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Understanding household preferences for alternative-fuel vehicles technologies

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Understanding Household Preferences For Alternative-Fuel Vehicle Technologies

MTI Report 10-11

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UNDERSTANDING HOUSEHOLD PREFERENCES FOR ALTERNATIVE-FUEL VEHICLE TECHNOLOGIES

Hilary Nixon, Ph.D.
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16. Abstract
This report explores consumer preferences among four different alternative-fuel vehicles (AFVs): hybrid electric vehicles (HEVs), compressed natural gas (CNG) vehicles, hydrogen fuel cell (HFC) vehicles, and electric vehicles (EVs). Although researchers have been interested in understanding consumer preferences for AFVs for more than three decades, it is important to update our estimates of the trade-offs people are willing to make between cost, environmental performance, vehicle range, and refueling convenience. We conducted a nationwide, Internet-based survey to assess consumer preferences for AFVs. Respondents participated in a stated-preference ranking exercise in which they ranked a series of five vehicles (four AFVs and a traditional gasoline-fueled vehicle) that differ primarily in fuel type, price, environmental performance, vehicle range, and refueling convenience. Our findings indicate that, in general, gasoline-fueled vehicles are still preferred over AFVs, however there is a strong interest in AFVs. No AFV type is overwhelmingly preferred, although HEVs seem to have an edge. Using a panel rank-ordered mixed logit model, we assessed the trade-offs people make between key AFV characteristics. We found that, in order to leave a person's utility unchanged, a $1,000 increase in AFV cost needs to be compensated by either: (1) a $300 savings in driving cost over 12,000 miles; (2) a 17.5 mile increase in vehicle range; or (3) a 7.8-minute decrease in total refueling time (e.g. finding a gas station and refueling).

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EXECUTIVE SUMMARY

This report explores consumer preferences among four different alternative-fuel vehicles (AFVs): hybrid electric vehicles (HEVs), compressed natural gas (CNG) vehicles, hydrogen fuel cell (HFC) vehicles, and electric vehicles (EVs). Soaring fuel prices and growing concerns about air pollution and global warming have heightened public interest in AFVs. Although researchers have been interested in understanding consumer preferences for AFVs for more than three decades, it is important to update our estimates of the trade-offs people are willing to make between cost, environmental performance, vehicle range, and refueling convenience, as more information has become available about the environmental impacts of motor vehicles and the risks of U.S. dependence on foreign oil, but also to take advantage of more powerful econometric techniques such as mixed logit models.

SURVEY DESIGN AND RESEARCH METHODOLOGY OVERVIEW

A nationwide three-part, Internet-based survey of 835 households was administered in February and March 2010 by Knowledge Networks (KN), which maintains an online research panel of approximately 43,000 U.S. households. The completion rate of the survey was 60.2 percent, which is similar to the completion rate of other online surveys conducted by KN.

Survey respondents were first asked to provide their views on a wide range of transportation-related issues, including congestion, noise, and the environmental impacts of vehicles. Next, we inquired about current vehicle ownership and plans for future vehicle ownership over the next nine years, which corresponds to the median age of household vehicles in the United States. Our goal was to better understand preferences for current vehicles and their use, as well as to customize the third part of our survey. In this last part, we asked respondents to participate in a stated-preference ranking exercise in which they ranked a series of five vehicles (four AFVs and a traditional gasoline-fueled vehicle) that differed primarily in fuel type, price, environmental performance, vehicle range, and refueling convenience. Depending on current and future vehicle ownership plans, each participant was eligible to evaluate up to nine sets of five vehicles, which provided us with a rich dataset.

We then used a panel rank-order mixed logit model to analyze consumer preferences for AFVs. This model has specific advantages over more common models in the stated-preference literature, such as rank-ordered logits.[1]

SUMMARY OF RESEARCH FINDINGS

Our findings indicate that, in general, gasoline-fueled vehicles are still preferred over AFVs—one-third of respondents ranked gasoline-fueled vehicles first. However, 20 percent of respondents ranked gasoline vehicles last, and there is a strong interest in AFVs. Although no AFV type is overwhelmingly preferred, HEVs seem to have an edge, which probably reflects the fact that a number of popular HEVs have been available for several years. Full EVs are the least popular of the AFVs we asked our respondents to consider (EVs were ranked last by 40 percent of the respondents); it is apparent that the current limitations of these vehicles (e.g., range and recharging time) are still a deterrent to their widespread adoption by households.

Our panel rank-order mixed logit model found that vehicle type (e.g., truck, sport utility vehicle (SUV), minivan, passenger car) is an important characteristic for AFV preference. With the exception of CNG, for which vehicle type did not make a difference, our respondents preferred AFV technology in cars rather than larger vehicles such as trucks, SUVs, or minivans. The region in which people live (West, Midwest, Northeast, South) is not a significant predictor of AFV preferences. Education matters only in the case of HEVs, and gender has no significant impact on AFV preferences (probably because households select vehicles as a unit). The influence of age depends on the specific vehicle technology: midrange adults (30 to 59 years of age) are less interested in fuel-cell vehicles, while young adults (18 to 29) and older adults (45 and older) are more interested in EVs. Finally, we find that environmental attitudes are a strong predictor of AFV support, particularly for HFC vehicles and EVs.

A major focus of this research was the trade-offs people are willing to make among key AFV characteristics, including vehicle cost, fuel cost, vehicle range, and refueling time. The following trade-offs (based on median values) leave people's utility unchanged:

- A $1,000 increase in AFV cost needs to be compensated by either:
  1. A $300 savings in driving cost over 12,000 miles,
  2. A 17.5-mile increase in vehicle range, or
  3. A 7.8-minute decrease in total refueling time (e.g., finding a gas station and refueling).
- A 10-mile decrease in vehicle range needs to be compensated by a 4.2-minute decrease in total refueling time.

The vehicle range trade-off primarily concerns EVs, and it highlights the importance of range for our respondents. The respondents also place a very high value on refueling convenience, which emphasizes the importance of providing enough refueling infrastructure to make AFVs a viable transportation option for households.

RECOMMENDATIONS AND POLICY IMPLICATIONS

Our analysis reveals that consumers are receptive to AFVs—an outcome that bodes well for policymakers and manufacturers. Nearly two-thirds of the survey respondents listed an AFV (including HEVs) as their top choice in the ranking exercises. While no technology is overwhelmingly preferred, HEVs seem to be currently the most popular alternative to gasoline-fueled vehicles. Except among a small group of respondents, EVs are not favored, despite an emphasis on this technology by the Obama administration. Although the environmental benefits of AFVs are often touted by the media, this characteristic does not seem to be a determinant for consumers when making large purchases, like motor vehicles. Economic concerns are consumers' priority, so policymakers and manufacturers who would like to increase the market share for AFVs must make environmental issues a greater priority. More than one-quarter of our respondents were misinformed about the environmental impacts of motor vehicles or about current vehicle gas-mileage regulations; in particular, educating the public about the advantages of AFVs and the public health impacts of pollution from current vehicles will be necessary to increase support for AFVs.

I. INTRODUCTION

Concerns about steep fluctuations in fuel prices, dependence on foreign oil, air pollution, and global warming have steadily increased interest in alternative-fuel vehicles (AFVs). In addition, the recent oil spill in the Gulf of Mexico highlighted the urgency to develop alternative energy sources.[2] For households, AFVs are becoming more attractive, partly because of various measures implemented to promote their use, such as tax breaks[3] and access to carpool lanes.[4] In a recent survey of Californians, 74 percent of respondents stated they would "seriously consider getting a more fuel-efficient car" in their next vehicle purchase.[5] Despite the numerous incentives that have been offered and public opinion polls indicating that individuals are interested in AFVs, they constitute less than 1 percent of all highway vehicles in use nationwide.[6] It is clear that we do not fully understand the trade-offs consumers are willing (and unwilling) to make with regard to cost, environmental characteristics, and other vehicle characteristics, such as range and refueling convenience, in their vehicle purchase decision. It is essential for regulators and public agencies concerned about air quality and the environment to understand these trade-offs. Indeed, because cleaner vehicles have the potential to improve local air quality, reduce dependence on foreign oil, reduce greenhouse gas emissions, and support economic development, promoting them is of interest at multiple levels of government.[7] This study attempts to evaluate these trade-offs in order to determine U.S. consumers' willingness to pay for AFVs.

To obtain data with which to assess these trade-offs, we conducted a nationwide survey that asked respondents in 835 households about their views on a range of transportation-related issues and attitudes toward new technologies. Respondents were also asked about their current vehicle ownership, which allowed us to customize an exercise in which they ranked a series of five vehicles that differed in fuel type, price, and various other characteristics in order of preference. These data enabled us to explicitly model the trade-offs individuals make when selecting among vehicles, including AFVs.

In the next chapter, we review the stated-preference literature analyzing willingness to pay for AFVs. We also summarize some of the known relationships between socioeconomic, demographic, and attitudinal characteristics that influence preferences for AFVs. The following chapter presents detailed information about our survey design and modeling strategy. We next present a discussion of our survey administration and some basic descriptive information about our survey respondents. The results of our analysis are presented in the next section, and we conclude with some policy recommendations based on the results of the research. Appendices A through C present complementary statistical results, and the questionnaire is reproduced in Appendix D, along with a summary of the respondents' answers.

A REVIEW OF THE LITERATURE ON CONSUMER PREFERENCES FOR AFVs

The literature on consumer preferences for conventional vehicles and AFVs extends back three decades. It relies on either revealed or stated preferences.[8] An excellent review of this literature is given in Potoglou and Kanaroglou.[9] For the purposes of our research, we focus on stated-preference studies.

In this section, we first review key studies on consumer preferences for AFVs. Next, we discuss demographic and socioeconomic characteristics often used to model demand for AFVs. Finally, since our methodological approach is not common, we briefly discuss some studies that rely on mixed logit models to assess consumer preferences on transportation-related topics, including AFVs.

STATED-PREFERENCE STUDIES ON AFVS

Although some of the earliest studies on AFV demand relied on revealed preferences,[10] stated-preference models are better suited for this type of analysis for two reasons: (1) many potential AFVs are not yet available; and (2) there is often little variability in the existing market for AFVs. By using hypothetical alternatives to ask people for their preferences among AFVs, we are able to assess the trade-offs consumers may make between different attributes.

However, it is important to keep in mind the main limitation of preference surveys, i.e., they are based on hypothetical situations—and in our case, hypothetical vehicles as well. One possibility for alleviating this weakness is to combine revealed and stated preferences, as suggested by Brownstone et al. (2000). However, because of time constraints, we leave this for future research.

According to Golob et al., the seven most important attributes consumers use to evaluate vehicles are purchase price, fuel cost, range between refuelings/rechargings, availability of fuel/recharging opportunities, vehicle performance (e.g., acceleration, top speed), single- versus multiple-fuel capability, and environmental performance (e.g., vehicle emissions).[11] Potoglou and Kanaroglou generalize these into three categories: monetary, nonmonetary, and environmental. Appendix A presents of summary of vehicle attributes assessed in key stated-preference studies published since 1981.

Monetary Attributes

Monetary attributes most commonly examined in stated-preference studies include vehicle purchase price, fuel operating cost, and, to a lesser extent, maintenance cost. In a small number of studies, other monetary attributes such as tax incentives or subsidies,[12] free parking,[13] and commute costs, including access to express lanes,[14] are considered. Findings across stated-preference studies are fairly consistent: vehicle purchase price and fuel operating costs tend to be the primary factors influencing consumer demand for AFVs.[15]

Nonmonetary Attributes

For AFVs, nonmonetary attributes such as vehicle range between refuelings (or rechargings, in the case of EVs), availability of fuel or recharging locations, and vehicle performance (e.g., acceleration, top speed) are the factors most commonly examined in the stated-preference literature. Other nonmonetary attributes considered include dual-fuel capability,[16] refueling time,[17] luggage space limitations due to constraints imposed by some AFVs for fuel or battery storage,[18] and the number of existing AFVs in the consumer's region.[19]

Findings suggest that range and fuel availability are key limiting factors, after monetary concerns, for adopting AFVs. According to Ewing and Sarigöllü, although consumers recognize the environmental benefits of AFVs and generally have a positive attitude toward them, they are unwilling to give up standard features of conventional vehicles.[20] Similarly, in their analysis of AFV preferences among Southern California residents, Bunch et al. note the importance of vehicle range, particularly when the AFV range is noticeably less than that of a conventional gasoline-powered vehicle.[21]

Environmental Attributes

Given increasing concerns about air pollution and climate change due to fossil-fuel burning, a significant benefit of AFVs is their potential to emit fewer pollutants than conventional vehicles. Although most AFV stated-preference studies evaluate the importance of environmental attributes, rarely do results indicate that pollution level is a significant factor influencing consumer decision making (monetary attributes tend to outweigh most other concerns). However, findings from a recent study of drivers in Hamilton, Ontario (Canada) indicate that emissions are a significant influence there.[22] The likelihood of choosing a hybrid or other AFV was found to be greater if pollution levels were 90 percent less than today's levels (significant at $p < 0.05$). However, as emissions levels for AFVs increased to 75 percent of today's levels, the likelihood of selecting a hybrid or other AFV decreased. Bunch et al. note that caution is needed when interpreting coefficients associated with environmental attributes, as respondents may give a socially responsible answer that might not play out in an actual purchase decision.[23]

KEY SOCIO-DEMOGRAPHIC CHARACTERISTICS AND ENVIRONMENTAL ATTITUDES

To effectively model consumer preferences for AFVs, it is important to assess the influence of demographic and socioeconomic characteristics, as well as environmental attitudes. Appendix B presents a summary of the characteristics most commonly found in the stated-preference literature. Unfortunately, the literature does not assess these factors consistently, although some trends emerge from the studies that do consider them. In general, males tend to be more skeptical of AFVs and more concerned with some of their common limitations (e.g., acceleration, top speed).[24] Similarly, older adults are less receptive to AFVs,[25] while more-educated respondents favor them.[26] Not unexpectedly, larger households and those with longer commutes tend to be more concerned about the potential limitations of AFVs (e.g., vehicle size, range).[27] Finally, although environmental attitudes are not consistently evaluated in the literature on consumer preferences for AFVs, available evidence suggests that they are important and those who express stronger environmental concern are more likely to purchase an AFV.[28]

USING MIXED LOGIT TO ASSESS CONSUMER PREFERENCES

The mixed logit model has the advantage of flexibility; it allows for "random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time."[29] Unlike the standard logit model, where coefficients for the independent variables are fixed, mixed logit models allow for coefficients to vary with each decision maker. In addition, the independence-of-irrelevant-alternatives (IIA) property[30] does not need to hold. Finally, the model supports situations in which individuals make repeated choices over time and thus avoids the constraint that any unobserved factors affecting the choice decision are new each time. Some of the earliest applications of the mixed logit model to assess automobile demand were made by Boyd and Mellman[31] and Cardell and Dunbar,[32] although Train and Ben-Akiva, Morikawa, and Shiroishi were among the first to use the model for individuals' choices, as opposed to market shares.[33]

Our review focuses on applications of mixed logit published since 2000. Calfee, Winston, and Stempski provide an interesting analysis of consumers' willingness to pay to save travel time; they consider ordered probit and rank-ordered logit models but find that mixed logit models perform much better than either.[34] Other applications of mixed logit include an assessment of recreational choice preferences,[35] travel behavior responses to changes in travel conditions (particularly congestion pricing),[36] and preferences regarding transit attributes such as bus rapid transit or rural bus service.[37] Of particular relevance for our research, Brownstone, Bunch, and Train[38] used a stated-preference survey in conjunction with revealed-preference data to assess consumer preferences for AFVs (gasoline, electric, methanol, and natural gas), using both multinomial and mixed logit models. Similar to Calfee, Winston, and Stempski[39] and Brownstone and Train,[40] they report that the mixed logit model performs better. Additionally, since they considered both stated-preference and revealed-preference approaches, their findings suggest that the limitations of stated-preference models are outweighed by the ability to carefully consider a wide range of vehicle attributes; revealed-preference data are not sufficiently variable in the current market to do this effectively, although they are useful for evaluating preferences regarding vehicle body type.

Much of the literature on choice behavior relies on assessing the determinants of a single preferred choice from a set of alternatives. The analysis can be enhanced, however, by taking advantage of the information obtained through rank ordering of consumer preferences.[41] The mixed logit model has the ability to handle this type of ranking data, particularly when respondents provide repeated rankings over time. Panel rank-ordered mixed logit models are not particularly common, although Srinavasan, Bhat, and Holguin-Veras asked respondents to rank order four intercity travel modes across nine separate scenarios to assess attitudes toward travel safety and security.[42] Our review of methodologically relevant literature indicates that our analysis is an appropriate methodological approach given the goals of our study.

II. SURVEY DESIGN AND PREFERENCE-MODELING METHODOLOGY

EXPERIMENTAL DESIGN

We examined household preferences for AFVs over the next nine years, which corresponds approximately to the median age of vehicles in the United States.[43] We asked survey respondents to consider HEVs, CNG vehicles, HFC vehicles, and EVs similar to a baseline vehicle fueled by gasoline. Since we were particularly interested in understanding trade-offs households are willing to make between vehicle cost, fuel cost, vehicle range, and refueling convenience, we developed a series of scenarios in which these attributes were varied across technologies.

Potoglou and Kanaroglou (2008) review the attributes that play an important role in a household's decision to acquire a vehicle.[44] To create a cognitively manageable survey, we selected a subset of these attributes to focus on key aspects of AFVs and organized them into three categories: monetary, nonmonetary, and environmental.[45]

Our monetary attributes include purchase and fuel costs; for simplicity, we assume that all vehicles considered have similar maintenance costs, as few data are currently available for AFVs. In any case, to make its vehicles competitive, a manufacturer may offer to cover routine maintenance, as is currently done for some higher-end vehicles. Our nonmonetary attributes include range, refueling time, and fuel availability (e.g., recharging stations); the first two are of particular concern for EVs, and the third is salient for CNG vehicles, HFC vehicles, and EVs. Finally, environmental performance is captured by an indication of greenhouse gas emissions, chosen for simplicity and also because concern about greenhouse gas emissions is a key factor in the push for AFVs.

To keep our design manageable, vehicle attributes have at most two levels, but these levels vary between vehicle types. The exception is the range of EVs, for which we explored three levels (40 miles, 120 miles, and 250 miles), which correspond to choices currently considered by automobile manufacturers. Since vehicle range and refueling time differ little for all but EVs, we considered only one level for these characteristics, except for EVs. Again for simplicity, we also focused on vehicle operation for the emission of greenhouse gases (and ignored how different fuels are likely to be produced) and asked our respondents to consider only one level for each AFV type. It is not possible to consider all possibilities of these attributes, as it would require evaluating 12,288 (3×2^{12}) scenarios.

Survey design is a critical step in choice experiments. As explained in Louviere, Hensher, and Swait (2000), to obtain unbiased estimates of "main effects" (i.e., the impact of single attributes on choice), it is necessary to capture important interactions between attributes (an interaction is present if preferences for levels of one attribute depend on the levels of other attributes).[46] Estimating interactions requires a number of additional survey responses, however, and this number increases exponentially with the number of vehicle attributes considered. To balance realism with the need to create a manageable and statistically sound model, we relied on well-known results obtained for linear models: typically, between 70 percent and 90 percent of the variance can be captured by main effects, and two-way interactions can explain another 5 percent to 15 percent, so little is lost by ignoring higher-order interactions, and bias is minimized.[47]

After examining a number of different alternatives, we chose Design Expert®, version 8.0, to design our survey. It gave us a design with 110 scenarios capable of identifying all main and second-order interactions.

