AUTO BUYERS' VALUATION OF FUEL ECONOMY:

A RANDOMIZED STATED CHOICE EXPERIMENT

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Executive Summary

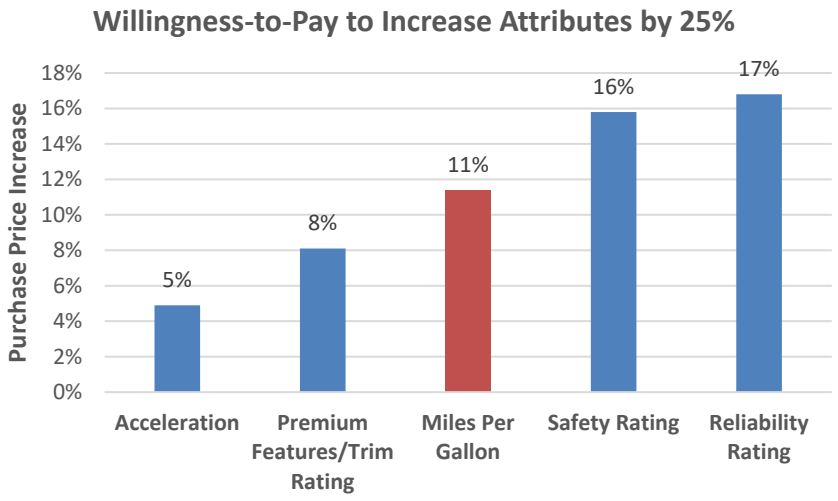
This study evaluates the degree to which consumers value fuel economy, as well as whether or not consumer valuation of fuel economy depends on the metrics by which it is presented. We contribute a novel approach to existing literature by employing a methodology that integrates the strengths of stated choice experiments – which allow for the estimation of economic models of valuation and willingness-to-pay using implicit measures of preference – with the strengths of randomized controlled trials (i.e., robust experimental assessment of causal effects) and surveys (i.e., collecting data on demographics and explicit vehicle preferences). Please note that all differences reported are statistically significant, $p < .05$ (95% confidence intervals), unless otherwise noted.

Key Findings

RESEARCH QUESTION #1: ***How much do consumers value fuel economy?***

- **We found high, statistically significant willingness-to-pay (WTP) values for fuel economy, which indicates that consumers are willing to pay a premium for improved fuel economy.** On average across all experimental conditions, respondents were willing to pay about $690 more for each additional mile per gallon (MPG) – or roughly $5,050 for each gallon saved per 100 miles (gal./100 miles). Similarly, they were willing to pay $10,730 more to save $1,000/year in fuel costs across experimental conditions, and respondents particularly valued increasing the fuel economy of the least efficient vehicles.
- **Consumers value fuel economy (MPG) more than acceleration and premium features/trim, but less than safety and reliability** (Figure 1).
- **Self-reported findings also indicate that fuel economy is important to consumers**. Using both open-ended questions and a list of 19 possible vehicle attributes, four primary vehicle attributes emerged as most important: fuel economy, safety, reliability, and price.

Figure 1. Willingness-to-pay for MPG relative to other vehicle attributes (Assuming a $30,000 base vehicle purchase price)



