. C.4. Survey labels presented to treatment group 2.