MODELING PREFERENCES

Stated-preference techniques such as contingent valuation (CV) and contingent ranking (CR) are popular methods for analyzing consumer preferences when markets are unavailable (e.g., the value of an endangered species or clean air). Unlike CV studies, where individuals must explicitly indicate their willingness to pay, CR simply asks respondents to rank a series of alternatives that vary by cost and various attributes such as environmental benefits, performance, or convenience to elicit their willingness to pay. Contingent ranking is particularly effective for analyzing multidimensional problems, and it has been argued that it avoids some of the common problems associated with CV, including strategic-response bias and starting-point bias.[48, 49]

One advantage of CR is that ranked data contain more information than datasets that record only top choices to limit the number of observations necessary to achieve a given level of precision. However, some economists have pointed out that preferred alternatives are likely to be ranked with much more certainty than less preferred options, because ranking a set of alternatives is used less frequently than selecting a best option.[50] Carson et al. (1994) also invoked selection fatigue and the limitations of hypothetical experiments to explain decreasing precision in ranking less preferred alternatives.[51] To alleviate these concerns, we asked only the 489 respondents to our survey who are planning on replacing or buying a car within nine years to perform the ranking exercise, and we tried to contextualize their choices by describing AFVs more specifically than has been done in previous studies. We also note that Caparrós, Oviedo, and Campos (2008) found that preferred-choice and ranking experiments give similar outcomes, and they argued that the discrepancies uncovered in previous studies were probably caused by differences in experimental design rather than by human limitations.[52]

The random utility model forms the basis for modeling consumer behavior using contingent ranking. Consider a decision maker n who can choose one alternative from a set of size J, and denote by U_{nj}, the utility from selecting alternative $j \in \{1,\ldots,J\}$. We assume that he selects alternative $i \in \{1,\ldots,J\}$ if that alternative provides the greatest utility, i.e., if $U_{ni} > U_{nj}$ for $j \in \{1,\ldots,J\} \backslash \{i\}$. A researcher would not know the decision maker's utility function, however; instead, he would observe some of his characteristics and some of the characteristics of the J alternatives he faces. Without loss of generality, the utility U_{nj} that the decision maker obtains from choosing alternative j can then be written as the sum of an observed term, denoted by V_{nj}, that is called representative utility, and an unknown error term ε_{nj}: $U_{nj} = V_{nj} + \varepsilon_{nj}$. In line with the discrete-choice literature, we assume that V_{nj} can be written

$$V_{nj} = \beta' x_{nj}, \tag{1}$$

where x_{nj} is a vector of observed variables that relate to decision maker n and alternative j, and β' is a vector of unknown coefficients that need to be estimated from the data. The error terms ε_{nj} are treated as random variables; their distribution is selected to fit specific choice situations. This framework enables the researcher to analyze the decision maker's choice as follows:

$$\begin{aligned} P_{ni} &= \Pr\left(U_{ni} > U_{nj}, \forall j \in \{1,...,J\}\right) = \Pr\left(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}, \forall j \in \{1,...,J\} \setminus \{i\}\right) \\ &= \Pr\left(\varepsilon_{nj} - \varepsilon_{ni} > V_{ni} - V_{nj}, \forall j \in \{1,...,J\} \setminus \{i\}\right) = \Pr\left(\zeta_{nji} > V_{ni} - V_{nj}, \forall j \in \{1,...,J\} \setminus \{i\}\right) \end{aligned} \quad (2)$$

where $\zeta_{nji} \equiv \varepsilon_{nj} - \varepsilon_{ni}$, for $j \in \{1,\ldots,J\} \setminus \{i\}$. The last equality in Equation (2) expresses P_{ni} as a cumulative distribution. It can be calculated from the $J - 1$ dimensional integral

$$P_{ni} = \int I\left(\zeta_{nji} < V_{ni} - V_{nj}, \forall j \in \{1,...,J\} \setminus \{i\}\right) f\left(\zeta_{ni}\right) d\zeta_{ni}, \quad (3)$$

where I(*expression*) equals 1 when *expression* is true and zero otherwise; and $\zeta_{ni} = (\zeta_{n1i}, \ldots, \zeta_{ni-1i}, \zeta_{ni+1i}, \ldots, \zeta_{nJi})$.

In general, P_{ni} does not have an explicit expression, which slightly complicates its analysis. However, if we assume that the error terms (ε_{nj}) have independent and identically distributed (i.i.d.) extreme value distributions,[53] we obtain an explicit expression for the probability of any preference ordering; this defines the rank-ordered logit model. For example, if decision maker n is facing five choices ($J = 5$) denoted by A, B, C, D, and E, the probability that he prefers the ranking A, C, D, B, E (from most to least preferred) is given by

$$\Pr\left(A,C,D,B,E\right) = \frac{e^{\beta' x_{nA}}}{\sum_{j \in \{A,B,C,D,E\}} e^{\beta' x_{nj}}} \frac{e^{\beta' x_{nC}}}{\sum_{j \in \{B,C,D,E\}} e^{\beta' x_{nj}}} \frac{e^{\beta' x_{nD}}}{\sum_{j \in \{B,D,E\}} e^{\beta' x_{nj}}} \frac{e^{\beta' x_{nB}}}{\sum_{j \in \{B,E\}} e^{\beta' x_{nj}}}. \quad (4)$$

This expression is the product of four logit probabilities with choice sets that exclude previously preferred alternatives, so it is as if the rank-ordered logit model decomposed a person's ranking into a series of statistically independent choices: After the person selects the preferred alternative from a set of J options, this top choice is discarded and the next best alternative is selected from the new set of $J - 1$ options, and so on until the ranking is complete.

Many published papers[54] have relied on this approach, which is attractive for two reasons: First, the probability of selecting an option has an explicit expression, and its log likelihood function is globally concave,[55] which simplifies estimating model parameters numerically. Second, the interpretation of its results is relatively straightforward. However, this model implies restricted substitution patterns, because it assumes that the ratio of the probabilities of any two alternatives is constant, no matter what other alternatives are present in the choice set, i.e., the IIA property. However, rankings from best to worst are not compatible with rankings from worst to best unless the probability of each alternative is 1/J, where J is the number of alternatives. Luce and Suppes (1965) call this the "impossibility theorem."[56]

To overcome these limitations, we also estimated a panel rank-ordered mixed logit model. This model is a slight generalization of the mixed logit model,[57] which is obtained by assuming that some model parameters are (possibly correlated) random variables with a specified distribution. It provides a flexible alternative that can reproduce any substitution pattern.[58]

We hypothesize that if an AFV's performance is otherwise similar to that of a conventional gasoline-fueled vehicle, preferences for an AFV may depend on the cost premium over that of a conventional vehicle, fuel savings, vehicle range (especially for electric vehicles), and total refueling time (extra time to find a refueling station and extra time to fuel up/recharge). To account for heterogeneity among our respondents, we assume that the utility coefficients of these four variables are stochastic. They should clearly be positive, so we postulate that their distribution is lognormal. In addition, someone's preferences for an AFV may depend on vehicle type (car, SUV, pickup truck, or minivan), broad region of the country (e.g., people may have concerns about a particular technology because of the climate in their area), education, and beliefs.

To estimate our mixed logit models, we used the command "mixlogit" in Stata. This command gives us only the choice between a normal and a lognormal distribution for the distribution of a parameter; moreover, for its computations, it takes the logarithm of the latter and presents results for the transformed parameters. To recover the untransformed parameters, we use the relationships linking the parameters of a multivariate normal distribution and those of the corresponding multivariate lognormal distribution. More specifically, if $\mathbf{X} = (X_1, \ldots, X_p)$ is a multivariate normal vector with mean $\mathbf{v} = (v_1, \ldots, v_p)$ and covariance matrix $\mathbf{D}$, then $\boldsymbol{\gamma} = (\gamma_1, \ldots, \gamma_p)$, where $\gamma_i = \exp(X_i)$ has mean[59]

$$E(\gamma_i) = \exp(v_i + 0.5 * D_{ii}), \qquad (5)$$

and covariance matrix Σ, with components (for $(i,j) \in \{1,\ldots,p\}^2$),

$$\Sigma_{ij} = [\exp(v_i + v_j + 0.5\,[D_{ij} + D_{jj}])*[\exp(D_{ij})\ -1] \qquad (6)$$

Moreover, the median value of γ_i is given by

$$Median(\gamma_i) = \exp(v_i) \qquad (7)$$

Since the log-likelihood function of a mixed logit model is known within the evaluation of a multidimensional integral, we also need to select an integration scheme. The "mixlogit" command in Stata relies on Halton sequences, which are quasi-random sequences of points used to calculate multidimensional integrals. Hole recommends using a relatively small number of draws (say, 25 to 50) for a specification search, and a larger number (such as 500) for a final model.[60] We followed her advice and estimated models with 50, 125, 250, and 500 points to assess convergence; we present results for 500 Halton points. The issue of accuracy is further discussed by Train, Cappellari, and Jenkins, and Haan and Uhlendorff.[61]

III. SURVEY ADMINISTRATION AND DATA

As noted above, we collected our dataset via an Internet-based survey of a random subset of the KN online research panel, which currently has approximately 43,000 members. Unlike typical Internet research that involves only volunteers who have Internet access, the KN research panel is representative of the U.S. population, based on probability sampling. Prospective panel members are recruited by telephone, using random-digit-dialing sampling of the country's entire residential population with telephone access. This approach meets the federal government's quality standards for such surveys.

Households that join KN's panel provide KN with demographic information such as gender, age, education, ethnicity, and income. This core information, which is updated every year, is available for subsequent surveys. Households tha=t do not have Internet access are provided with a free WebTV appliance and monthly access in exchange for taking part in online surveys. Households that already have a home computer and Internet access are asked to use their own equipment in exchange for points redeemable for cash. Points may also be offered to increase the response rates for longer surveys. Panel members need to complete at least one of every six surveys to which they are assigned to remain on KN's panel—a maximum of four surveys per month.

Panel members are notified by email or surface mail when they have been assigned an Internet survey. Non-respondents receive email reminders, followed by a phone reminder after at least three days.[62]

After receiving comments on our survey design from students and colleagues at the University of California, Irvine (UCI), we asked KN to conduct a pilot study of the survey in December 2009. Forty-two panelists were solicited, and 24 completed the survey. Using their answers and comments, we updated the survey to clarify some questions and improve the design of the contingent ranking exercise. The revised survey was then fielded from February 12, 2010, to March 14, 2010; 1,387 panelists were solicited, and 835 agreed to participate, for a completion rate of 60.2 percent, which is similar to the rates of other online surveys conducted by KN.

The survey had three parts. The first part questioned respondents about their views on transportation-related issues such as congestion, noise, and pollution; the environmental impacts of motor vehicles; and their attitude toward the adoption of new technologies. We then inquired about current vehicle ownership (for up to two vehicles in the household), plans to acquire a new vehicle or replace a current vehicle over the next nine years, and the household's current driving behavior. Finally, we used a CR exercise to obtain respondents' preferences for various AFVs that differed in fuel type/AFV technology, purchase price, range, accessibility of refueling infrastructure, driving cost, and greenhouse gas emissions. In addition, respondents were asked to indicate how important the various factors were in determining their preferred vehicle.

Table 1. Comparison of Respondent Sociodemographic Characteristics to Those of the U.S. Population

Sociodemographic Category	% of Survey Respondents	% of U.S. Population (U.S. Census Bureau data)
Gender		
Male	49.9	49.3
Female	50.1	50.7
Age		
18–24 years	7.5	9.5[a]
25–34 years	14.7	18.2
35–44 years	18.1	19.3
45–54 years	17.7	20.1
55–64 years	19.0	15.3
65–74 years	14.6	9.1
75+ years	8.5	8.4
Ethnicity		
White, non-Hispanic	74.3	65.4
Black, non-Hispanic	9.8	12.1
Other, non-Hispanic	3.5	5.4
Hispanic	8.3	15.4
2+ Races, non-Hispanic	4.2	1.7
Own/rent residence		
Own	86.4	66.6[b]
Rent	21.7	33.4
Other (occupied without payment of cash rent)	1.9	—
Education level		
Less than high school	13.2	15.1[c]
High school graduate or equivalent	31.7	28.5
Some college, no degree	19.9	21.3
Associate degree	5.9	7.5
Bachelor's degree	17.5	17.5
Graduate or professional degree	11.5	10.2
Annual household income		
Less than $25,000	21.3	23.3
$25,000–$49,999	26.6	24.6
$50,000–$74,999	19.8	18.8
$75,000–$99,999	14.1	12.4
$100,000–$149,999	12.9	12.3
$150,000 or more	5.5	8.7

[a] ACS data are for 20–24 years.

[b] ACS data distinguish only between owner- and renter-occupied.

[c] ACS data are for adults 25 years of age and older.

Source: U.S. Bureau of the Census, "Selected Social/Economic/Housing/Demographic Characteristics in United States: 2008," results from the *2008 American Community Survey 1-Year Estimates*, http://factfinder.census.gov (accessed April 15, 2010).

The generalizability of our results depends on the representativeness of our sample. Using data from the 2008 American Community Survey (ACS), we find that our respondents' demographic characteristics are generally similar to those of the U.S. population (see table 1). Our respondents are slightly less ethnically diverse, more likely to be older (age 55+), and more likely to own their homes, but these differences are relatively minor, so we believe our analysis yields useful insights regarding preferences for AFVs among U.S. households.

IV. SURVEY AND PREFERENCE-MODELING RESULTS

TRANSPORTATION ISSUES, THE ENVIRONMENT, AND TECHNOLOGY ADOPTION

To develop a better understanding of our respondents' attitudes toward transportation-related issues, we solicited their opinions regarding several common "problems" associated with transportation. These included congestion, noise, and pollution, as well as issues concerning safety and importing fuel from foreign countries. Respondents were asked to indicate how problematic each issue was on a 5-point Likert scale ranging from "not a problem" to "a major problem." Figure 1 presents the results for respondents who indicated that a particular transportation-related issue was a major problem. More than half of the respondents expressed significant concerns about the amount of oil imported from foreign countries. This result was not unexpected, given the amount of media attention paid to this issue over the past several years, and it is important for policymakers to keep in mind when they consider new transportation policies. Safety was another pressing concern for respondents, particularly as it relates to aggressive or absentminded drivers; more than 40 percent of the respondents rated safety as a major problem. Since our focus for this series of questions was on respondents' "daily experiences," it is possible that safety is something they are faced with on a more regular basis than some of the other issues. Pollution-related issues, including vehicle emissions that contribute to global climate change and those that affect local air quality, were rated as major problems by 28 percent and 20 percent of respondents, respectively. The lower level of concern for local air quality might be geographically related—respondents in areas with poorer air quality indicated that this is a more significant problem. The fact that global climate change is not something one necessarily experiences on a local level might explain why a higher percentage of respondents indicated that it was a major problem. The transportation-related issue of least concern to respondents was noise, with only 6 percent indicating that it was a major problem.

To assess their views about the environmental impacts of motor vehicles, we asked respondents to indicate their level of agreement, ranging from "strongly disagree" to "strongly agree," with a series of five statements. The answers to these statements are summarized in table 2. Our respondents tended to be fairly unsure of their level of agreement with the statements. More than 50 percent indicated that they were unsure about the statement "government rules allow minivans, pickups, and SUVs to pollute more than passenger cars, for every gallon of gas used." This statement is correct, yet respondents were equally divided between disagreeing (22 percent) and agreeing (25 percent). Likewise, almost 50 percent were unsure about the statement "government rules require minivans, vans, pickups, and SUVs to meet the same miles-per-gallon standards as passenger cars." This statement is false, yet our respondents were again equally divided in their level of agreement. These findings suggest that there is clearly a lack of knowledge of regulations that target the environmental impacts of vehicles and that a public education campaign could be an effective mechanism to increase support for new regulations directed at improving the environmental performance of motor vehicles.

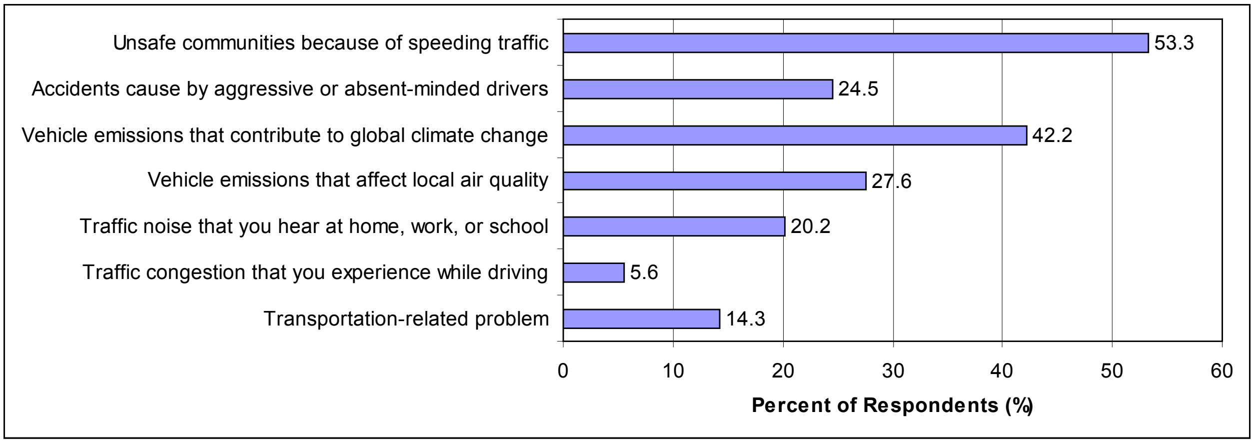

Figure 1. Percentage of Respondents Indicating Issues Are Major Problems

Table 2. Respondents' Views on Environmental Impacts of Motor Vehicles

Statement	Strongly or Mildly Disagree (%)	Unsure (%)	Strongly or Mildly Agree (%)
Cars, minivans, pickups, and SUVs are not an important source of air pollution anymore. (Note: FALSE statement)	46.0	28.7	25.3
Government rules allow minivans, pickups, and SUVs to pollute more than passenger cars, for every gallon of gas used. (Note: TRUE statement)	22.4	52.5	25.1
Cars, minivans, pickups, and SUVs are an important source of the greenhouse gases that many scientists believe are warming the earth's climate. (Note: TRUE statement)	26.6	35.9	37.5
Government rules require minivans, vans, pickups, and SUVs to meet the same miles-per-gallon standards as passenger cars. (Note: FALSE statement)	25.9	47.2	26.9
Exhaust from cars, minivans, pickups, and SUVs is an important source of the pollution that causes asthma and makes asthma attacks worse. (Note: TRUE statement)	17.8	39.5	42.7

Our respondents exhibited a higher level of knowledge about some of the environmental impacts of vehicles in general than about regulations, but a large percentage were still unsure; in fact, the percentage of respondents with "correct" answers never reached 50 percent. Forty-six percent disagreed with the statement "cars, minivans, pickups, and SUVs are not an important source of air pollution anymore," while 25 percent agreed with it. Similarly, only 38 percent of the respondents agreed that "cars, minivans, pickups, and SUVS are an important source of the greenhouse gases that many scientists believe are warming the earth's climate," while 27 percent disagreed. Finally, two-fifths of the respondents agreed that "exhaust from cars, minivans, pickups, and SUVs is an important source of the pollution that causes asthma and makes asthma attacks worse," and only 18 percent disagreed. Given the amount of media attention paid to this issue over the past several decades, the lack of knowledge indicated by these results should be of concern. The results highlight the fact that most people simply do not know about some of the basic environmental impacts of motor vehicles or have inaccurate views. This is likely to be a considerable hurdle for policymakers to overcome, as evidence in the literature ties environmental knowledge, attitudes, and beliefs to pro-environmental behavior.[63]

Since the choice to purchase and drive an AFV is often associated with a pro-environmental motivation, we asked respondents how often they engaged in certain pro-environmental behaviors. Nearly 60 percent indicated that they recycle "very often," and only 9 percent said that they never recycle. Twenty-eight percent responded that they drive differently to save fuel or reduce emissions, and approximately 14 percent choose one product over another "very often" because of environmentally friendly ingredients or packaging.

Finally, we were interested in respondents' attitudes toward new technologies. Although some AFV technologies have been around for decades (e.g., EVs, natural gas), others, such as HFC vehicles, are fairly new. In addition, even "older" technologies are constantly undergoing improvements, so understanding how people react to new technologies is important for understanding AFV preferences. We asked respondents how quickly they typically purchase products that incorporate a new technology. The vast majority (69 percent) indicated that they tend to wait until the new technology has been widely accepted and proven before considering using it. Nearly 20 percent indicated that they are willing to buy a new technology after reading a favorable review. Only 3 percent are among the first to purchase a new technology. Among the respondents, 3 percent indicated that they wait until the price comes down to purchase a new technology, while another 7 percent provided other responses, such as stating that they would purchase the new technology when it was time to replace the current product providing a similar service.

VEHICLE-OWNERSHIP INFORMATION AND DRIVING BEHAVIOR

We asked several questions about current vehicle ownership and driving behavior and used much of this information to customize the contingent ranking scenarios in the third part of the survey.

As expected, most households have at least one licensed driver, and many have two or more. Only 3 percent of the households surveyed had no licensed drivers, while more than 70 percent had two or more. Nearly 94 percent of the households had at least one vehicle, and 62 percent had two or more. Table 3 presents a breakdown of ownership, by common vehicle types.

We also asked respondents to provide specific details about their vehicles (or, for households with more than two vehicles, the two they use most frequently). We obtained information on make, model, year, annual miles driven, vehicle mileage, fuel type, vehicle usage, and factors that originally influenced the decision to purchase the vehicle.

The respondents listed 35 vehicle makes. Ford and Chevrolet were the two most common manufacturers; Toyota was third for primary vehicles (11 percent of vehicles), and Dodge was third for the second vehicle (10 percent). The oldest vehicle still used as the household's

Table 3. Number of Vehicles Per Household, by Type (percent)

	Number of Vehicles		
Vehicle Type	None	1	2 or more
Automobile	29	48	23
SUV	75	21	4
Pickup truck	69	27	4
Minivan	82	16	2
Total	6	32	62

primary vehicle in our sample was a 1971 Volkswagen Karmann Ghia, while a 1953 Jeep Willys was the oldest secondary vehicle. On average, respondents drove their primary vehicle approximately 10,000 miles annually and their second vehicle about 9,000 miles.