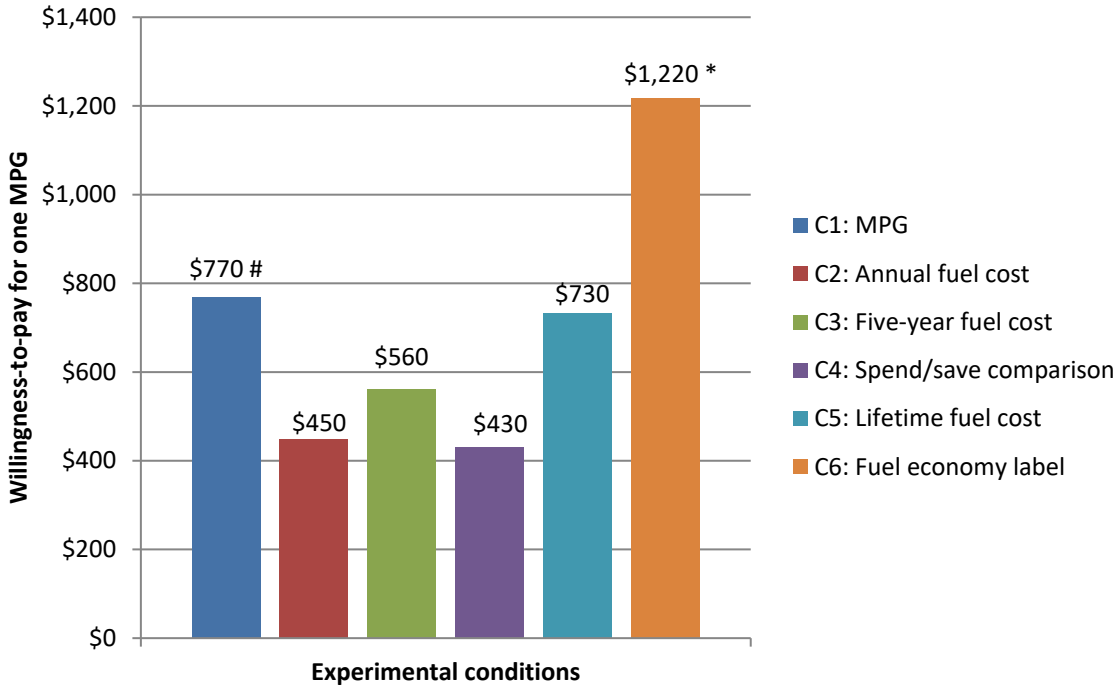
RESEARCH QUESTION #2: ***Does the presence of information on fuel economy affect consumers' valuation of fuel economy?***

- **The presence of fuel economy information affects stated vehicle decisions.** With all attributes held constant, respondents who were presented with fuel economy information made different vehicle choices than those who were not – they chose vehicles that are more efficient.
- **The presence of fuel economy information affects attitudes about fuel economy**. When respondents were presented with fuel economy information during the first part of the study, they subsequently ranked it higher in importance at the end of the study (relative to other attributes).
- **However, not all fuel economy metrics are equal: The full fuel economy label resulted in the highest WTP for fuel economy.**
    - Consumers who saw fuel economy presented as the full EPA-mandated fuel economy label were willing to pay[1] the most for fuel economy (roughly $1,200 for one additional MPG). This was significantly more than consumers who saw fuel economy presented as annual fuel cost (approximately $450 for one MPG), five-year fuel cost (slightly more than $560 for one MPG), and amount spent/saved over five years relative to the average vehicle in that class (more than $430 for one MPG) (Figure 2).[2]
    - Consumers who saw fuel economy information presented as the full fuel economy label or as MPG were most likely to select more fuel-efficient vehicles and to rank fuel economy as important, relative to other attributes.
    - **Taken together, these findings reveal that valuation of fuel economy can vary depending on the information provided.**

[1] We calculate WTP values as the ratio of how much respondents (in each condition) value an extra unit of MPG in relation to an increase or decrease in purchase price.

[2] Based on current EIA gas prices (Annual Energy Outlook 2018) and annual mileage used by EPA fuel economy labels, all respondents (except those assigned to the lifetime fuel cost condition) were asked to assume a travel distance of 15,000 miles per year at $2.61 per gallon. Those in the lifetime fuel cost condition were asked to assume a 25-year VMT of 152,137 miles per vehicle for all 8 classes (based on the NHTSA's VMT Schedule for Passenger Cars) and $3.00/gallon, given that EIA projections predict higher gasoline prices. Respondents in all experimental conditions were asked to assume 55% of miles driven in the city and 45% driven on the highway, similar to the assumptions of EPA fuel economy labels.