Respondents were also asked to indicate the current estimated fuel efficiency of the two vehicles used most in the household. The average mileage reported for a household's primary vehicle was 23.5 mpg, and average mileage for the second vehicle was 21.8 mpg. Respondents appeared to have a fairly good understanding of their vehicles' overall fuel efficiency. Figure 2 shows respondents' estimated mileage for their two main vehicles, along with U.S. fleet fuel economy as reported by the National Highway Traffic and Safety Administration for model years 1991–2009. For these model years, our respondents reported slightly lower average fuel economy than that reported for the U.S. fleet. For primary vehicles, this difference averaged 1.9 mpg, and for secondary vehicles, the difference was 3.4 mpg. Since mileage varies slightly depending on individual driving behavior, and fuel economy tends to worsen as a vehicle ages, the respondents' estimates seem to be in line with expectations. In addition, the respondents appear to use their more efficient vehicle as their primary vehicle, although the difference in fuel economy between the two main vehicles in the household was only 1.4 mpg.

We were particularly interested in behaviors and attitudes related to driving, in terms of both how people use their vehicles and the factors that influenced their purchase decision. Table 4 presents a breakdown of vehicle usage, by the percentage of time the vehicle is used to commute to work, drive to school, run errands and shopping, or perform other activities. There is little difference in usage, on average, for a household's two main vehicles. A vehicle is used for shopping and/or running errands approximately 45 percent of the time, and it is used to commute to work one-third of the time. The average commute to work is 26 miles for the primary vehicle and 32 miles for the secondary vehicla. Less than 10 percent of the vehicles' time is used to drive to and from school (either taking family members to school or taking classes). Other common usages listed by respondents included recreational purposes, such as vacations, and visiting family and friends.

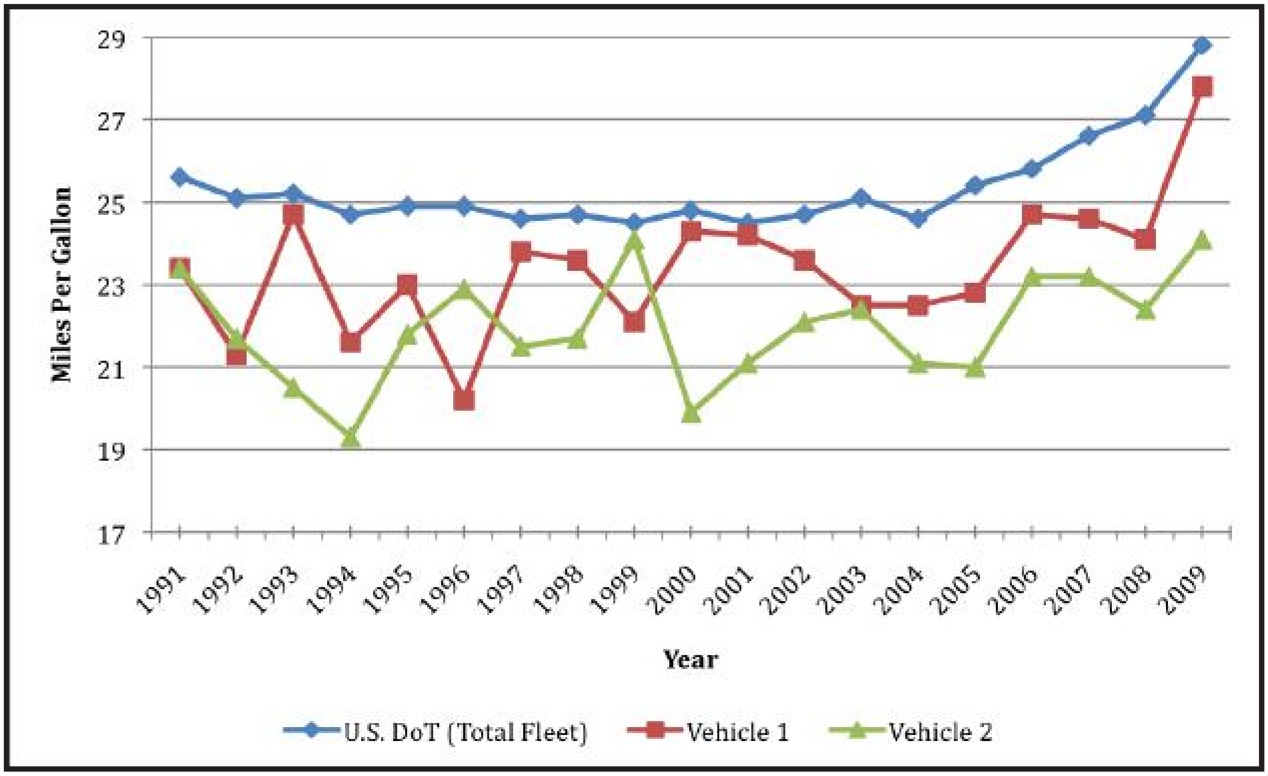

Figure 2. Average Fuel Efficiency of the U.S. Fleet and Respondents' Two Main Vehicles, by Model Year

Table 4. Breakdown of Respondents' Use of Their Vehicles, by Percent of Time

	Usage (% of time)	
Vehicle Use	Vehicle 1	Vehicle 2
Commuting to work	35	37
Driving to school	8	8
Shopping	44	41
Other	13	14

Respondents were asked to rate the importance of various factors in their decision to buy the two primary vehicles in the household. Factors included purchase price, fuel economy, performance, safety, seating capacity, reliability, appearance and styling, and environmental impacts. Table 5 presents a summary of responses for households' primary vehicle. Two-thirds of respondents indicated that reliability was "very important" in their decision, while more than half indicated that purchase price was "very important." Environmental impacts were listed as "very important" by only 14 percent of respondents, and an almost equal number (12 percent) listed this factor as "not important at all." Similarly, fuel economy was mentioned as "very important" by less than one-third of respondents, no more important then seating capacity.

Table 5. Importance of Factors in Purchase of Household's Primary Vehicle (percent of respondents)

Factor	Very Important	Quite Important	Somewhat Important	Not Very Important	Not Important at All	Don't Know
Reliability	66	21	8	2	1	2
Purchase price	54	22	14	2	5	3
Performance	47	30	14	4	2	3
Safety	45	29	16	5	3	3
Appearance and styling	34	28	21	8	7	2
Fuel economy	32	26	27	7	6	3
Seating capacity	32	24	20	12	10	3
Environmental impacts	14	21	32	16	12	3

IMPACT OF DEMOGRAPHIC CHARACTERISTICS

Before performing our multivariate analysis of AFV preferences, we explored some of the bivariate relationships between demographic and socioeconomic characteristics of our respondents and their attitudes toward transportation-related issues, the environment, and adoption of new technology. For cases with two categorical variables, we used standard chi-square tests; for those with a categorical independent variable and a normally distributed interval-dependent variable, we used a one-way analysis of variance (ANOVA). Appendix C provides a detailed summary of the statistical results. Tables 6 through 9 summarize key results.

Gender

We next explored how opinions on transportation issues such as noise and emissions differed between men and women. Our results indicate that women are more likely than men to consider traffic noise a problem. In addition, women appear to be more concerned about problems associated with vehicle emissions that contribute to local air quality or global climate change. Finally, women were also more likely to identify speeding traffic as a problem. For other transportation-related concerns (e.g., congestion and accidents caused by aggressive or absentminded drivers), there was no statistically significant difference between men and women. However, women are slightly more concerned than men about importing oil from foreign countries ($p = 0.10$).

Responses to the survey question designed to elicit basic levels of knowledge on some of the environmental impacts of motor vehicles and relevant government regulations revealed that the men tended to have stronger convictions and to explicitly indicate whether they agree or disagree with statements regarding these issues, while the women were consistently more likely to indicate that they were unsure. For example, men were significantly more likely to agree with the statement, "cars, minivans, vans, pickups, and SUVs are not an important source of air pollution anymore." Men were significantly more likely than women to either agree or disagree with our statement that "government rules allow minivans,

vans, pickups, and SUVs to pollute more than passenger cars," while women were far more likely to take a neutral stance and respond that they were unsure. We observed similar patterns for the question dealing with motor vehicles as an important source of greenhouse gases. Additionally, women were more likely to indicate that they were unsure about the statement that "government rules require minivans, vans, pickups, and SUVs to meet the same miles-per-gallon standards as passenger cars," while men showed a fairly strong understanding that this was an inaccurate statement and were more likely to disagree.

Table 6. Chi-Square Test and ANOVA Results for the Relationship Between Demographic/Socioeconomic Characteristics and Views on Transportation Issues

	Demographic/Socioeconomic Characteristic			
Issue	Gender	Age	Education	Household Income
Traffic congestion	—	—	—	—
Traffic noise	**	*	**	—
Impact of vehicle emissions on local air quality	**	—	—	—
Impact of vehicle emissions on climate change	**	—	—	—
Accidents caused by aggressive or absent-minded drivers	—	—	—	—
Impact of speeding traffic on community safety because	**	—	*	—
Importing oil from foreign countries	—	**	—	—

Notes: — = non-significant result; * = p < 0.05; ** = p < 0.01.

Table 7. Chi-Square Test and ANOVA Results for the Relationship Between Demographic/Socioeconomic Characteristics and Views on the Environmental Impact of Motor Vehicles

	Demographic/Socioeconomic Characteristic			
Variable	Gender	Age	Education	Household Income
Vehicles "not an important source of air pollution anymore"	*	*	*	—
"Government rules allow minivans, vans, pickups, and SUVs to pollute more than passenger cars, for every gallon of gas used"	**	—	**	—
Vehicles "are an important sources of the greenhouse gases that many scientists believe are warming the Earth's climate"	**	—	—	—
"Government rules require minivans, vans, pickups, and SUVs to meet the same miles-per-gallon standards as passenger cars"	**	—	—	*
Exhaust from vehicles "is an important source of the pollution that causes asthma and makes asthma attacks worse"	—	—	—	—

Notes: — = non-significant result; * = p < 0.05; ** = p < 0.01.

Table 8. Chi-Square Test and ANOVA Results for the Relationship Between Demographic/Socioeconomic Characteristics and Environmental Behaviors and Views on Technology Adoption

	Demographic/Socioeconomic Characteristic			
Variable	Gender	Age	Education	Household Income
Recycling frequency	*	—	**	**
Driving differently to save fuel and/or reduce emissions	—	*	**	—
Choosing environmentally-friendly products	**	—	**	—
Being the first person to adopt a new technology	—	—	—	—
Adopting technology after reading favorable reviews	**	—	*	*
Adopting technology when it is widely accepted	*	—	*	—
Adopting technology when price comes down	—	—	—	—

Notes: — = non-significant result; * = p < 0.05; ** = p < 0.01.

Table 9. Chi-Square Test and ANOVA Results for the Relationship Between Demographic/Socioeconomic Characteristics and Factors Influencing Vehicle Purchase Decision

	Demographic/Socioeconomic Characteristic			
Variable	Gender	Age	Education	Household Income
Purchase price	—	—	—	—
Fuel economy	—	—	—	—
Performance	—	—	—	—
Safety	—	—	—	—
Seating capacity	*	—	—	—
Reliability	—	—	—	—
Styling	*	—	—	*
Environmental impacts	—	—	—	*

Notes: — = non-significant result; * = p < 0.05; ** = p < 0.01.

Our contingency-table analysis of the relationship between gender and environmental behaviors or technology adoption confirmed the finding in the existing literature that women tend to support or engage in pro-environmental behaviors more often than men.[64] We found that women are much more likely to indicate that they "very often" or "quite often" recycle, while men are more likely to indicate that they recycle only "sometimes" or "never." We also found that women are far more likely to choose environmentally friendly products than men. Since many AFVs utilize new technologies, we were also interested in the relationship between gender and behavior associated with technology adoption. Our marginally significant results (p = 0.05) indicate that men are more likely than women to be “among the first people” to try out a new technology. Similarly, men are more likely to buy a new technology once they have read a favorable review. Women are more likely to wait until the technology is “widely accepted and proven” before they will consider it. However, there is no significant difference between men and women in terms of waiting until the price comes down before adopting a new technology.

We asked our respondents to select among eight reasons for selecting their current vehicle, and only two factors—seating capacity and styling—showed significant differences by gender. Men tended to place higher importance on seating capacity and styling, although the results are rather nuanced. Men were far less likely than women to state that seating is “not important at all” in their purchase decision, and women indicated that seating was “very important” more often than men. Men, however, stated that seating was “quite important” far more often than women. Similarly, while there was little difference between actual and expected responses from men and women about whether styling was “very important,” men were much more likely to indicate that it was “quite important,” while women tended to state that it was “somewhat” important.

Age

Our exploration of the relationship between age and attitudes toward the seriousness of various transportation-related problems produced few significant bivariate results. Only concerns about traffic noise and importing oil from foreign countries showed significant variation by age. However, as shown in table 10, the relationships are not linear. There appears to be a bimodal distribution, with older adults (mean age = 52.1 years) indicating that traffic noise is “not a problem,” and younger adults (50.7 years) indicating that it is “a major problem.” The middle-of-the-road response, “a small problem,” was found among those with the lowest mean age, 46.4 years. The relationship between age and opinions about importing oil from foreign sources shows a slightly more linear pattern. In general, as respondents age, they tend to be more concerned about importing oil.

Our analysis of the relationship between age and knowledge about the environmental impacts of transportation and relevant government regulations also produced few significant results. Only in responses to the statement that vehicles are “not an important source of air pollution anymore” was age statistically significant. The mean age of respondents who agreed with this statement was 52.3 years, compared with a mean age of 50.1 years for those who disagreed and 47.3 years for those who were unsure. Although motor vehicles are still an important source of air pollution, one can fairly easily understand why older adults—who are generally more familiar with the large, heavy, polluting cars of the past—may feel that vehicles have come a long way in terms of environmental improvements.

The only significant relationship between age and environmental behaviors or technology adoption appeared in responses to the question about whether respondents drove differently to save fuel and/or reduce emissions. In general, older adults were more likely to indicate that they engage in these behaviors, while younger respondents were less likely to do so.

Table 10. Summary of Responses to Concerns About Traffic Noise and Importing Foreign Oil, by Age

	Mean Age of Respondents (years)	
Response (Likert Scale Value)[a]	Traffic Noise	Importing Oil from Foreign Sources
Not a problem (1)	52.1	47.1
Not really a problem (2)	49.2	44.3
A small problem (3)	46.4	45.2
Somewhat of a problem (4)	53.0	49.0
A major problem (5)	50.7	52.9

[a] Respondents rated the problems on a scale from 1 to 5, with 1 being “not a problem” and 5 being “a major problem.” For purposes of presentation, we have assigned qualitative phrases that correspond with the Likert-scale values.

Finally, we found no statistically significant relationships between age and any of our eight factors influencing the purchase decision for respondents’ current primary vehicles.

Education

The relationship between age and attitude toward the seriousness of selected transportation-related problems is mixed. We found statistically significant results for traffic noise and the impact of speeding vehicles on community safety and marginally significant results for traffic congestion ($p = 0.09$) and local air pollution from vehicle emissions ($p = 0.05$). However, our results are not clearly linear. Traffic congestion tends to be viewed as a more significant problem by people with more formal education, while the relationship between education and concerns about traffic noise is bifurcated. Respondents whose mean level of formal education is high school were split on the issue, stating either that traffic noise is not a problem or that it is a major problem. Individuals with more years of formal education (i.e., college) tended to view traffic noise as a minor problem.

We found very similar results for concerns about speeding traffic, but results for attitudes toward emissions from vehicles contributing to local air pollution were clearer. These results underscore the importance of conducting more-sophisticated multivariate analyses to better tease out the underlying relationships.

Respondents with higher levels of formal education were more likely to indicate that speeding traffic is a problem, and we found two statistically significant results regarding the relationship between knowledge about the environmental impact of vehicles and education. Respondents with more years of formal education were more likely to disagree with the statement that motor vehicles are “not an important source of air pollution anymore” (a false statement) and to agree with the statement that “government rules allow minivans, vans, pickups, and SUVs to pollute more than passenger cars for every gallon of gas used” (a true statement). These results are in line with a priori expectations that education plays a key role in making individuals knowledgeable about environmental impacts and relevant government regulations (see Ostman and Parker and Dee).[65]

Our analysis of the relationship between education and environmental behavior or technology adoption produced several statistically significant results. As expected, respondents with more formal education tended to recycle more frequently. Similarly, the general trend between education and the frequency of choosing environmentally friendly products was positive. The results for driving behavior were less clear, as respondents with higher levels of formal education tended to clump in the middle, indicating that they do drive differently, but not often, while respondents with fewer years of formal education seemed to split between “very often” and “never.” It may be useful to explore this outcome further in another research venue to see what factors might contribute to this finding. Our results for technology adoption suggest that respondents with more years of formal education are more likely to adopt new technology after reading a favorable review, while those with fewer years of formal education are more likely to wait until a technology is widespread and proven before adopting it.

We found no statistically significant results for the relationship between education and factors influencing the decision to purchase households’ current vehicles.

Household Income

We found little statistical significance between household income and attitudes toward transportation-related problems. We found only that respondents with higher household incomes (mean = $42,100/year) were more likely to state that vehicle emissions that contribute to climate change are a “small problem” ($p = 0.08$); there were no discernible trends. The mean annual household income for respondents indicating that such vehicle emissions are “not a problem” is $41,700, while that of respondents indicating that it is “somewhat of a problem” or “a major problem” is $39,900.

Our analysis of our respondents’ knowledge of transportation-related policies and environmental impacts also produced few significant results. Respondents with higher household incomes were more likely to disagree with the (inaccurate) statement that “government rules require minivans, vans, pickups, and SUVs to meet the same miles-per-gallon standards as passengers cars,” but unfortunately, this bivariate analysis cannot determine the extent to which other factors might influence this result, which reinforces the importance of a multivariate analysis.

Statistically significant results point to a relationship between income and recycling frequency, but the trend is difficult to determine. Table 11 summarizes respondents’ answers to the survey question on recycling behavior, by mean annual household income. We found one additional significant result concerning household income and technology adoption: respondents with lower mean annual household incomes (average = $39,500) were more likely to adopt new technology after reading favorable reviews.

Table 11. Summary of Responses to Recycling Frequency, by Annual Household Income

Response	Mean Annual Household Income ($ thousands)
Very often	39.2
Quite often	42.2
Sometimes	39.3
Rarely	42.8
Never	37.2

Finally, our analysis of the relationship between income and factors influencing vehicle purchase decisions indicated that higher-income households tend to place greater importance on safety when selecting a vehicle ($p = 0.06$). Likewise, higher-income households tend to rate styling as an important feature—interestingly, those who indicated that styling was “not very important” had the highest average income ($44,000), but this was an anomaly in an otherwise fairly linear trend.

We found a significant relationship between income and the importance of environmental impacts in decisions to purchase respondents’ current vehicles, although the trends are not encouraging when we consider the typical price premium associated with AFVs. Table 12 provides a detailed summary of responses, by mean annual household income. The trend suggests that as incomes rise (and presumably as people are more able to pay a premium for a vehicle that is more environmentally friendly), respondents—with the exception of those who indicated that environmental impacts were “not important at all”—place less importance on this factor in their purchase decision. This result is not altogether surprising, and it is in line with results from Bunch et al. (1993), who found that higher-income households indicated a preference for gasoline vehicles over AFVs.[66]

Table 12. Summary of Responses Regarding the Importance of Environmental Impacts in the Decision to Purchase Current Vehicles, by Mean Annual Household Income

Response	Mean Annual Household Income ($ thousands)
Very important	40.3
Quite important	41.7
Somewhat important	42.6
Not very important	44.1
Not important at all	38.9

PREFERENCE-MODELING RESULTS

We used Stata 10.1 to analyze respondent preferences. Table 13 contrasts results from a rank-ordered logit model, where errors are clustered by respondent, with results from a panel rank-order mixed logit model, where the coefficients of vehicle cost premium, fuel cost savings, vehicle range difference, and total refueling cost (i.e., γ_1 to γ_4) are assumed to be lognormally distributed and correlated.

The estimated parameters in table 13 are the means of the (fixed and random) coefficients plus (for the mixed logit model) the elements of the lower-triangular matrix L, where the covariance matrix for the random coefficients is given by V = LL'. We see that results between these two models differ for a number of variables. In the following, we focus on results for the panel rank-ordered mixed logit model.

Variables pertaining to an AFV type combined with variables dealing with vehicle cost premium, fuel cost savings, vehicle range, and total refueling-time increase and an error term quantify the difference in utility for that vehicle type compared with a similar gasoline-fueled vehicle. Thus, if the value of a parameter in front of an interaction between a vehicle type and a binary variable (e.g., truck, SUV, minivan, college education, lives in Northeast, lives in Midwest, concerned with greenhouse gases, concerned with oil imports, or early adopter) is negative and significant, utility decreases when that binary variable is 1, so people are less likely to prefer the corresponding AFV.

We first considered factors that impact the choice of an AFV for the 489 respondents who anticipate buying a new vehicle within nine years. We see that vehicle types have an impact on preferences for AFVs and that this impact depends on the type of AFV considered. Our respondents are less likely to prefer HEV SUVs, HFC trucks, HFC SUVs, and EV trucks and minivans; by contrast, vehicle type does not seem to matter for CNG vehicles. Note that our baseline vehicle is a passenger car.

The region in which people live does not seem to statistically affect their preferences for AFVs, which is good news for car manufacturers. There are two exceptions: CNG vehicles and EVs are preferred less by residents in the Northeast.

People with a college education usually have a more favorable attitude toward HEVs, but not toward CNG vehicles or to less proven technologies such as HFC or EV. This may reflect respondents' skepticism about the latter.

We expected gender to have an influence on preferences for AFVs, because the environmental-psychology literature suggests that women tend to have more pro-environmental behaviors. However, we did not find gender to be statistically significant here, probably because purchasing a new vehicle is a household decision.

Table 13. Results of Ranking-Analysis Models

	Rank-Ordered Logit Model with Clustered Errors		Panel Rank-Ordered Mixed Logit Model	
Variable	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
$\beta_{1,0}$: HEV (hybrid electric vehicle)	0.1084	0.2624	0.0047	0.3312
$\beta_{1,1}$: HEV * Truck	–0.2491	0.1897	–0.3454	0.2467
$\beta_{1,2}$: HEV * SUV	–0.2959*	0.1651	–0.4035**	0.1984
$\beta_{1,3}$: HEV * Minivan	–0.3350	0.2459	–0.4334	0.3217
$\beta_{1,4}$: HEV * Lives in Northeast	–0.1978	0.2204	–0.2134	0.2985
$\beta_{1,5}$: HEV * Lives in Midwest	–0.4868**	0.2283	–0.4739	0.3013
$\beta_{1,6}$: HEV * Lives in South	–0.0733	0.1937	–0.1396	0.2718
$\beta_{1,7}$: HEV * College education	0.3480**	0.1626	0.6834***	0.2200
$\beta_{1,8}$: HEV * Female	0.2078	0.1510	0.2220	0.2072
$\beta_{1,9}$: HEV * Age(30 to 44 years old)	–0.0563	0.2419	–0.4304	0.3169
$\beta_{1,10}$: HEV * Age(45 to 59 years old)	–0.0848	0.2466	–0.4836	0.3331
$\beta_{1,11}$: HEV * Age(60 and older)	–0.1450	0.2472	–0.4689	0.3239
$\beta_{1,12}$: HEV * Concerned with greenhouse gases	0.5752***	0.1538	0.7609***	0.2198
$\beta_{1,13}$: HEV * Concerned with oil imports	0.2823*	0.1591	0.4607**	0.2137
$\beta_{1,14}$: HEV * Early adopter	0.1566	0.5025	0.1076	0.5687
$\beta_{2,0}$: CNG (compressed natural gas vehicles)	–0.3885	0.2713	–0.4056	0.3671
$\beta_{2,1}$: CNG * Truck	–0.1146	0.2136	–0.3283	0.2608
$\beta_{2,2}$: CNG * SUV	–0.2886*	0.1620	–0.2328	0.1899
$\beta_{2,3}$: CNG * Minivan	–0.1988	0.2660	–0.1038	0.3006
$\beta_{2,4}$: CNG * Lives in Northeast	–0.2671	0.2595	–0.5955*	0.3387
$\beta_{2,5}$: CNG * Lives in Midwest	–0.0914	0.2274	–0.1495	0.2920
$\beta_{2,6}$: CNG * Lives in South	0.1781	0.2159	–0.0897	0.3001
$\beta_{2,7}$: CNG * College education	0.0107	0.1696	0.3479	0.2338
$\beta_{2,8}$: CNG * Female	0.1227	0.1611	0.0845	0.2213
$\beta_{2,9}$: CNG * Age (30 to 44)	0.1667	0.2424	–0.3912	0.3384
$\beta_{2,10}$: CNG * Age (45 to 59)	0.2906	0.2552	–0.1350	0.3781
$\beta_{2,11}$: CNG * Age(60 and older)	0.4622**	0.2281	0.2407	0.3223
$\beta_{2,12}$: CNG * Concerned with greenhouse gases	0.6291***	0.1742	0.7309***	0.2479
$\beta_{2,13}$: CNG * Concerned with oil imports	0.3153*	0.1683	0.6318***	0.2285
$\beta_{2,14}$: CNG * Early adopter	0.2281	0.4335	0.1602	0.5419
$\beta_{3,0}$: HFC (hydrogen fuel cell vehicles)	–0.2530	0.3008	–0.2193	0.3944
$\beta_{3,1}$: HFC * Truck	–0.2326	0.2208	–0.4288*	0.2427
$\beta_{3,2}$: HFC * SUV	–0.4993**	0.1996	–0.5497**	0.2240
$\beta_{3,3}$: HFC * Minivan	–0.3133	0.2939	–0.2813	0.2981
$\beta_{3,4}$: HFC * Lives in Northeast	–0.2883	0.2870	–0.5507	0.3712
$\beta_{3,5}$: HFC * Lives in Midwest	–0.1006	0.2573	0.0068	0.3310
$\beta_{3,6}$: HFC * Lives in South	0.2955	0.2299	0.1155	0.3315
$\beta_{3,7}$: HFC * College education	–0.2472	0.2012	0.1848	0.2768
$\beta_{3,8}$: HFC * Female	0.2120	0.1799	0.1066	0.2445
$\beta_{3,9}$: HFC * Age (30 to 44)	–0.0249	0.2766	–0.7653**	0.3718
$\beta_{3,10}$: HFC * Age (45 to 59)	–0.1117	0.2753	–0.8498**	0.4161
$\beta_{3,11}$: HFC * Age (60 and older)	0.5118**	0.2585	0.0795	0.3577
$\beta_{3,14}$: HFC * Early adopter	0.2438	0.5679	0.3876	0.7021
$\beta_{3,12}$: HFC * Concerned with greenhouse gases	0.8740***	0.2030	1.1307***	0.2860
$\beta_{3,13}$: HFC * Concerned with oil imports	0.3363*	0.1863	0.7210***	0.2553
$\beta_{4,0}$: EV (electric vehicle)	–0.3313	0.3320	0.0864	0.4251
$\beta_{4,1}$: EV * Truck	–0.4397*	0.2514	–0.6220**	0.2812
$\beta_{4,2}$: EV * SUV	–0.4459**	0.1967	–0.2478	0.2227
$\beta_{4,3}$: EV * Minivan	–0.6339*	0.3408	–0.6174*	0.3255
$\beta_{4,4}$: EV * Lives in Northeast	–0.2007	0.3029	–0.7119*	0.3908
$\beta_{4,5}$: EV * Lives in Midwest	–0.1264	0.2751	–0.3537	0.3461
$\beta_{4,6}$: EV * Lives in South	0.2470	0.2509	–0.0776	0.3351
$\beta_{4,7}$: EV * College education	–0.4317**	0.2075	0.0149	0.2856
$\beta_{4,8}$: EV * Female	0.3083	0.1920	0.3117	0.2537
$\beta_{4,9}$: EV * Age (30 to 44)	0.0900	0.2955	–0.6756*	0.3882
$\beta_{4,10}$: EV * Age (45 to 59)	0.0923	0.2866	–0.6575	0.4077
$\beta_{4,11}$: EV * Age(60 and older)	0.2346	0.2624	–0.3819	0.3554
$\beta_{4,12}$: EV * Concerned with greenhouse gases	0.9566***	0.2140	1.0950***	0.2940
$\beta_{4,13}$: EV * Concerned with oil imports	0.3511*	0.1936	0.8168***	0.2584
$\beta_{4,14}$: EV * Early adopter	0.4908	0.5482	0.7627	0.6330
γ_1: Vehicle cost premium ($1,000)	–0.0453***	0.0048		
$\ln(-\gamma_1)$			–2.9393***	0.1150
γ_2: Fuel cost savings for 12,000 mi ($1,000)	0.0993**	0.0432		
$\ln(\gamma_2)$			–1.7194***	0.1906
γ_3: Vehicle range difference [AFV – GV] (10 mi)	0.0233***	0.0038		
$\ln(\gamma_3)$			–3.4986***	0.1633
γ_4: Total refueling-time increase (hrs)	–0.5532***	0.0967		
$\ln(-\gamma_4)$			–0.8600***	0.2496

Table 13. Results of Ranking-Analysis Models (continued)

	Rank-Ordered Logit Model with Clustered Errors		Panel Rank-Ordered Mixed Logit Model	
Variable	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
Estimated coefficients of the lower triangular decomposition of the covariance matrix of ln(g1) to ln(g4)				
L_{11}	—		1.3207***	0.0682
L_{21}	—		–0.4103***	0.1428
L_{31}	—		0.4558***	0.0768
L_{41}	—		0.4474***	0.0686
L_{22}	—		1.8330***	0.0882
L_{32}	—		0.3509***	0.0575
L_{42}	—		–1.3005***	0.1307
L_{33}	—		1.2544***	0.0828
L_{43}	—		0.4869***	0.0555
L_{44}	—		0.1571**	0.0676
Estimation statistics				
Log-likelihood function	–9834.51		-8748.23	
χ^2 test	507.33		2093.46	
AIC	19797.03		17644.46	
BIC	20265.43		18262.24	

Notes:*, **, and *** represent statistical significance at p ≤ 0.10, 0.05, and 0.01, respectively; number of scenarios ranked = 11,145; g1, g2, g3, and g4 are assumed to be lognormally distributed and correlated for the panel rank-ordered mixed logit model; Stata's "mixlogit" command estimated their logarithm. To estimate the value of g1 and g4 with the mixed logit model, their signs had to be reversed because coefficients that are lognormally distributed must be positive. Both models were estimated on the same dataset: for each ranking of five observations for the rank-order logit model, there are 5+4+3+2=14 observations for the panel rank-ordered mixed logit model, because each ranking is decomposed into four simpler rankings (see Equation (4)).

Age does not seem to strongly influence preferences for HEVs or CNG vehicles. However, respondents 30 to 59 years of age exhibit less interest in HFC vehicles; likewise, those 30 to 44 years of age are less interested in EVs than either younger (18 to 29) or more mature respondents (45 and older). This may not bode well for HFC vehicles, because mature, active adults are typically more affluent and more likely to afford the premium commanded by AFVs.

Beliefs about greenhouse gases and concerns with oil imports play an important role in people's preferences for AFVs, especially for less proven technologies such as HFC vehicles and EVs, but also to a lesser extent for HEVs and CNG vehicles. This makes sense, as the latter two still require fossil fuels. Somewhat surprisingly, being an early adopter of new technology does not play a statistically significant role here, but this may be due to the relatively small number of respondents who see themselves as early adopters and to the broad scope of our question on the early adoption of new technologies (which is not restricted to transportation technologies).

The four key vehicle characteristics that are of interest for understanding trade-offs that people are willing to make are vehicle cost, fuel cost, vehicle range, and total refueling time. It is important to note that we cannot directly compare these coefficients for our two models, because Stata estimated the logarithm of γ_i for $i \in \{1, ..., 4\}$, which are assumed to be stochastic and to follow a normal distribution. Moreover, these four random coefficients are assumed to be correlated, and the covariance matrix of their logarithm, denoted by the 4×4 matrix V, is given by the product $L*L'$, where the components of the lower diagonal matrix L are those shown at the bottom of table 14. Hence,

$$\mathbf{V} = \begin{pmatrix} 1.7442 & -0.5419 & 0.6019 & 0.5909 \\ -0.5419 & 3.5282 & 0.4562 & -2.5674 \\ 0.6019 & 0.4562 & 1.9043 & 0.3583 \\ 0.5909 & -2.5674 & 0.3583 & 2.1532 \end{pmatrix} \quad (8)$$

so that

$$\begin{pmatrix} \ln(-\gamma_1) \\ \ln(\gamma_2) \\ \ln(\gamma_3) \\ \ln(-\gamma_4) \end{pmatrix} \sim N\left(\begin{pmatrix} -2.9393 \\ -1.7194 \\ -3.4986 \\ -0.8600 \end{pmatrix}, \mathbf{V}\right) \quad (9)$$

The coefficients of L are all significantly different from 0 (see table 13), so the γ_is for $i \in \{1, ..., 4\}$ are correlated. We see that there is substantial heterogeneity in the way our respondents value differences in vehicle cost, fuel cost savings, vehicle range difference, and total increase in refueling time. This heterogeneity likely reflects differences in taste for cars, in income, in the number of miles driven per year, and in the cost of gasoline for our respondents.

The untransformed values of the γ_is for $i \in \{1, ..., 4\}$ can be obtained from Equations (5) and (6), with care to account for the sign reversal of γ_1 and γ_4 (see the notes to table 13).

To examine the trade-offs people are willing to make between vehicle cost, fuel cost savings, vehicle range difference, and total increase in refueling time, we simulated 100 times 500,000 draws of the multivariate lognormal distribution given by Equation (9). We used these data to estimate the median value of the ratios γ_i/γ_j, with $(i,j) \in \{1, \ldots, 4\}$. We chose to report the median trade-off because it is less sensitive than the mean to large values in the tail of a lognormal distribution.

Results suggest the following trade-offs needed to leave utility unchanged: A $1,000 increase in the price difference between an AFV and a conventional vehicle needs to be compensated either by a $300 increase in savings from driving 12,000 miles, a 17.5-mile increase in range, or a 7.8-minute reduction in total refueling time (finding a gas station or refueling). Likewise, a 10-mile decrease in vehicle range needs to be compensated by a 4.2-minute decrease in total refueling time. Other trade-offs between vehicle cost, fuel cost savings, vehicle range difference, and total increase in refueling time can be easily calculated using the same approach.

AFV PREFERENCES: A SUMMARY OF RANKINGS

As indicated in the description of the survey design, respondents were asked to indicate their preference order for five vehicles for three different scenarios for each vehicle they were planning on replacing or buying within the next nine years, for a maximum of nine rankings per respondent. Table 14 presents summary statistics for these rankings.

Table 14. Summary of AFV Rankings

	Preference Ranking (percent of respondents)				
Vehicle Type	First	Second	Third	Fourth	Fifth
Gas	36[a] (30–39)[b]	19 (15–24)	13 (9–17)	12 (10–16)	21 (15–26)
HEV	26 (21–31)	31 (26–35)	19 (14–24)	17 (15–21)	8 (6–11)
CNG	13 (10–14)	24 (19–28)	28 (25–32)	25 (23–28)	10 (7–13)
FC	18 (12–22)	16 (9–19)	23 (18–29)	25 (19–30)	19 (17–22)
EV	9 (7–12)	11 (9–16)	17 (13–19)	20 (17–25)	42 (36–50)

[a] The top number in each cell is the average across all nine rankings by respondents.
[b] The bottom number in each cell represents the range across all nine rankings by respondents.

There were scenarios under which some respondents ranked each type of AFV first, which validates the range of parameters we selected for our scenarios. Overall, respondents preferred gasoline-fueled vehicles, which were ranked first 36 percent of the time, followed by HEVs, which were preferred 26 percent of the time. EVs were least likely to be ranked first (only 9 percent of the time). HEVs were a very popular second choice among respondents (31 percent). Among second choices, CNG vehicles were the next most popular, at 24 percent. HFC vehicles were ranked third or fourth almost half of the time. Finally, EVs were by far the least popular: 42 percent of the respondents ranked EVs as their least preferred choice.

Although gasoline-fueled vehicles were the preferred choice overall, one-fifth of respondents ranked them last. This could suggest that there is strong interest in AFVs; however, no specific type of AFV stands out from the crowd. Nevertheless, HEVs appear to be the most likely technology to win the race; 57 percent of respondents listed HEVs as either their first or their second choice. These results suggest that consumers still view the limitations associated with EVs (e.g., range, recharging time) quite negatively.

Table 15 provides a summary of the importance of various AFV characteristics in respondents' ranking decisions. Although much of the literature on AFV preferences lists vehicle price as the most important factor, our respondents seemed to view fuel availability/refueling time as slightly more important (55 percent thought it was "very important," compared with 53 percent who cited price). Range and fuel cost were also significant factors, followed by confidence in the various technologies used by AFVs. Environmental concerns were definitely not considered important factors in ranking decisions; only 25 percent listed them as “very important.” More telling, however, 12 percent of the respondents listed environmental concerns as “not very important,” and 9 percent considered them “not important at all.” Two-thirds of the respondents stated that the issue of U.S. dependence on foreign oil was “very important” or “quite important” in their ranking decision. Having a clear understanding of the importance households place on various vehicle characteristics is essential both for policymakers designing new programs and policies to encourage the use of AFVs and for manufacturers seeking to improve the design and marketing of their vehicles.

Table 15. Importance of AFV Characteristics in Ranking Decisions (percent of respondents)

Characteristic	Very Important	Quite Important	Somewhat Important	Not Very Important	Not Important at All
Price	53	30	13	2	2
Fuel availability/refueling time	55	31	11	2	1
Range	49	34	14	1	1
Fuel cost	46	34	15	3	1
Concerns about greenhouse gas emissions	25	26	28	12	9
Confidence in the specific technologies	42	34	19	4	2
U.S. dependence on foreign oil	37	30	23	7	4

V. CONCLUSIONS AND RECOMMENDATIONS

Despite some of the current limitations of AFVs and nationwide concern regarding the state of the economy, consumers are interested in these new technologies. This chapter summarizes our key findings and presents some recommendations based on them.

KEY FINDINGS

At least one-quarter of the respondents to our survey were unsure about the impacts of motor vehicles on the environment and therefore did not understand related government regulations and some of the motivations for promoting AFVs. They ranked environmental impacts last among eight criteria they considered when they purchased their existing vehicles: only 35 percent deemed environmental impacts "very important" or "quite important," and fuel economy ranked only sixth in importance (58 percent considered it "very important" or "quite important"). The top concerns were reliability (87 percent), performance (77 percent), and purchase price (76 percent). It appears that decisions about purchasing new vehicles over the next nine years will not be driven by environmental concerns or national security: concern about U.S. dependence on foreign oil and concerns about greenhouse gas emissions finished last in importance (67 percent and 51 percent of our respondents, respectively, considered them "very important" or "quite important"). The most important criteria for our respondents were fuel availability/refueling time (86 percent), price (83 percent), range (86 percent), and fuel cost (80 percent).

Although most American households are not going to turn in their gasoline vehicles as soon as new AFVs become available, there is hope that AFVs will be adopted by some households. Indeed, each type of AFV considered was ranked first by some respondents for some combination of vehicle characteristics considered. These characteristics (vehicle cost, fuel cost, vehicle range, and density of refueling stations) were deemed likely or possible to favor AFVs within the next nine years, based on current knowledge.

To assess trade-offs between vehicle cost, fuel cost, vehicle range, and total refueling time, we designed a ranking exercise in which survey respondents ranked five vehicles (gasoline-fueled, HEV, CNG vehicles, HFC vehicles, and EVs) in terms of likely values of these characteristics. Using a panel rank-ordered mixed logit model, we estimated how vehicle type (e.g., truck, car, SUV, minivan) and individual demographic and socioeconomic characteristics influenced preferences for AFVs. We found that

- Larger vehicle types using alternative technologies are favored less than traditional car models.
- Geographic location does not seem to broadly influence AFV preferences.
- College-educated individuals show a preference for HEVs but not necessarily for HFC vehicles or EVs.

- Unlike gender, age seems to influence preferences for specific vehicle types: middle-aged individuals (30 to 59) do not favor HFC vehicles, and young adults (18 to 29) and older adults (45 and older) prefer EVs.

- Beliefs about greenhouse gases and concerns with oil imports strongly influence AFV preferences, especially for HFC vehicles and EVs, both of which do not directly use fossil fuels.

Our assessment of the trade-offs consumers are willing to make indicates that an individual's utility remains unchanged under the following conditions:

- A $1,000 increase in AFV cost is equivalent to

  – A $300 savings in driving cost over 12,000 miles.

  – A 7.8-minute decrease in total refueling time (e.g., finding a gas station and refueling); this highlights the importance of providing a dense enough network of refueling stations.

  – A 17.5-mile increase in the vehicle's range; this trade-off applies primarily to EVs, since the range of other AFVs is similar to that of conventional vehicles. It implies that vehicle range is very valuable to households.

- A 10-mile decrease in vehicle range can be compensated by a 4.2-minute decrease in total refueling time. Other trade-offs between these characteristics can be obtained by combining these results.

RECOMMENDATIONS FOR POLICYMAKERS, MANUFACTURERS, AND TRANSPORTATION PROFESSIONALS

In light of these results, we present the following recommendations for policymakers, manufacturers, and other transportation professionals.

Consumers are receptive to AFVs—nearly two-thirds of our survey respondents ranked an AFV (including HEVs) first for the range of parameters considered. However, no single technology is overwhelmingly preferred, and gasoline vehicles still have a high overall level of support. Among AFVs, HEVs are currently preferred, and it is likely that policy decisions made now concerning, e.g., tax rebates, financial incentives for research and development, and continued access to high-occupancy vehicle (HOV) lanes will have a significant impact on their popularity.

Despite media attention to EVs and the Obama administration's push for them, they were the least popular vehicle in our ranking exercise. Current technological limitations, particularly range constraints and battery charging time, appear to be driving consumers' negative view of these vehicles. A significant investment in research and development will be required to improve the perception and popularity of pure EVs.

Finally, a disappointing outcome of our research, although not necessarily a surprising one, is the lack of understanding of the links between motor vehicle use, air pollution, human health, and global climate change. Because of this lack, environmental issues play a limited role in the decision making process households use when they buy a new vehicle. To increase the acceptance and use of AFVs, the public must be better educated about these links, and in addition, AFVs could be made more competitive by decreasing their cost premium and improving the other characteristics that consumers traditionally value.

APPENDIX A: SUMMARY OF VEHICLE CHARACTERISTICS IN THE STATED-PREFERENCE LITERATURE

		Monetary			Nonmonetary				Environmental	Other
Study	Vehicle Type	Purchase Price	Fuel operating cost (Including Mileage)	Maintenance Cost	Range Between Refuelings/Rechargings	Fuel Availability	Vehicle Performance (e.g., Acceleration, Top Speed, Engine Size)	Dual-Fuel Capability	Emissions	
Adler et al., 2003	Gas; diesel; hybrid	X	X	X			X			Incentives (no purchase tax, free parking, HOV access; gradability
Ahn , Jeong, and Kim, 2008	Gas; CNG; diesel; LPG; hybrid	X	X	X			X			
Beggs, Cardell, and Hausman, 1981		X	X		X		X			Number of seats; A/C; type of warranty
Bolduc , Boucher, and Alvarez-Daziano, 2008	Gas; CNG; hybrid, HFC	X	X			X	X		X	Express-lane access
Brownstone , Bunch, and Train, 2000	Gas; CNG; methanol; EV	X	X		X	X	X		X	Luggage space
Bunch et al., 1993	Gas; EV; AFV (Type not specified)	X	X		X	X		X	X	
Dagsvik et al., 2002	Gas; EV; LPG; hybrid	X	X		X		X			
Ewing and Sarigollu, 1998	Conventional; fuel-efficient; EV	X		X	X		X			Refueling rate; commute cost and time

		Monetary			Nonmonetary				Environmental	Other
Study	Vehicle Type	Purchase Price	Fuel operating cost (Including Mileage)	Maintenance Cost	Range Between Refuelings/Rechargings	Fuel Availability	Vehicle Performance (e.g., Acceleration, Top Speed, Engine Size)	Dual-Fuel Capability	Emissions	
Adler et al., 2003	Gas; diesel; hybrid	X	X	X			X			Incentives (no purchase tax, free parking, HOV access; gradability
Ahn , Jeong, and Kim, 2008	Gas; CNG; diesel; LPG; hybrid	X	X	X			X			
Beggs, Cardell, and Hausman, 1981		X	X		X		X			Number of seats; A/C; type of warranty
Bolduc , Boucher, and Alvarez-Daziano, 2008	Gas; CNG; hybrid, HFC	X	X			X	X		X	Express-lane access
Brownstone , Bunch, and Train, 2000	Gas; CNG; methanol; EV	X	X		X	X	X		X	Luggage space
Bunch et al., 1993	Gas; EV; AFV (Type not specified)	X	X		X	X		X	X	
Dagsvik et al., 2002	Gas; EV; LPG; hybrid	X	X		X		X			
Ewing and Sarigollu, 1998	Conventional; fuel-efficient; EV	X		X	X		X			Refueling rate; commute cost and time

APPENDIX B: SUMMARY OF DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS IN THE STATED-PREFERENCE LITERATURE

Study	Gender	Age	Income	House-hold Size	Commuter	Educa-tion	Transit/ Carpool	Other
Adler et al., 2003			X	X				Residence location
Ahn , Jeong, and Kim, 2008								
Beggs, Cardell, & Hausman, 1981	X		X	X	X			Residence location
Bolduc , Boucher, and Alvarez-Daziano, 2008	X	X	X		X	X	X	
Brownstone , Bunch, and Train, 2000			X	X		X		
Bunch et al., 1993	X	X	X	X	X	X		Number of vehicles
Dagsvik et al., 2002	X	X						
Ewing and Sarigollu, 1998	X	X	X		X		X	Language (French/ English, Canadian study) Home owner/renter Number of vehicles Environmental con-cerns
Ewing and Sarigollu, 2000								
Golob et al., 1993								
Greene , 1996	X	X	X	X		X		
Horne , Jaccard, and Tiedemann, 2005								
Kavalec , 1999	X	X	X			X		Number of vehicles Residence location (in California)
Mau et al. 2008								
Molin and Brinkman, 2010	X	X	X			X		Number of vehicles Employment Household vehicle characteristics Environmental attitudes
Molin, Aouden and van Wee, 2007	X	X				X		Household vehicle characteristics
Potoglou and Kanaroglou, 2007	X	X	X			X		Number of vehicles Residence location (Hamilton, Ontario, Canada)
Thompkins et al., 1998								

APPENDIX C: SUMMARY OF BIVARIATE STATISTICAL ANALYSES

Table 16. Chi-Square Test and ANOVA Results for Relationship Between Demographic/Socioeconomic Characteristics and Views on Transportation Issues

	Variable			
Issue	Gender	Age	Education	Household Income
Traffic congestion	χ^2 = 5.18 p = 0.27	F = 1.20 p = 0.13	F = 1.59 P = 0.09	F = 1.94 P = 0.39
Traffic noise	χ^2 = 11.42 p = 0.02	F = 1.33 p = 0.04	F = 2.22 P = 0.01	F = 1.03 P = 0.42
Impact of vehicle emissions on local air quality	χ^2 = 13.18 p = 0.01	F = 1.11 P = 0.25	F = 1.77 P = 0.05	F = 1.08 P = 0.38
Impact of vehicle emissions on climate change	χ^2 = 17.60 p < 0.01	F = 1.25 P = 0.09	F = 1.34 P = 0.20	F = 1.55 P = 0.08
Accidents caused by aggressive or absentminded drivers	χ^2 = 4.39 p = 0.36	F = 1.10 P = 0.28	F = 1.30 P = 0.21	F = 1.09 P = 0.36
Impact of speeding traffic on community safety	χ^2 = 16.82 p < 0.01	F = 1.01 P = 0.46	F = 1.90 P = 0.03	F = 1.48 P = 0.11
Importing oil from foreign countries	χ^2 = 7.88 p = 0.10	F = 1.71 P < 0.01	F = 0.76 P = 0.69	F = 1.28 P = 0.19

Table 17. Chi-Square Test and ANOVA Results for Relationship Between Demographic/Socioeconomic Characteristics and Views on the Environmental Impact of Motor Vehicles

	Variable			
Issue	Gender	Age	Education	Household Income
Vehicles “not an important source of air pollution anymore”	χ^2 = 8.63 p = 0.01	F = 1.37 P = 0.03	F = 1.89 P = 0.03	F = 0.50 P = 0.94
“Government rules allow mini-vans, vans, pickups and SUVs to pollute more than passenger cars, for every gallon of gas used”	χ^2 = 16.22 p < 0.01	F = 0.74 P = 0.95	F = 2.81 P < 0.01	F = 0.78 P = 0.70
Vehicles “are an important sources of the greenhouse gases that many scientists believe are warming the earth’s climate.”	χ^2 = 9.39 p < 0.01	F = 0.84 P = 0.83	F = 0.76 P = 0.69	F = 0.87 P = 0.60
“Government rules require mini-vans, vans, pickups, and SUVs to meet the same miles-per-gallon standards as passenger cars”	χ^2 = 12.56 p < 0.01	F = 1.00 P = 0.48	F = 1.35 P = 0.18	F = 1.83 P = 0.03
Exhaust from vehicles “is an important source of the pollution that causes asthma and makes asthma attacks worse”	χ^2 = 1.04 p = 0.60	F = 1.05 P = 0.37	F = 1.13 P = 0.33	F = 1.39 P = 0.14

Table 18. Chi-Square Test and ANOVA Results for Relationship Between Demographic/Socioeconomic Characteristics and Environmental Behaviors and Views on Technology Adoption

	Variable			
Behavior	Gender	Age	Education	Household Income
Recycle frequently	$\chi^2 = 9.84$ $p = 0.04$	$F = 0.95$ $P = 0.60$	$F = 2.98$ $P < 0.01$	$F = 3.72$ $P < 0.01$
Drive differently to save fuel and/or reduce emissions	$\chi^2 = 4.70$ $p = 0.32$	$F = 1.37$ $P = 0.03$	$F = 2.81$ $P < 0.01$	$F = 1.37$ $P = 0.15$
Choose environmentally friendly products	$\chi^2 = 17.15$ $p < 0.01$	$F = 0.85$ $P = 0.80$	$F = 2.88$ $P < 0.01$	$F = 0.99$ $P = 0.47$
Be among first persons to adopt a new technology	$\chi^2 = 3.91$ $p = 0.05$	$F = 0.97$ $P = 0.54$	$F = 0.44$ $P = 0.95$	$F = 0.94$ $P = 0.52$
Adopt technology after reading a favorable reviews	$\chi^2 = 9.12$ $p < 0.01$	$F = 0.83$ $P = 0.84$	$F = 2.30$ $P = 0.01$	$F = 1.93$ $P = 0.02$
Adopt technology after it is widely accepted	$\chi^2 = 6.27$ $p = 0.01$	$F = 1.00$ $P = 0.48$	$F = 1.96$ $P = 0.03$	$F = 0.93$ $P = 0.53$
Adopt technology when price comes down	$\chi^2 = 0.04$ $p = 0.84$	$F = 0.83$ $P = 0.85$	$F = 0.74$ $P = 0.71$	$F = 0.99$ $P = 0.46$

Table 19. Chi-Square Test and ANOVA Results for Relationship Between Demographic/Socioeconomic Characteristics and Factors Influencing Vehicle Purchase Decision

	Variable			
Factor	Gender	Age	Education	Household Income
Purchase price	$\chi^2 = 2.23$ $p = 0.69$	$F = 0.93$ $P = 0.64$	$F = 0.93$ $P = 0.52$	$F = 0.97$ $P = 0.49$
Fuel economy	$\chi^2 = 7.20$ $p = 0.13$	$F = 0.96$ $P = 0.58$	$F = 0.77$ $P = 0.69$	$F = 1.37$ $P = 0.16$
Performance	$\chi^2 = 7.29$ $p = 0.12$	$F = 1.16$ $P = 0.18$	$F = 0.59$ $P = 0.85$	$F = 0.88$ $P = 0.61$
Safety	$\chi^2 = 8.49$ $p = 0.08$	$F = 0.82$ $P = 0.85$	$F = 1.13$ $P = 0.33$	$F = 1.64$ $P = 0.06$
Seating capacity	$\chi^2 = 10.88$ $p = 0.03$	$F = 1.15$ $P = 0.19$	$F = 1.17$ $P = 0.30$	$F = 1.30$ $P = 0.18$
Reliability	$\chi^2 = 0.97$ $p = 0.91$	$F = 0.98$ $P = 0.53$	$F = 1.07$ $P = 0.38$	$F = 1.37$ $P = 0.16$
Styling	$\chi^2 = 11.15$ $p = 0.03$	$F = 0.90$ $P = 0.71$	$F = 0.45$ $P = 0.94$	$F = 2.13$ $P = 0.01$
Environmental impacts	$\chi^2 = 6.31$ $p = 0.18$	$F = 118$ $P = 0.16$	$F = 1.29$ $P = 0.22$	$F = 2.22$ $P = 0.01$

APPENDIX D: AFV SURVEY QUESTIONNAIRE AND TOP-LINE RESULTS

This survey is conducted on behalf of the Mineta Transportation Institute at San José State University and the University of California, Irvine. The main goal of this survey is to understand your preferences for alternative-fuel vehicles such as hybrid, electric, or fuel cell vehicles compared to gasoline vehicles.[67]

This survey has three parts:

- In Part 1 of this survey, we ask about your views on transportation issues, the environment, and technology adoption.

- In Part 2 we inquire about the vehicles you own and about driving in your household.

- In Part 3, if your household is planning on either replacing one of its vehicles or buying a new one over the next nine years, we ask for your preferences over a set of alternatives that includes alternative-fuel vehicles.

Thank you for taking the time to complete our survey. Rest assured that your privacy will be strictly preserved. Please try to answer each question as completely as you can. Completing this survey should take approximately 12 to 15 minutes *(Note: the median completion time ended up being 21 minutes)*.

Part I. Views on transportation issues, the environment, and technology adoption.

First, we would now like to ask you a couple of questions about your views on transportation issues, the environment, and technology adoption.

Q1.1 Thinking about your daily experiences, how serious do you consider the following problems related to transportation to be?

From 1 (Not a problem) to 5 (A major problem) with "Don't know" option.

a. Traffic congestion that you experience while driving.

19.8% (1) Not a problem
18.1% (2)
22.7% (3)
20.8% (4)
14.3% (5) A major problem
4.4% Don't know

b. Traffic noise that you hear at home, work, or school.

37.6%	(1) Not a problem
26.4%	(2)
18.1%	(3)
9.9%	(4)
5.6%	(5) A major problem
2.4%	Don't know

c. Vehicle emissions that affect local air quality.

14.3%	(1) Not a problem
16.6%	(2)
24.8%	(3)
20.4%	(4)
20.2%	(5) A major problem
3.7%	Don't know

d. Vehicle emissions that contribute to global climate change.

15.4%	(1) Not a problem
11.4%	(2)
20.0%	(3)
20.4%	(4)
27.5%	(5) A major problem
5.2%	Don't know

e. Accidents caused by aggressive or absentminded drivers.

3.4%	(1) Not a problem
7.3%	(2)
15.5%	(3)
29.1%	(4)
42.2%	(5) A major problem
2.4%	Don't know

f. Unsafe communities because of speeding traffic.

7.2%	(1) Not a problem
14.1%	(2)
23.6%	(3)
27.2%	(4)
24.5%	(5) A major problem
3.4%	Don't know

g. Importing much of our oil from foreign countries.

3.3%	(1) Not a problem
4.6%	(2)
10.8%	(3)
22.8%	(4)
53.3%	(5) A major problem
5.1%	Don't know

Q1.2 This question deals with your views about the environmental impacts of motor vehicles. For each of the following statements, please indicate how much you agree or disagree. There is no correct answer.

Strongly Agree Mildly Agree Unsure Mildly Disagree Strongly Disagree

a. Cars, minivans, vans, pickups, and SUVs are not an important source of air pollution anymore.
8.1% (1) Strongly agree
17.2% (2) Mildly agree
28.7% (3) Unsure
26.4% (4) Mildly disagree
19.6% (5) Strongly disagree

b. Government rules allow minivans, vans, pickups, and SUVs to pollute more than passenger cars, for every gallon of gas used.
9.0% (1) Strongly agree
16.0% (2) Mildly agree
52.5% (3) Unsure
15.2% (4) Mildly disagree
7.2% (5) Strongly disagree

c. Cars, minivans, vans, pickups, and SUVs are an important source of the greenhouse gases that many scientists believe are warming the earth's climate.
14.0% (1) Strongly agree
23.4% (2) Mildly agree
35.9% (3) Unsure
14.4% (4) Mildly disagree
12.2% (5) Strongly disagree

d. Government rules require minivans, vans, pickups, and SUVs to meet the same miles-per-gallon standards as passenger cars.
6.5% (1) Strongly agree
20.4% (2) Mildly agree
47.2% (3) Unsure
14.9% (4) Mildly disagree
11.0% (5) Strongly disagree

e. Exhaust from cars, minivans, vans, pickups, and SUVs is an important source of the pollution that causes asthma and makes asthma attacks worse.
15.4% (1) Strongly agree
27.3% (2) Mildly agree
39.5% (3) Unsure
10.8% (4) Mildly disagree
7.0% (5) Strongly disagree

Q1.3 How often do you engage in the following behaviors?

From 1=Very often to 5=Never, with "Don't know" as an option

a. Recycle cans, glass or paper.

59.0% (1) Very often
11.8% (2)
12.8% (3)
6.0% (4)
8.8% (5) Never
1.6% Don't know

b. Drive differently in order to save fuel and/or reduce emissions.

28.2% (1) Very often
21.9% (2)
23.8% (3)
10.8% (4)
11.4% (5) Never
4.4% Don't know

c. Choose a product instead of another because of environmentally friendly ingredients or packaging.

13.6% (1) Very often
18.8% (2)
32.6% (3)
17.9% (4)
13.9% (5) Never
3.3% Don't know

Finally, we would like to know about your attitude toward new technologies.

Q1.4 When a new technology you are interested in becomes available for purchase, what do you do?

1.9% (1) I am among the first people to purchase it.
18.4% (2) I wait to read a review of it and then buy it if the review is favorable.
68.2% (3) I wait until this new technology has been widely accepted and proven before considering it.
11.4% (4) Other.

Part II. Vehicle ownership

In this part, we would like to gather information about the vehicles you own.

Q2.1 How many of the following types of vehicles does your household have available for use?

Cars:

18.0%	0
55.1%	1
21.2%	2
3.5%	3
2.2%	4 or more

Minivans/vans:

70.5%	0
26.6%	1
2.8%	2

Sport utility vehicles:

60.4%	0
33.0%	1
6.0%	2
0.6%	3

Pickup trucks:

53.7%	0
40.3%	1
5.5%	2
0.2%	3
0.4%	4 or more

[Let NC=cars+mini-vans/vans+SUVs+pickup trucks; if NC > 0 in previous question, then ask:]

For each of the vehicles that your household owns or uses, please answer the following questions. If your household has 3 or more vehicles, please answer the questions below for the 2 vehicles your household drives the most.

[If NC > 1, loop on 2 vehicles]

Q2.2 What is the make (e.g., Ford or Toyota) and model (e.g., Ford Explorer or Toyota Corolla) of vehicle #?

Table 20. Distribution of Respondents' Vehicles' Makes, by Percent

Vehicle Make	Vehicle 1 (%)	Vehicle 2 (%)
Acura	0.92	0.80
Audi	0.39	0.20
BMW	0.79	1.81
Buick	5.77	1.61
Cadillac	1.97	1.81
Chevy	11.42	18.27
Chrysler	4.20	2.41
Dodge	6.04	10.44
Ford	15.75	17.27
GM	0.26	3.41
GMC	1.44	7.83
Honda	8.92	0.40
Hummer	0.13	0.60
Hyundai	2.23	0.60
Infiniti	0.66	0.20
Jaguar	0.13	0.20
Jeep	2.49	3.41
Kia	0.66	1.41
Lexus	0.79	0.60
Lincoln	0.66	0.40
Mazda	1.05	0.20
Mercedes	1.44	1.81
Mercury	3.02	1.00
Mitsubishi	0.39	1.41
Nissan	4.46	0.60
Oldsmobile	1.57	0.40
Plymouth	0.39	2.61
Pontiac	2.62	1.20
Saab	0.13	1.00
Saturn	2.23	2.01
Scion	0.52	1.00
Subaru	1.84	0.40
Suzuki	0.39	1.41
Toyota	10.50	9.04
VW	2.10	1.61
Volvo	1.71	0.60

Most common vehicle models for Vehicle 1 include:

Accord (Honda)	3.02%
Camry (Toyota)	2.89%
Taurus (Ford)	2.76%
LeSabre (Buick)	2.36%
Corolla (Toyota)	2.23%
Civic (Honda)	2.10%

Most common vehicle models for Vehicle 2 include:

Silverado (Chevy)	4.22%
F150 (Ford)	3.41%
Ranger (Ford)	2.81%
Ram (Dodge)	2.61%
Accord (Honda)	2.61%
Dakota (Dodge)	2.41%

For your <*Make Model from Q2.2*>, please enter the following information:

Q2.3 Model year (Please type the four digit year):

Vehicle 1:

2.1%	1900–1984
9.4%	1985–1993
23.6%	1994–1999
26.6%	2000–2003
38.3%	2004–2010

Vehicle 2:

3.0%	1900–1984
13.5%	1985–1993
22.7%	1994–1999
26.6%	2000–2003
34.2%	2004–2010

Q2.4 Trim level: _____ (Examples of trim for a 2010 Ford Explorer include RWD XLT, AWD Limited, or AWD Eddie Bauer Edition)

Q2.5 Fuel used (Please check one):

Vehicle 1:

97.9%	(1) Gasoline
1.6%	(2) Diesel
0.5%	(3) Other

Vehicle 2:

97.6%	(1) Gasoline
1.4%	(2) Diesel
1.0%	(3) Other

Q2.6 Approximate gas mileage:

Vehicle 1:

3.4%	Less than 13 mpg
12.9%	13–17 mpg
32.3%	18–22 mpg
24.0%	23–27 mpg
27.4%	Greater than 27 mpg

Vehicle 2:

5.5%	Less than 13 mpg
19.0%	13–17 mpg
34.8%	18–22 mpg
20.9%	23–27 mpg
19.8%	Greater than 27 mpg

Q2.7 Approximate number of miles driven each year: _____ miles per year

Vehicle 1:

>0 to 1,500	10.57%
1,501 to 5,000	22.7%
5,001 to 10,000	33.8%
10,001 to 15,000	21.14%
15,001 to 25,000	10.0%
25,001+	3.27%

Vehicle 2:

>0 to 1,500	13.53%
1,501 to 5,000	24.2%
5,001 to 10,000	33.12%
10,001 to 15,000	18.74%
15,001 to 25,000	7.41%
25,001+	3.05%

Q2.8A Please indicate the percentage of time your *<Year from Q2.3> <Make Model from Q2.2>* is used on average for the following:

Vehicle 1:

a. Commute to work:

31.1%	None
14.5%	1 to 25% of the time
20.9%	26 to 50% of the time
14.7%	51 to 75% of the time
18.8%	76 to 100% of the time

b. Drive yourself, a child, or a family member to school:

60.1%	None
24.4%	1 to 25% of the time
12.9%	26 to 50% of the time
1.3%	51 to 75% of the time
1.3%	76 to 100% of the time

c. Run household and personal errands:

1.9%	None
38.5%	1 to 25% of the time
26.4%	26 to 50% of the time
10.3%	51 to 75% of the time
22.9%	76 to 100% of the time

d. Other: _______. Please indicate purpose: ____________________

Vehicle 2:

a. Commute to work:

28.7%	None
11.9%	1 to 25% of the time
18.8%	26 to 50% of the time
18.7%	51 to 75% of the time
21.9%	76 to 100% of the time

b. Drive yourself, a child, or a family member to school:

57.7%	None
26.6%	1 to 25% of the time
11.3%	26 to 50% of the time
1.6%	51 to 75% of the time
2.8%	76 to 100% of the time

c. Run household and personal errands:

6.7%	None
40.3%	1 to 25% of the time
22.0%	26 to 50% of the time
6.7%	51 to 75% of the time
24.3%	76 to 100% of the time

d. Other: _______. Please indicate purpose: ____________________

*[If answer "**a**" to **Q2.8A** >0, ask]*

Q2.8B How many miles is a typical trip from home to work and back for the household member who drives the most your *<Year from Q2.3>* *<Make Model from Q2.2>*? ____ miles

Vehicle 1:

<10	25.2%
10 to 19	28.38%
20 to 29	20.33%
30 to 49	12.08%
50 to 74	8.04%
75+	5.9%

Vehicle 2:

<10	23.12%
10 to 19	22.49%
20 to 29	16.95%
30 to 49	20.86%
50 to 74	9.45%
75+	7.2%

Q2.9 What importance did the following factors have in your family's decision to acquire your *<Year from Q2.3> <Make Model from Q2.2>*?

From 1=Very important to 5=Not at all important, with "Don't know" as an option.

Vehicle 1:

a. Purchase price:

53.8%	(1) Very important
22.1%	(2)
14.1%	(3)
2.3%	(4)
4.8%	(5) Not at all important
2.9%	Don't know

b. Fuel economy

31.7%	(1) Very important
26.1%	(2)
26.3%	(3)
6.9%	(4)
5.7%	(5) Not at all important
3.3%	Don't know

c. Performance

47.1%	(1) Very important
29.7%	(2)
14.4%	(3)
3.7%	(4)
1.7%	(5) Not at all important
3.4%	Don't know

d. Safety

45.6%	(1) Very important
28.3%	(2)
15.7%	(3)
4.8%	(4)
2.5%	(5) Not at all important
3.1%	Don't know

e. Seating capacity

31.7%	(1) Very important
24.2%	(2)
19.9%	(3)
11.4%	(4)
10.0%	(5) Not at all important
2.8%	Don't know

f. Reliability

65.4%	(1) Very important
21.3%	(2)
8.4%	(3)
1.6%	(4)
1.3%	(5) Not at all important
2.1%	Don't know

g. Appearance and styling

33.8%	(1) Very important
28.0%	(2)
20.8%	(3)
8.3%	(4)
6.8%	(5) Not at all important
2.2%	Don't know

h. Environmental impacts

14.0%	(1) Very important
21.4%	(2)
32.2%	(3)
16.1%	(4)
12.1%	(5) Not at all important
4.2%	Don't know

i. Other [please indicate]: ____________

Vehicle 2:

a. Purchase price:

57.5%	(1) Very important
20.7%	(2)
10.1%	(3)
3.2%	(4)
4.8%	(5) Not at all important
3.8%	Don't know

b. Fuel economy

27.1%	(1) Very important
23.4%	(2)
29.9%	(3)
9.3%	(4)
6.9%	(5) Not at all important
3.4%	Don't know

c. Performance

44.4%	(1) Very important
30.0%	(2)
16.7%	(3)
3.6%	(4)
2.0%	(5) Not at all important
3.4%	Don’t know

d. Safety

41.2%	(1) Very important
28.9%	(2)
18.3%	(3)
5.0%	(4)
3.2%	(5) Not at all important
3.4%	Don’t know

e. Seating capacity

32.5%	(1) Very important
19.2%	(2)
21.6%	(3)
10.1%	(4)
12.9%	(5) Not at all important
3.6%	Don’t know

f. Reliability

59.4%	(1) Very important
25.2%	(2)
10.3%	(3)
1.0%	(4)
1.0%	(5) Not at all important
3.0%	Don’t know

g. Appearance and styling

34.1%	(1) Very important
29.9%	(2)
18.5%	(3)
7.6%	(4)
7.0%	(5) Not at all important
3.0%	Don’t know

h. Environmental impacts

12.7%	(1) Very important
19.5%	(2)
30.9%	(3)
16.9%	(4)
13.9%	(5) Not at all important
6.0%	Don’t know

i. Other [please indicate]: ____________

Q2.10A How long is your household planning on keeping your <*Year from **Q2.3***> <*Make Model from **Q2.2***> (Please select the most likely answer):

Vehicle 1:

20.5%	0 to 3 years
22.0%	4 to 6 years
10.6%	7 to 9 years
19.5%	More than 9 years
27.4%	Don't know

Vehicle 2:

20.1%	0 to 3 years
19.5%	4 to 6 years
11.0%	7 to 9 years
21.5%	More than 9 years
27.8%	Don't know

*[If Q2.10A="**d**" or "**e**" then*

*If NC >1 & this is vehicle #1, go back to **Q2.2***

*If NC = 1 or if this is vehicle #2, skip to **Q2.14B**;*

Otherwise continue.]

Q2.10B Once you are done with it, will you likely replace your <*Year from Q2.3*> <*Make Model from Q2.2*> with another vehicle?

Vehicle 1:

92.5%	Yes
7.6%	No

Vehicle 2:

87.9%	Yes
12.1%	No

*[If **Q2.10B** = "Yes", then ask]*

Q2.11 Considering your likely income and your financial responsibilities, could you tell us what vehicle type you are most likely to choose to replace your <*Year from Q2.3*> <*Make Model from Q2.2*>?

Vehicle 1:

60.9%	(a) A car
23.5%	(b) A sport-utility vehicle (SUV) or crossover
6.1%	(c) A pickup truck
6.6%	(d) A minivan
2.9%	(e) Other. Please specify: ______________

Vehicle 2:

39.8%	(a) A car
25.7%	(b) A sport-utility vehicle (SUV) or crossover
23.5%	(c) A pickup truck
7.1%	(d) A minivan
4.0%	(e) Other. Please specify: ______________

Vehicle 3 (referred from Q2.14a and Q2.14b):

50.7%	(a) A car
17.9%	(b) A sport-utility vehicle (SUV) or crossover
16.9%	(c) A pickup truck
7.5%	(d) A minivan
2.0%	(e) A motorcycle
4.0%	(f) Other. Please specify: ______________

[If Q2.11 = A or B, then ask]

Q2.12 Are you going to buy a luxury vehicle?

Vehicle 1:

17.9%	Yes
82.1%	No

Vehicle 2:

18.9%	Yes
81.1%	No

Vehicle 3 (referred from Q2.14a and Q2.14b):

18.1%	Yes
81.9%	No

[If Q2.12 = Yes, then

Case Q2.11=A then]

Q2.13A1 Please select the size of the luxury car you would like to buy:

Vehicle 1:

17.1%	Small or compact (such as a BMW 1 series or an Audi A4)
51.2%	Mid-size (such as a BMW 5 series or a Mercedes C-Class)
31.7%	Full-size (such as a BMW 7 series, a Cadillac DTS, or a Mercedes E-Class)

Vehicle 2:
12.5% Small or compact (such as a BMW 1 series or an Audi A4)
56.3% Mid-size (such as a BMW 5 series or a Mercedes C-Class)
31.3% Full-size (such as a BMW 7 series, a Cadillac DTS, or a Mercedes E-Class)

Vehicle 3 (referred from Q2.14a & Q2.14b):
50.0% Small or compact (such as a BMW 1 series or an Audi A4)
28.6% Mid-size (such as a BMW 5 series or a Mercedes C-Class)
21.4% Full-size (such as a BMW 7 series, a Cadillac DTS, or a Mercedes E-Class)

[If *case Q2.11 = B, then don't ask a specific question about size else if Q2.12 =No then*

case Q2.11 = A, then][THIS IS NOT CLEAR. IS SOMETHING MISSING?]

Q2.13A2 Please select the size of the car you would like to buy:

Vehicle 1:
32.8% Small or compact (such as a Chevrolet Cobalt or a Toyota Corolla)
57.7% Midsize (such as a Ford Fusion or a Honda Accord)
9.5% Full-size (such as a Buick Lucerne or a Chrysler 300)

Vehicle 2:
37.8% Small or compact (such as a Chevrolet Cobalt or a Toyota Corolla)
55.4% Midsize (such as a Ford Fusion or a Honda Accord)
6.8% Full-size (such as a Buick Lucerne or a Chrysler 300)

Vehicle 3 (referred from Q2.14a and Q2.14b):
35.2% Small or compact (such as a Chevrolet Cobalt or a Toyota Corolla)
53.4% Midsize (such as a Ford Fusion or a Honda Accord)
11.4% Full-size (such as a Buick Lucerne or a Chrysler 300)

[If case Q2.11 = B, then]

Q2.13B Please select the size of the SUV/crossover you would like to buy:

Vehicle 1:
35.6% Compact (such as a Ford Escape or a Honda CR-V)
49.3% Midsize (such as a Ford Edge or a Toyota Highlander)
15.1% Full-size (such as a GMC Yukon or a Ford Expedition)

Vehicle 2:
32.6% Compact (such as a Ford Escape or a Honda CR-V)
54.3% Midsize (such as a Ford Edge or a Toyota Highlander)
13.0% Full-size (such as a GMC Yukon or a Ford Expedition)

Vehicle 3 (referred from Q2.14a & Q2.14b):

44.0% Compact (such as a Ford Escape or a Honda CR-V)
40.0% Midsize (such as a Ford Edge or a Toyota Highlander)
16.0% Full-size (such as a GMC Yukon or a Ford Expedition)

[endif]

If Q2.11 = C, then show a pull-down menu and ask:]

Q2.13C Please select the size of pickup truck you would like to buy:

Vehicle 1:

39.1% Compact/midsize (such as a Ford Ranger or a Nissan Frontier)
60.9% Full-size (such as a Ford F-150 or a Toyota Tundra)

Vehicle 2:

39.6% Compact/midsize (such as a Ford Ranger or a Nissan Frontier)
60.4% Full-size (such as a Ford F-150 or a Toyota Tundra)

Vehicle 3 (referred from Q2.14a and Q2.14b):

32.4% Compact/midsize (such as a Ford Ranger or a Nissan Frontier)
67.6% Full-size (such as a Ford F-150 or a Toyota Tundra)

*[If NC >1 and if this is vehicle #1, go back to **Q2.2**, otherwise continue.*

If planning on replacing at least one vehicle, ask]

Q2.14A Are you also considering buying another vehicle, in addition to those that you already own or use, over the next 9 years?

24.4% Yes
75.6% No

[else ask]

Q2.14B Are you planning on buying another vehicle in addition to those that you already own or use, over the next 9 years?

24.6% Yes
75.4% No

[endif]

If Q2.14A = Yes or Q2.14 B= Yes, ask Q2.11 (with Q2.12/Q2.13 if necessary) and then go to Q2.15.]

[If not planning on replacing or buying another vehicle within the next 9 years, go to Q3.4.]

Part III. Preferences for alternative-fuel vehicles

We would now like to understand your preferences for various alternative-fuel vehicles. New technologies are being promoted to reduce the emissions of air pollutants and greenhouse gases emitted by vehicles and to decrease our reliance on foreign oil. In 2007, over two-thirds of the oil consumed in the United States was imported.

According to the U.S. Environmental Protection Agency, highway vehicles account for half of carbon monoxide emissions and one-third of nitrogen oxide emissions in the United States. These pollutants can cause or aggravate respiratory problems such as asthma, bronchitis, or emphysema. Other impacts include reduced visibility, impaired water quality, vegetation damage, and acid rain.

In addition, the transportation sector emits approximately one-third of all U.S. greenhouse gas emissions. Greenhouse gases have been found to cause climate change, which will likely result in more storms, more severe droughts, and an increase in average sea levels. **Since it is difficult to estimate how much air pollution will be reduced following the adoption of alternative-fuel vehicles, we focus here on greenhouse gases during vehicle operation.**

Let us assume that you have the choice between five vehicles; **they look the same, they are equally reliable and safe, and they come with the same warranty**. **They also have similar maintenance costs.** They differ based on their engine technology and the fuel they use, their purchase price, their range, and their emissions of various air pollutants. **The availability of refueling stations (characterized by how much longer it takes to find one) and refueling time also differ**. The key characteristics of the vehicles considered are summarized below. We ask you to rank these vehicles based on your preferences.

Here are the vehicles we would like you to consider:

1. **A gasoline vehicle**. This vehicle is similar to the ones on the road today.

2. **A hybrid electric vehicle**. To improve its gas mileage and reduce its emission of air pollutants, a hybrid electric vehicle combines a conventional internal combustion engine with an electric motor. Better gas mileage reduces our country's dependence on foreign oil. Compared to a gasoline vehicle, a hybrid electric vehicle cuts emissions of greenhouse gases by 33%.

Approximately 1.2 million hybrid electric vehicles were sold in the United States between 2004 and 2008, and many manufacturers are increasing their offering of hybrid electric vehicles.

3. **A compressed natural gas vehicle**. A compressed natural gas vehicle relies on the same basic principles as a gasoline-powered vehicle with slight engine modifications. The United States has abundant reserves of natural gas. Compared to a gasoline vehicle, a compressed natural gas vehicle reduces greenhouse gases by 25%.

There are over 9 million natural gas vehicles in the world and 110,000 in the United States; a number of manufacturers offer kits to convert gasoline vehicles to compressed natural gas vehicles.

4. **A fuel cell vehicle**. A fuel cell vehicle is propelled by electric motors, but it creates its own electricity through a chemical process that combines hydrogen fuel and oxygen from the air. Hydrogen can be produced from a variety of sources, including natural gas, for which the country has abundant reserves. A fuel cell vehicle emits no air pollutants while operating.

A number of fuel cell vehicles are currently being tested in the United States, and several car manufacturers are considering mass producing hydrogen fuel cell vehicles within the next 2 to 3 years.

5. **An electric vehicle**. An electric vehicle relies only on electric motors for propulsion. Almost 90% of the electricity in the United States is produced from coal, nuclear, or natural gas plants, for which the country has abundant reserves. An electric vehicle emits no air pollutants while operating.

Electric vehicles are currently being tested in the United States, Japan, and Europe. Several large manufacturers are planning on mass producing and selling electric vehicles in North America within the next 2 years. To overcome long battery charging time, car manufacturers are considering either installing fast chargers in gas stations or leasing batteries and building battery swapping facilities.

A. *[If the respondent wants to replace vehicle #1 with a car, a pickup truck, an SUV, or a minivan, say:]* “You indicated you are planning on replacing your <*year*> <*make*> <*model*> with a <*indicate vehicle type from **Q2.11-13***> within the next <*range of years from **Q2.10A***>. We would like you to rank vehicles based on your preferences for each of the three following scenarios.”

*[For i=1 to 3: Randomly select without replacement a scenario from Scenarios Table; ask **Q3.1** and **Q3.2**; Next i;*

Go to B.]

B. *[If the respondent wants to replace vehicle #2 with a car, a pickup truck, an SUV, or a minivan:]* “You indicated you are planning on replacing your <*year*> <*make*> <*model*> with a <*indicate vehicle type from **Q2.11-13***> within the next <*range of years from **Q2.10A***>. We would like you to rank vehicles based on your preferences for each of the three following scenarios.”

*[For i=1 to 3: Randomly select without replacement a scenario from Scenarios Table; ask **Q3.1** and **Q3.2**; Next i;*

Go to C.]

C. [If the respondent wants to buy another vehicle in the next 5 years:] “You indicated you are planning on buying another vehicle (a <*indicate vehicle type from **Q2.11-13***>) within the next <*range of years from **Q2.10A***>. We would like you to rank vehicles based on your preferences for each of the three following scenarios.”

*[For i=1 to 3: Randomly select without replacement a scenario from Scenarios Table; ask **Q3.1** and **Q3.2**; Next i;*

*Ask **Q3.3**]*

Q3.1 The table below summarizes the characteristics of five <*indicate vehicle type from **Q2.11–13***> that rely on different technologies; however, **they look the same, they are equally reliable, and they come with the same warranty. They also have similar maintenance costs**. Please rank each option from most preferred (1) to least preferred (5), with no ties. Please keep in mind the information about vehicle characteristics and how much they reduce pollution when you make your choice. Click on a vehicle type to review some of its key characteristics.

Your selection: Small/compact car	**Gasoline vehicle**	**Hybrid electric vehicle**	**Compressed natural gas vehicle**	**Fuel cell vehicle**	**Electric vehicle**
Purchase price	**~$17,000** (from Car Price Table)	Purchase cost * **1.10**	Purchase cost * **1.05**	Purchase cost * **1.20**	Purchase cost * **1.25**
Vehicle range on one tank/charge	**350 miles** (from Vehicle Range Table)	**400 miles** (from Vehicle Range Table)	**300 miles** (from Vehicle Range Table)	**350 miles** (from Vehicle Range Table)	**40** miles
Extra driving time needed to find a refueling station	No extra time needed	No extra time needed	Drive an extra **10** minutes for a station with natural gas	Drive an extra **30** minutes for a station with hydrogen	Drive an extra **10** minutes for a charging station
Refueling time	10 minutes	10 minutes	10 minutes	10 minutes	Batteries **swapped in 10 minutes**
Fuel/power cost for driving 12,000 miles	**$1,200** (from Fuel Costs Table based on car type and gas price from Scenarios Table)	Fuel cost * 0.80	Fuel cost * **0.30**	Fuel cost * **0.40**	Fuel cost * **0.20**
Emissions of greenhouse gases while operating	Baseline	-33%	-25%	No emissions	No emissions
Your ranking:					

*[Data in red come from the scenarios (see Scenarios Table); data in blue are related to the answers to **Q2.11–13**. These data should all be in black for the survey. If a respondent clicks on a vehicle type, please show the description of that vehicle from items 1–5 above. If a respondent clicks on "greenhouse gases," please show the 3rd paragraph from the section introduction text in a pop-up window.]*

Table 21. Scenarios Table for Survey Administration

Scenario	Purchase cost (Multiplicative factors)				Range (miles)	Fuel availability (minutes)			Refueling time (minutes)	Fuel cost (combine with Fuel Cost Table)			
#	HEV	CNG	FC	EV	EV	CNG	FC	EV	EV	Gas	CNG	FC	EV
1	1.10	1.20	1.60	1.50	40 mi	30	30	10	Swapped in 10 minutes	$3	0.3	0.4	0.2
2	1.10	1.05	1.60	1.50	120 mi	10	10	30	Fast-charged in 30 minutes	$6	0.3	0.2	0.4
3	1.10	1.20	1.60	1.10	250 mi	30	30	30	Fast-charged in 30 minutes	$6	0.3	0.4	0.4
4	1.10	1.05	1.20	1.50	40 mi	10	10	10	Fast-charged in 30 minutes	$3	0.3	0.2	0.4
5	1.25	1.05	1.20	1.50	120 mi	30	10	30	Swapped in 10 minutes	$6	0.6	0.2	0.2
6	1.10	1.05	1.60	1.50	40 mi	30	10	30	Swapped in 10 minutes	$6	0.3	0.4	0.4
7	1.10	1.20	1.20	1.50	120 mi	30	10	30	Fast-charged in 30 minutes	$6	0.6	0.4	0.4
8	1.10	1.05	1.20	1.10	40 mi	30	30	30	Swapped in 10 minutes	$3	0.6	0.4	0.4
9	1.25	1.20	1.20	1.50	120 mi	10	30	30	Fast-charged in 30 minutes	$6	0.3	0.2	0.2
10	1.25	1.20	1.20	1.50	120 mi	10	10	10	Swapped in 10 minutes	$3	0.3	0.4	0.2
11	1.10	1.05	1.60	1.10	250 mi	30	30	10	Fast-charged in 30 minutes	$6	0.6	0.4	0.2
12	1.25	1.20	1.20	1.10	120 mi	30	30	10	Fast-charged in 30 minutes	$6	0.3	0.4	0.2
13	1.25	1.05	1.20	1.10	40 mi	10	10	30	Swapped in 10 minutes	$3	0.3	0.4	0.4
14	1.10	1.05	1.60	1.10	40 mi	10	30	30	Fast-charged in 30 minutes	$6	0.3	0.4	0.2
15	1.10	1.05	1.60	1.50	120 mi	30	30	30	Swapped in 10 minutes	$6	0.3	0.4	0.2
16	1.25	1.05	1.20	1.10	250 mi	10	30	10	Swapped in 10 minutes	$3	0.6	0.2	0.4
17	1.25	1.05	1.60	1.10	40 mi	30	10	30	Fast-charged in 30 minutes	$3	0.3	0.2	0.2
18	1.10	1.05	1.60	1.10	250 mi	10	10	30	Fast-charged in 30 minutes	$3	0.6	0.4	0.4
19	1.25	1.20	1.60	1.50	120 mi	10	10	30	Swapped in 10 minutes	$6	0.6	0.2	0.4
20	1.10	1.20	1.20	1.10	250 mi	30	10	30	Fast-charged in 30 minutes	$6	0.6	0.2	0.2
21	1.10	1.20	1.20	1.10	250 mi	10	30	10	Fast-charged in 30 minutes	$6	0.3	0.2	0.4
22	1.25	1.20	1.20	1.50	250 mi	30	30	10	Fast-charged in 30 minutes	$3	0.3	0.2	0.2
23	1.25	1.05	1.20	1.10	120 mi	10	30	10	Fast-charged in 30 minutes	$3	0.3	0.4	0.4
24	1.10	1.20	1.20	1.50	40 mi	30	30	10	Swapped in 10 minutes	$6	0.6	0.2	0.4
25	1.25	1.20	1.20	1.50	120 mi	10	30	10	Fast-charged in 30 minutes	$3	0.6	0.2	0.4
26	1.25	1.05	1.60	1.50	120 mi	30	30	30	Swapped in 10 minutes	$3	0.3	0.2	0.4
27	1.25	1.20	1.20	1.10	120 mi	10	10	10	Fast-charged in 30 minutes	$3	0.3	0.2	0.4
28	1.10	1.05	1.60	1.10	120 mi	30	10	30	Swapped in 10 minutes	$3	0.6	0.4	0.4
29	1.25	1.05	1.60	1.10	250 mi	10	10	10	Fast-charged in 30 minutes	$6	0.3	0.2	0.4
30	1.10	1.05	1.60	1.50	40 mi	10	30	10	Fast-charged in 30 minutes	$3	0.6	0.4	0.4

Table 21. Scenarios Table for Survey Administration (continued)

Scenario	Purchase cost (Multiplicative factors)				Range (miles)	Fuel availability (minutes)			Refueling time (minutes)	Fuel cost (combine with Fuel Cost Table)			
#	HEV	CNG	FC	EV	EV	CNG	FC	EV	EV	Gas	CNG	FC	EV
31	1.10	1.05	1.20	1.50	40 mi	30	30	30	Fast-charged in 30 minutes	$6	0.3	0.2	0.2
32	1.10	1.05	1.60	1.10	120 mi	10	10	30	swapped in 10 minutes	$6	0.6	0.2	0.2
33	1.10	1.20	1.20	1.10	250 mi	30	10	10	swapped in 10 minutes	$3	0.6	0.4	0.4
34	1.10	1.05	1.20	1.50	120 mi	10	30	30	Fast-charged in 30 minutes	$3	0.3	0.4	0.2
35	1.10	1.20	1.60	1.50	40 mi	10	30	30	Fast-charged in 30 minutes	$3	0.6	0.2	0.2
36	1.25	1.20	1.20	1.50	250 mi	10	10	10	Fast-charged in 30 minutes	$6	0.6	0.4	0.4
37	1.10	1.20	1.60	1.10	40 mi	10	10	30	Swapped in 10 minutes	$3	0.6	0.2	0.4
38	1.10	1.20	1.60	1.50	120 mi	30	10	10	Swapped in 10 minutes	$6	0.3	0.2	0.4
39	1.25	1.05	1.20	1.10	250 mi	10	30	30	Swapped in 10 minutes	$6	0.3	0.4	0.2
40	1.25	1.05	1.60	1.10	120 mi	10	30	30	Fast-charged in 30 minutes	$3	0.6	0.2	0.2
41	1.25	1.20	1.60	1.10	40 mi	30	30	30	Swapped in 10 minutes	$6	0.3	0.2	0.2
42	1.25	1.05	1.60	1.50	40 mi	30	30	10	Fast-charged in 30 minutes	$6	0.3	0.4	0.4
43	1.10	1.05	1.20	1.50	250 mi	30	30	10	Fast-charged in 30 minutes	$3	0.6	0.2	0.4
44	1.25	1.20	1.60	1.50	40 mi	10	10	30	Fast-charged in 30 minutes	$3	0.3	0.4	0.4
45	1.25	1.05	1.20	1.50	40 mi	10	10	10	Swapped in 10 minutes	$6	0.3	0.2	0.2
46	1.25	1.05	1.20	1.50	250 mi	30	10	30	Fast-charged in 30 minutes	$6	0.3	0.4	0.4
47	1.25	1.05	1.60	1.50	250 mi	10	30	10	Swapped in 10 minutes	$6	0.6	0.2	0.2
48	1.25	1.05	1.60	1.10	40 mi	10	10	10	Swapped in 10 minutes	$3	0.6	0.4	0.2
49	1.25	1.05	1.20	1.10	120 mi	30	10	30	Swapped in 10 minutes	$3	0.3	0.4	0.2
50	1.10	1.20	1.60	1.50	120 mi	10	30	30	Swapped in 10 minutes	$3	0.3	0.4	0.4
51	1.25	1.20	1.20	1.50	40 mi	30	10	30	Fast-charged in 30 minutes	$6	0.3	0.2	0.4
52	1.25	1.20	1.60	1.50	40 mi	30	10	10	Fast-charged in 30 minutes	$6	0.6	0.2	0.2
53	1.25	1.05	1.20	1.10	120 mi	30	30	10	Fast-charged in 30 minutes	$6	0.6	0.2	0.4
54	1.10	1.20	1.60	1.10	40 mi	10	10	10	Fast-charged in 30 minutes	$6	0.3	0.2	0.2
55	1.25	1.05	1.60	1.10	120 mi	30	10	10	Fast-charged in 30 minutes	$3	0.6	0.2	0.4
56	1.10	1.05	1.20	1.10	40 mi	30	10	10	Fast-charged in 30 minutes	$6	0.3	0.4	0.4
57	1.25	1.20	1.20	1.10	250 mi	10	10	10	Swapped in 10 minutes	$6	0.6	0.2	0.2
58	1.10	1.05	1.20	1.50	250 mi	30	10	10	Swapped in 10 minutes	$3	0.6	0.4	0.2
59	1.25	1.05	1.20	1.50	40 mi	30	10	10	Swapped in 10 minutes	$3	0.6	0.4	0.4

Table 21. Scenarios Table for Survey Administration (continued)

Scenario	Purchase cost (Multiplicative factors)				Range (miles)	Fuel availability (minutes)			Refueling time (minutes)	Fuel cost (combine with Fuel Cost Table)			
#	HEV	CNG	FC	EV	EV	CNG	FC	EV	EV	Gas	CNG	FC	EV
60	1.10	1.20	1.20	1.10	120 mi	30	30	10	Fast-charged in 30 minutes	$3	0.6	0.4	0.2
61	1.10	1.20	1.20	1.50	40 mi	10	10	10	Swapped in 10 minutes	$3	0.6	0.4	0.4
62	1.25	1.20	1.20	1.10	40 mi	10	30	10	Swapped in 10 minutes	$6	0.3	0.4	0.4
63	1.10	1.20	1.20	1.50	120 mi	30	10	30	Swapped in 10 minutes	$3	0.3	0.2	0.2
64	1.25	1.20	1.60	1.10	40 mi	30	30	10	Fast-charged in 30 minutes	$3	0.6	0.2	0.4
65	1.10	1.05	1.60	1.50	250 mi	10	10	10	Swapped in 10 minutes	$6	0.3	0.4	0.4
66	1.10	1.05	1.20	1.10	40 mi	10	10	10	Swapped in 10 minutes	$6	0.6	0.2	0.4
67	1.25	1.20	1.20	1.10	120 mi	10	30	30	Swapped in 10 minutes	$3	0.6	0.4	0.4
68	1.25	1.05	1.20	1.10	250 mi	30	30	30	Fast-charged in 30 minutes	$3	0.3	0.2	0.4
69	1.25	1.20	1.60	1.50	40 mi	10	30	10	Swapped in 10 minutes	$3	0.3	0.2	0.4
70	1.10	1.20	1.20	1.50	250 mi	30	30	30	Swapped in 10 minutes	$3	0.6	0.4	0.2
71	1.10	1.05	1.20	1.50	120 mi	10	30	30	Swapped in 10 minutes	$6	0.6	0.2	0.4
72	1.10	1.20	1.20	1.10	40 mi	30	10	30	Swapped in 10 minutes	$6	0.6	0.4	0.2
73	1.25	1.05	1.20	1.50	40 mi	10	30	30	Fast-charged in 30 minutes	$6	0.6	0.2	0.4
74	1.25	1.20	1.20	1.50	40 mi	30	30	30	Fast-charged in 30 minutes	$6	0.6	0.4	0.2
75	1.25	1.05	1.60	1.10	250 mi	30	30	10	Swapped in 10 minutes	$3	0.3	0.4	0.4
76	1.10	1.20	1.60	1.50	250 mi	10	10	10	Fast-charged in 30 minutes	$3	0.6	0.2	0.2
77	1.10	1.05	1.20	1.10	120 mi	30	10	10	Fast-charged in 30 minutes	$6	0.3	0.2	0.2
78	1.10	1.20	1.60	1.10	120 mi	30	30	10	Fast-charged in 30 minutes	$3	0.3	0.2	0.4
79	1.25	1.20	1.60	1.10	40 mi	30	10	30	Swapped in 10 minutes	$3	0.3	0.4	0.4
80	1.10	1.20	1.60	1.50	250 mi	30	10	10	Fast-charged in 30 minutes	$3	0.3	0.4	0.4
81	1.10	1.05	1.20	1.10	250 mi	30	10	30	Swapped in 10 minutes	$6	0.3	0.2	0.4
82	1.10	1.05	1.20	1.10	40 mi	10	30	10	Fast-charged in 30 minutes	$3	0.6	0.2	0.2
83	1.10	1.20	1.20	1.10	250 mi	10	10	30	Fast-charged in 30 minutes	$3	0.3	0.4	0.2
84	1.10	1.20	1.60	1.50	250 mi	10	10	30	Fast-charged in 30 minutes	$6	0.6	0.4	0.2
85	1.10	1.05	1.20	1.50	40 mi	30	10	30	Fast-charged in 30 minutes	$3	0.6	0.4	0.2
86	1.10	1.05	1.60	1.50	120 mi	30	30	10	Swapped in 10 minutes	$3	0.6	0.2	0.2

Table 21. Scenarios Table for Survey Administration (continued)

	Purchase cost									Fuel cost			
Scenario	(Multiplicative factors)				Range (miles)	Fuel availability (minutes)			Refueling time (minutes)	(combine with Fuel Cost Table)			
#	HEV	CNG	FC	EV	EV	CNG	FC	EV	EV	Gas	CNG	FC	EV
87	1.25	1.05	1.20	1.50	250 mi	10	10	30	Fast-charged in 30 minutes	$3	0.6	0.2	0.2
88	1.10	1.20	1.60	1.10	120 mi	30	30	30	Swapped in 10 minutes	$6	0.6	0.2	0.4
89	1.10	1.05	1.60	1.50	120 mi	10	10	10	Fast-charged in 30 minutes	$3	0.3	0.4	0.2
90	1.10	1.20	1.20	1.10	40 mi	10	30	30	Fast-charged in 30 minutes	$6	0.6	0.4	0.4
91	1.10	1.20	1.20	1.10	40 mi	30	10	10	Swapped in 10 minutes	$3	0.3	0.2	0.2
92	1.25	1.05	1.60	1.50	250 mi	10	30	30	Swapped in 10 minutes	$3	0.3	0.4	0.2
93	1.25	1.05	1.60	1.10	250 mi	30	10	30	Swapped in 10 minutes	$3	0.6	0.2	0.2
94	1.10	1.20	1.20	1.10	120 mi	10	10	30	Swapped in 10 minutes	$6	0.3	0.2	0.4
95	1.25	1.20	1.60	1.50	120 mi	30	30	10	Swapped in 10 minutes	$6	0.6	0.4	0.4
96	1.25	1.20	1.20	1.10	40 mi	10	30	30	Fast-charged in 30 minutes	$3	0.3	0.2	0.2
97	1.25	1.20	1.60	1.10	120 mi	30	10	30	Fast-charged in 30 minutes	$3	0.6	0.4	0.2
98	1.25	1.20	1.60	1.50	250 mi	30	30	30	Fast-charged in 30 minutes	$6	0.6	0.2	0.4
99	1.25	1.05	1.60	1.10	120 mi	10	30	10	Swapped in 10 minutes	$6	0.3	0.2	0.2
100	1.25	1.05	1.60	1.10	250 mi	10	30	30	Swapped in 10 minutes	$6	0.6	0.4	0.4
101	1.10	1.20	1.60	1.10	250 mi	10	30	30	Swapped in 10 minutes	$3	0.3	0.2	0.2
102	1.25	1.20	1.60	1.10	250 mi	10	30	10	Fast-charged in 30 minutes	$6	0.3	0.4	0.2
103	1.10	1.20	1.60	1.10	120 mi	10	10	10	Fast-charged in 30 minutes	$6	0.6	0.4	0.4
104	1.25	1.20	1.60	1.50	250 mi	30	10	10	Swapped in 10 minutes	$6	0.3	0.4	0.2
105	1.10	1.05	1.20	1.50	40 mi	10	30	10	Swapped in 10 minutes	$6	0.6	0.4	0.2
106	1.25	1.05	1.20	1.10	120 mi	10	10	10	Fast-charged in 30 minutes	$6	0.6	0.4	0.2
107	1.25	1.05	1.60	1.10	40 mi	30	10	30	Fast-charged in 30 minutes	$6	0.6	0.4	0.4
108	1.10	1.05	1.60	1.50	250 mi	10	30	30	Fast-charged in 30 minutes	$6	0.3	0.2	0.4
109	1.10	1.05	1.20	1.50	120 mi	30	30	10	Swapped in 10 minutes	$3	0.3	0.4	0.4
110	1.25	1.20	1.20	1.50	250 mi	10	10	30	Swapped in 10 minutes	$3	0.3	0.2	0.4

Table 22. Car-Price Table for Survey Administration

	Category	
Non-luxury car	Small/compact	$17,000
	Midsize	$23,000
	Full size	$28,000
Luxury car	Compact	$35,000
	Midsize	$45,000
	Large	$51,000
Pickup truck	Compact/midsize	$22,000
	Full size	$31,000
SUV	Compact	$24,000
	Midsize	$26,000
	Full size	$35,000
	Luxury	$48,000
Minivan	Minivan	$22,000

Table 23. Vehicle-Range Table for Survey Administration

	Category	Gasoline (baseline)	HEV	CNG	FC	EV
Non-luxury car	Small/compact	350	400	300	350	
	Midsize	320	370	270	320	
	Full size	350	400	300	350	
Luxury car	Compact	330	380	280	330	
	Midsize	350	400	300	350	(1) 40 mi
	Full size	320	370	270	320	
Pickup truck	Compact/midsize	390	440	340	390	(2) 120 mi
	Full size	440	490	390	440	
SUV	Compact	350	400	300	350	(3) 250 mi
	Midsize	340	390	290	340	
	Full size	410	460	360	410	
	Luxury	330	380	280	330	
Minivan	Minivan	400	450	350	400	

Table 24. Fuel-Cost Table for Survey Administration

	Category	Cost/12K mi ($3/gal)	Cost/12K mi ($6/gal)	HEV	CNG	FCV	EV
Non luxury car	Small/compact	$1,200	$2,400	–20%	–45%	–65%	–60%
	Midsize	$1,440	$2,880	–20%	–45%	–65%	–60%
	Full size	$1,800	$3,600	–20%	–45%	–65%	–60%
Luxury car	Compact	$1,500	$3,000	–20%	–45%	–65%	–60%
	Midsize	$1,680	$3,360	–20%	–45%	–65%	–60%
	Full size	$1,920	$3,840	–20%	–45%	–65%	–60%
Pickup truck	Compact/midsize	$1,560	$3,120	–20%	–45%	–65%	–60%
	Full size	$2,160	$4,320	–20%	–45%	–65%	–60%
SUV	Compact	$1,560	$3,120	–20%	–45%	–65%	–60%
	Midsize	$1,800	$3,600	–20%	–45%	–65%	–60%
	Full size	$2,160	$4,320	–20%	–45%	–65%	–60%
	Luxury	$2,040	$4,080	–20%	–45%	–65%	–60%
Minivan	Minivan	$1,800	$3,600	–20%	–45%	–65%	–60%

Summary of Vehicle Rankings

Scenario 1, Vehicle 1

Rank of Gasoline Vehicle

1st 33.33%
2nd 15.43
3rd 15.43
4th 15.43
5th 20.39

Rank of Hybrid Electric Vehicle

1st 25.69%
2nd 28.73
3rd 19.61
4th 15.47
5th 10.50

Rank of Compressed Natural Gas Vehicle

1st 11.63%
2nd 23.27
3rd 24.93
4th 27.70
5th 12.47

Rank of Hydrogen Fuel Cell Vehicle

1st 19.83%
2nd 16.80
3rd 23.42
4th 19.28
5th 20.66

Rank of Electric Vehicle

1st	10.22%
2nd	16.02
3rd	16.30
4th	21.82
5th	35.64

Scenario 2, Vehicle 1

Rank of Gasoline Vehicle

1st	30.30%
2nd	17.91
3rd	17.36
4th	10.74
5th	23.69

Rank of Hybrid Electric Vehicle

1st	26.80%
2nd	29.56
3rd	18.78
4th	17.40
5th	7.46

Rank of Compressed Natural Gas Vehicle

1st	12.98%
2nd	25.14
3rd	26.24
4th	23.76
5th	11.88

Rank of Hydrogen Fuel Cell Vehicle

1st	21.55%
2nd	14.09
3rd	24.31
4th	22.93
5th	17.14

Rank of Electric Vehicle

1st	9.12%
2nd	13.26
3rd	13.26
4th	24.86
5th	39.50

Scenario 3, Vehicle 1

Rank of Gasoline Vehicle

1^{st}	31.59%
2^{nd}	18.41
3^{rd}	14.56
4^{th}	9.89
5^{th}	25.55

Rank of Hybrid Electric Vehicle

1^{st}	27.90%
2^{nd}	28.18
3^{rd}	17.68
4^{th}	20.44
5^{th}	5.80

Rank of Compressed Natural Gas Vehicle

1^{st}	13.77%
2^{nd}	24.52
3^{rd}	27.55
4^{th}	23.97
5^{th}	10.19

Rank of Hydrogen Fuel Cell Vehicle

1^{st}	18.78%
2^{nd}	16.57
3^{rd}	20.99
4^{th}	24.86
5^{th}	18.78

Rank of Electric Vehicle

1^{st}	8.79%
2^{nd}	12.36
3^{rd}	18.96
4^{th}	20.60
5^{th}	39.29

Scenario 1, Vehicle 2

Rank of Gasoline Vehicle

1^{st}	39.44%
2^{nd}	21.60
3^{rd}	8.92
4^{th}	15.49
5^{th}	14.55

Rank of Hybrid Electric Vehicle

1st 28.77%
2nd 31.60
3rd 18.40
4th 15.09
5th 6.13

Rank of Compressed Natural Gas Vehicle

1st 10.33%
2nd 19.25
3rd 32.39
4th 27.70
5th 10.33

Rank of Hydrogen Fuel Cell Vehicle

1st 15.49%
2nd 18.31
3rd 21.13
4th 23.00
5th 22.07

Rank of Electric Vehicle

1st 7.08%
2nd 8.96
3rd 18.87
4th 18.40
5th 46.70

Scenario 2, Vehicle 2

Rank of Gasoline Vehicle

1st 37.56%
2nd 23.47
3rd 11.74
4th 11.74
5th 15.49

Rank of Hybrid Electric Vehicle

1st 30.66%
2nd 33.02
3rd 13.68
4th 16.51
5th 6.13

Rank of Compressed Natural Gas Vehicle

1st	13.21%
2nd	19.34
3rd	28.77
4th	27.83
5th	10.85

Rank of Hydrogen Fuel Cell Vehicle

1st	11.79%
2nd	14.62
3rd	29.25
4th	26.89
5th	17.45

Rank of Electric Vehicle

1st	7.04%
2nd	9.86
3rd	16.43
4th	16.90
5th	49.77

Scenario 3, Vehicle 2

Rank of Gasoline Vehicle

1st	37.56%
2nd	19.72
3rd	13.15
4th	11.74
5th	17.84

Rank of Hybrid Electric Vehicle

1st	25.47%
2nd	35.38
3rd	17.45
4th	15.09
5th	6.60

Rank of Compressed Natural Gas Vehicle

1st	12.74%
2nd	26.89
3rd	25.00
4th	26.89
5th	8.49

Rank of Hydrogen Fuel Cell Vehicle

1^{st}	16.51%
2^{nd}	9.43
3^{rd}	27.36
4^{th}	28.77
5^{th}	17.92

Rank of Electric Vehicle

1^{st}	8.45%
2^{nd}	8.45
3^{rd}	16.90
4^{th}	17.37
5^{th}	48.83

Scenario 1, Vehicle 3

Rank of Gasoline Vehicle

1^{st}	36.96%
2^{nd}	18.48
3^{rd}	11.96
4^{th}	10.87
5^{th}	21.74

Rank of Hybrid Electric Vehicle

1^{st}	20.56%
2^{nd}	32.22
3^{rd}	22.78
4^{th}	15.00
5^{th}	9.44

Rank of Compressed Natural Gas Vehicle

1^{st}	14.29%
2^{nd}	24.73
3^{rd}	28.02
4^{th}	23.63
5^{th}	9.34

Rank of Hydrogen Fuel Cell Vehicle

1^{st}	17.68%
2^{nd}	15.47
3^{rd}	18.23
4^{th}	27.62
5^{th}	20.99

Rank of Electric Vehicle

1st	12.22%
2nd	9.44
3rd	18.33
4th	22.22
5th	37.78

Scenario 2, Vehicle 3

Rank of Gasoline Vehicle

1st	38.04%
2nd	15.76
3rd	11.96
4th	9.78
5th	24.46

Rank of Hybrid Electric Vehicle

1st	22.22%
2nd	26.11
3rd	23.89
4th	16.67
5th	11.11

Rank of Compressed Natural Gas Vehicle

1st	13.33%
2nd	26.67
3rd	30.00
4th	23.33
5th	6.67

Rank of Hydrogen Fuel Cell Vehicle

1st	16.94%
2nd	18.58
3rd	18.03
4th	29.51
5th	16.94

Rank of Electric Vehicle

1st	10.50%
2nd	12.71
3rd	16.02
4th	19.89
5th	40.88

Scenario 3, Vehicle 3

Rank of Gasoline Vehicle

1st	37.91%
2nd	15.93
3rd	10.44
4th	11.54
5th	24.18

Rank of Hybrid Electric Vehicle

1st	22.53%
2nd	29.67
3rd	20.88
4th	21.43
5th	5.49

Rank of Compressed Natural Gas Vehicle

1st	10.50%
2nd	28.18
3rd	27.62
4th	24.31
5th	9.39

Rank of Hydrogen Fuel Cell Vehicle

1st	19.78%
2nd	15.93
3rd	24.18
4th	21.43
5th	18.68

Rank of Electric Vehicle

1st	9.89%
2nd	10.44
3rd	17.03
4th	20.88
5th	41.76

Q3.2 Could you tell us about the importance of the following factors in determining your most preferred vehicle in the previous question?

From 1 = Very important to 5 = Not at all important, with "Don't know" as an option

Vehicle 1 (Iteration 1):

a. Purchase price
53.3% (1) Very important
29.5% (2)
11.5% (3)
3.3% (4)
1.9% (5) Not at all important
0.5% Don't know

b. Fuel availability and refueling time
57.2% (1) Very important
27.5% (2)
12.0% (3)
1.9% (4)
1.1% (5) Not at all important
0.3% Don't know

c. Vehicle range on one tank/charge
48.1% (1) Very important
34.1% (2)
14.8% (3)
2.2% (4)
0.5% (5) Not at all important
0.3% Don't know

d. Fuel/power cost
47.8% (1) Very important
32.1% (2)
15.9% (3)
2.7% (4)
1.1% (5) Not at all important
0.3% Don't know

e. Concerns about global climate change/air pollution
22.7% (1) Very important
27.3% (2)
26.5% (3)
12.3% (4)
10.1% (5) Not at all important
1.1% Don't know

f. Confidence in technological progress
42.9% (1) Very important
32.8% (2)
16.9% (3)
4.4% (4)
1.6% (5) Not at all important
1.4% Don't know

g. Concerns about U.S. dependence on foreign oil
36.7% (1) Very important
29.9% (2)
23.0% (3)
6.8% (4)
3.0% (5) Not at all important
0.5% Don't know

h. Other [please indicate]: _________________
6.1% (1) Very important
5.0% (2)
9.6% (3)
2.9% (4)
8.6% (5) Not at all important
67.9% Don't know

Vehicle 1 (Iteration 2):

a. Purchase price
50.8% (1) Very important
31.4% (2)
13.4% (3)
1.9% (4)
1.9% (5) Not at all important
0.5% Don't know

b. Fuel availability and refueling time
54.7% (1) Very important
32.3% (2)
9.1% (3)
2.2% (4)
1.1% (5) Not at all important
0.6% Don't know

c. Vehicle range on one tank/charge
48.8% (1) Very important
35.5% (2)
11.9% (3)
1.4% (4)
1.9% (5) Not at all important
0.6% Don't know

d. Fuel/power cost
45.7% (1) Very important
33.6% (2)
15.7% (3)
3.3% (4)
1.4% (5) Not at all important
0.3% Don't know

e. Concerns about global climate change/air pollution
25.3% (1) Very important
25.5% (2)
28.0% (3)
10.4% (4)
8.5% (5) Not at all important
2.2% Don't know

f. Confidence in technological progress
40.7% (1) Very important
34.1% (2)
19.5% (3)
2.7% (4)
1.4% (5) Not at all important
1.6% Don't know

g. Concerns about U.S. dependence on foreign oil
36.8% (1) Very important
29.7% (2)
22.3% (3)
6.0% (4)
4.1% (5) Not at all important
1.1% Don't know

h. Other [please indicate]: _________________
3.6% (1) Very important
3.3% (2)
6.9% (3)
2.9% (4)
9.5% (5) Not at all important
73.7% Don't know

Vehicle 1 (Iteration 3):

a. Purchase price
55.1% (1) Very important
27.8% (2)
11.8% (3)
2.2% (4)
1.9% (5) Not at all important
1.1% Don't know

b. Fuel availability and refueling time
53.4% (1) Very important
32.8% (2)
10.5% (3)
1.7% (4)
0.6% (5) Not at all important
1.1% Don't know

c. Vehicle range on one tank/charge
50.1% (1) Very important
32.1% (2)
14.8% (3)
1.1% (4)
0.8% (5) Not at all important
1.1% Don't know

d. Fuel/power cost
43.1% (1) Very important
35.9% (2)
14.1% (3)
4.1% (4)
1.7% (5) Not at all important
1.1% Don't know

e. Concerns about global climate change/air pollution
26.0% (1) Very important
23.5% (2)
26.5% (3)
11.6% (4)
9.1% (5) Not at all important
3.3% Don't know

f. Confidence in technological progress
39.0% (1) Very important
34.3% (2)
19.1% (3)
3.6% (4)
1.9% (5) Not at all important
2.2% Don't know

g. Concerns about U.S. dependence on foreign oil
36.8% (1) Very important
28.4% (2)
22.3% (3)
7.0% (4)
3.6% (5) Not at all important
1.9% Don’t know

h. Other [please indicate]: ________________
5.8% (1) Very important
2.2% (2)
4.7% (3)
2.6% (4)
9.5% (5) Not at all important
73.2% Don’t know

Vehicle 2 (Iteration 1):

a. Purchase price
59.1% (1) Very important
26.5% (2)
9.8% (3)
1.9% (4)
2.3% (5) Not at all important
0.5% Don’t know

b. Fuel availability and refueling time
57.5% (1) Very important
30.4% (2)
10.3% (3)
0.9% (4)
0.5% (5) Not at all important
0.5% Don’t know

c. Vehicle range on one tank/charge
51.9% (1) Very important
33.6% (2)
11.2% (3)
1.9% (4)
0.5% (5) Not at all important
0.9% Don’t know

d. Fuel/power cost
42.5% (1) Very important
39.3% (2)
15.4% (3)
1.4% (4)
0.9% (5) Not at all important
0.5% Don't know

e. Concerns about global climate change/air pollution
20.3% (1) Very important
27.4% (2)
24.5% (3)
13.7% (4)
11.8% (5) Not at all important
2.4% Don't know

f. Confidence in technological progress
40.5% (1) Very important
34.0% (2)
20.5% (3)
1.9% (4)
1.9% (5) Not at all important
1.4% Don't know

g. Concerns about U.S. dependence on foreign oil
30.7% (1) Very important
32.5% (2)
21.7% (3)
8.0% (4)
5.2% (5) Not at all important
1.9% Don't know

h. Other [please indicate]: ________________
5.7% (1) Very important
4.4% (2)
5.7% (3)
3.2% (4)
9.5% (5) Not at all important
71.5% Don't know

Vehicle 2 (Iteration 2):
a. Purchase price
58.4% (1) Very important
27.6% (2)
10.3% (3)
0.5% (4)
2.3% (5) Not at all important
0.9% Don't know

b. Fuel availability and refueling time
55.1% (1) Very important
32.2% (2)
7.9% (3)
2.8% (4)
0.9% (5) Not at all important
0.9% Don't know

c. Vehicle range on one tank/charge
53.3% (1) Very important
30.8% (2)
12.1% (3)
1.4% (4)
0.9% (5) Not at all important
1.4% Don't know

d. Fuel/power cost
41.6% (1) Very important
39.3% (2)
13.6% (3)
2.3% (4)
2.3% (5) Not at all important
0.9% Don't know

e. Concerns about global climate change/air pollution
18.7% (1) Very important
29.0% (2)
22.9% (3)
15.9% (4)
10.3% (5) Not at all important
3.3% Don't know

f. Confidence in technological progress
38.1% (1) Very important
34.4% (2)
21.9% (3)
1.9% (4)
1.9% (5) Not at all important
1.9% Don't know

g. Concerns about U.S. dependence on foreign oil
29.4% (1) Very important
28.5% (2)
24.8% (3)
9.3% (4)
5.6% (5) Not at all important
2.3% Don't know

h. Other [please indicate]: ________________
  2.6% (1) Very important
  2.6% (2)
  4.7% (3)
  2.0% (4)
  11.9% (5) Not at all important
  76.2% Don't know

Vehicle 2 (Iteration 3):

a. Purchase price
  57.9% (1) Very important
  29.2% (2)
  9.7% (3)
  0.9% (4)
  1.4% (5) Not at all important
  0.9% Don't know

b. Fuel availability and refueling time
  56.7% (1) Very important
  30.7% (2)
  8.8% (3)
  1.9% (4)
  0.9% (5) Not at all important
  0.9% Don't know

c. Vehicle range on one tank/charge
  56.6% (1) Very important
  29.7% (2)
  11.3% (3)
  0.5% (4)
  0.5% (5) Not at all important
  1.4% Don't know

d. Fuel/power cost
  43.0% (1) Very important
  39.3% (2)
  13.6% (3)
  2.3% (4)
  0.9% (5) Not at all important
  0.9% Don't know

e. Concerns about global climate change/air pollution
  17.5% (1) Very important
  31.6% (2)
  19.8% (3)
  16.5% (4)
  11.8% (5) Not at all important
  2.8% Don't know

f. Confidence in technological progress
39.3% (1) Very important
33.6% (2)
18.7% (3)
4.2% (4)
2.3% (5) Not at all important
1.9% Don’t know

g. Concerns about U.S. dependence on foreign oil
27.3% (1) Very important
31.0% (2)
23.6% (3)
10.2% (4)
5.6% (5) Not at all important
2.3% Don’t know

h. Other [please indicate]: _________________
2.7% (1) Very important
4.1% (2)
4.7% (3)
0.7% (4)
11.5% (5) Not at all important
76.4% Don’t know

Vehicle 3 (Iteration 1):

a. Purchase price
64.0% (1) Very important
23.7% (2)
9.1% (3)
0.5% (4)
2.2% (5) Not at all important
0.5% Don’t know

b. Fuel availability and refueling time
54.1% (1) Very important
31.4% (2)
11.4% (3)
1.1% (4)
1.1% (5) Not at all important
1.1% Don’t know

c. Vehicle range on one tank/charge
51.3% (1) Very important
31.0% (2)
13.9% (3)
2.7% (4)
0.5% (5) Not at all important
0.5% Don’t know

d. Fuel/power cost
50.8% (1) Very important
33.5% (2)
10.8% (3)
3.2% (4)
1.1% (5) Not at all important
0.5% Don't know

e. Concerns about global climate change/air pollution
29.2% (1) Very important
25.9% (2)
18.4% (3)
10.3% (4)
14.1% (5) Not at all important
2.2% Don't know

f. Confidence in technological progress
43.0% (1) Very important
29.6% (2)
18.8% (3)
2.7% (4)
4.3% (5) Not at all important
1.6% Don't know

g. Concerns about U.S. dependence on foreign oil
37.8% (1) Very important
30.3% (2)
17.8% (3)
5.9% (4)
5.9% (5) Not at all important
2.2% Don't know

h. Other [please indicate]: ________________
5.3% (1) Very important
4.5% (2)
12.0% (3)
0.8% (4)
12.8% (5) Not at all important
64.7% Don't know

Vehicle 3 (Iteration 2):
a. Purchase price
64.5% (1) Very important
21.5% (2)
10.2% (3)
1.6% (4)
1.1% (5) Not at all important
1.1% Don't know

b. Fuel availability and refueling time
55.7% (1) Very important
29.7% (2)
10.3% (3)
2.7% (4)
0.5% (5) Not at all important
1.1% Don't know

c. Vehicle range on one tank/charge
56.8% (1) Very important
23.5% (2)
14.8% (3)
2.7% (4)
1.1% (5) Not at all important
1.1% Don't know

d. Fuel/power cost
53.3% (1) Very important
27.5% (2)
14.3% (3)
3.3% (4)
0.5% (5) Not at all important
1.1% Don't know

e. Concerns about global climate change/air pollution
29.7% (1) Very important
24.7% (2)
22.0% (3)
8.2% (4)
13.2% (5) Not at all important
2.2% Don't know

f. Confidence in technological progress
41.8% (1) Very important
31.0% (2)
19.6% (3)
2.2% (4)
3.3% (5) Not at all important
2.2% Don't know

g. Concerns about U.S. dependence on foreign oil
41.3% (1) Very important
21.7% (2)
21.7% (3)
6.5% (4)
5.4% (5) Not at all important
3.3% Don't know

h. Other [please indicate]: ________________
5.1% (1) Very important
3.6% (2)
7.3% (3)
1.5% (4)
15.3% (5) Not at all important
67.2% Don't know

Vehicle 3 (Iteration 3):
a. Purchase price
59.7% (1) Very important
24.2% (2)
11.8% (3)
0.5% (4)
2.2% (5) Not at all important
1.6% Don't know

b. Fuel availability and refueling time
55.4% (1) Very important
29.0% (2)
11.8% (3)
0.5% (4)
1.6% (5) Not at all important
1.6% Don't know

c. Vehicle range on one tank/charge
53.5% (1) Very important
24.9% (2)
17.3% (3)
1.1% (4)
1.6% (5) Not at all important
1.6% Don't know

d. Fuel/power cost
51.4% (1) Very important
27.9% (2)
13.1% (3)
2.7% (4)
2.7% (5) Not at all important
2.2% Don't know

e. Concerns about global climate change/air pollution
30.4% (1) Very important
23.4% (2)
20.1% (3)
8.7% (4)
14.1% (5) Not at all important
3.3% Don't know

f. Confidence in technological progress
43.8% (1) Very important
29.7% (2)
16.8% (3)
3.2% (4)
4.3% (5) Not at all important
2.2% Don't know

g. Concerns about U.S. dependence on foreign oil
38.4% (1) Very important
28.6% (2)
16.2% (3)
6.5% (4)
7.6% (5) Not at all important
2.7% Don't know

h. Other [please indicate]: ________________
5.1% (1) Very important
4.4% (2)
5.1% (3)
1.5% (4)
15.3% (5) Not at all important
68.6% Don't know

Q3.3 If you have any comments about our survey, please let us know: ____________________
____
____.

Demographic Questions

Note, all demographic and socioeconomic characteristics of respondents are supplied by Knowledge Networks. In order to participate in KN's survey panel, participants must supply this information.

Age

7.5% 18 to 24 years
14.7% 25 to 34 years
18.1% 35 to 44 years
17.7% 45 to 54 years
19.0% 55 to 64 years
14.6% 65 to 74 years
8.3% 75 years +

Education (Highest Degree Received)

0.1%	No formal education
0.1%	5th or 6th grade
1.4%	7th or 8th grade
2.0%	9th grade
2.4%	10th grade
3.1%	11th grade
4.3%	12th grade (no diploma)
31.7%	High school graduate or equivalent
19.9%	Some college, no degree
5.9%	Associate degree
17.5%	Bachelors degree
8.7%	Masters degree
2.8%	Professional or Doctorate degree

Race/Ethnicity

74.3%	White, Non-Hispanic
9.8%	Black, Non-Hispanic
3.5%	Other, Non-Hispanic
8.3%	Hispanic
4.2%	2+ Races, Non-Hispanic

Gender

49.9%	Male
50.1%	Female

Head of Household

19.5%	No
80.5%	Yes

Household Size

21.7%	1
37.8%	2
15.8%	3
14.4%	4
5.5%	5
2.8%	6
1.3%	7
0.5%	8
0.1%	9
0.1%	13

Housing Type

74.5%	Single-family house, detached
6.6%	Single-family house, attached
14.0%	Building with 2 or more apartments
4.8%	Mobile home
0.1%	Boat, RV, van, or other

Household Income

1.6%	Less than $5,000
1.7%	$5,000 to $7,499
2.3%	$7,500 to $9,999
2.8%	$10,000 to $12,499
2.9%	$12,500 to $14,999
4.0%	$15,000 to $19,999
6.0%	$20,000 to $24,999
5.9%	$25,000 to $29,999
5.7%	$30,000 to $34,999
5.7%	$35,000 to $39,999
9.3%	$40,000 to $49,999
9.1%	$50,000 to $59,999
10.7%	$60,000 to $74,999
7.5%	$75,000 to $84,999
6.6%	$85,000 to $99,999
8.3%	$100,000 to $124,999
4.6%	$125,000 to $149,999
2.4%	$150,000 to $174,999
3.1%	$175,000 or more

Marital Status

55.3%	Married
5.9%	Widowed
9.1%	Divorced
1.8%	Separated
20.1%	Never married
7.8%	Living with partner

MSA Status

18.7%	Non-Metro
81.3%	Metro

Household Internet Access

35.0%	No
65.0%	Yes

Region (Based on State of Residence)

5.5%	New England
12.8%	Mid-Atlantic
16.8%	East-North Central
6.5%	West North Central
19.2%	South Atlantic
5.6%	East-South Central
11.0%	West-South Central
7.7%	Mountain
15.0%	Pacific

Ownership Status of Living Quarters

86.4%	Own or being bought by you or someone in your household
21.7%	Rented for cash
1.9%	Occupied without payment of cash rent

Presence of Household Members (Children, 0 to 2 years old)

95.9%	0
4.1%	1

Presence of Household Members (Children, 13 to 17 years old)

87.8%	0
9.3%	1
2.3%	2
0.5%	3
0.1%	4

Presence of Household Members (Adults, 18+ years old)

23.4%	1
56.3%	2
13.4%	3
4.9%	4
1.3%	5
0.6%	6
0.1%	7

Presence of Household Members (Children, 2 to 5 years old)

89.5%	0
8.6%	1
1.8%	2
0.1%	4

Presence of Household Members (Children, 6 to 12 years old)

84.4%	0
9.7%	1
4.7%	2
1.2%	3

Current Employment Status

44.7%	Working, as a paid employee
6.2%	Working, self-employed
1.9%	Not working, on temporary layoff from a job
8.0%	Not working, looking for work
20.4%	Not working, retired
10.3%	Not working, disabled
8.5%	Not working, other

ABBREVIATIONS AND ACRONYMS

ACS	American Community Survey
AFV	Alternative-Fuel Vehicle
ANOVA	Analysis of Variance
CNG	Compressed Natural Gas
CR	Contingent Ranking
CV	Contingent Valuation
E85	85 Percent Ethanol Blend
EV	Electric Vehicle
HEV	Hybrid Electric Vehicle
HFC	Hydrogen Fuel Cell Vehicle
HOV	High-Occupancy Vehicle
IIA	Independence of Irrelevant Alternatives
KN	Knowledge Networks
LPG	Liquid Petroleum Gas
mpg	Miles per Gallon
SUV	Sport Utility Vehicle

ENDNOTES

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