Figure 2. Willingness-to-pay in purchase price for fuel economy (one MPG) when it is presented using different metrics



** There is a significant difference between the fuel cost label and the EPA-mandated fuel economy label and each of the spend/save comparison over five years, five-year fuel cost, and annual fuel cost conditions ($p < .05$).*

 # The difference between the MPG and annual fuel cost conditions is borderline significant ($p < .1$).

RESEARCH QUESTION #3: ***Does valuation of fuel economy vary across consumer demographic characteristics or features of the vehicle they plan to buy/lease?***

- **Valuation of fuel economy varies across:**
  - **Age.** Respondents under the age of 50 were willing to pay more for fuel economy ($870 for one MPG) than those 50 years of age or older ($540 for one MPG).[3]
  - **Intended vehicle purchase price**. Respondents planning to spend $15,000 or more on their next vehicle had higher valuation of fuel economy, compared to those anticipating a purchase price of less than $15,000 ($180 for one MPG) (Figure 3).
  - **Intended vehicle class.** Willingness-to-pay for fuel economy (MPG) varied across some vehicle classes, as shown in Figure 4.[4]

Figure 3. Willingness-to-pay for one MPG across categories of anticipated purchase price for next vehicle

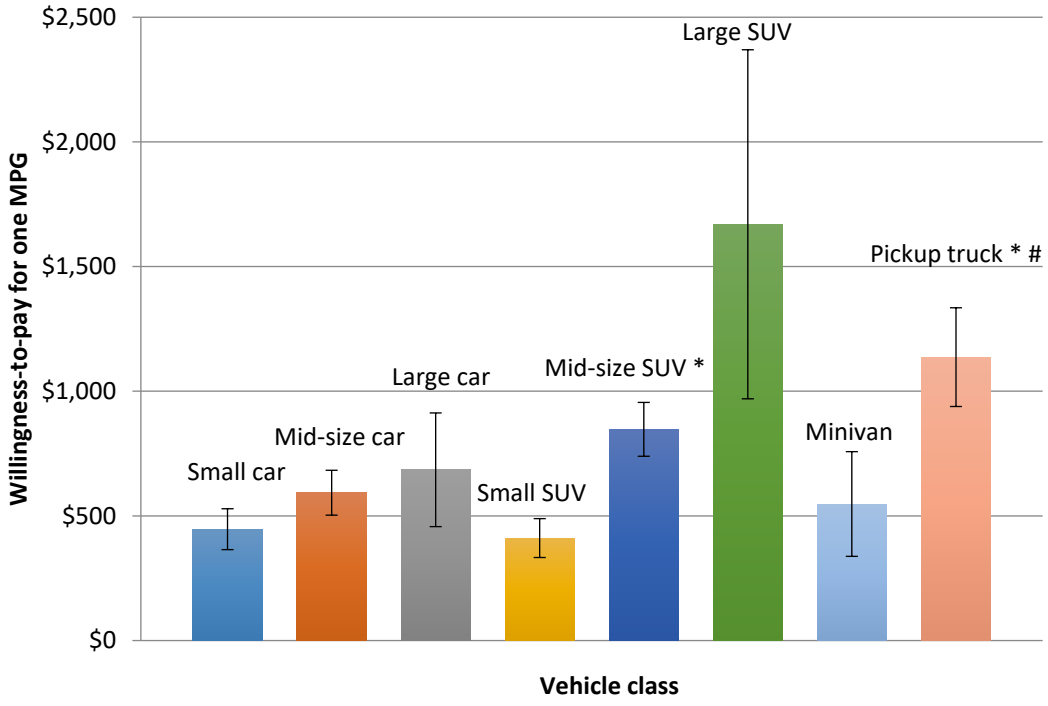
** Respondents planning to spend less than $15,000 on their next vehicle had lower valuation of fuel economy, compared to all other categories of anticipated purchase price (p < .05). The difference in consumer valuation of fuel economy between those planning to spend more than $35,000 and between $15,000 - $25,000 was also significant (p < .05).*

 # The difference between those planning to spend more than $35,000 and between $25,000 - $34,999 is borderline significant (p < .1).

[3] Note: 50 years of age was the median split of the sample.

[4] Further investigation revealed no significant differences in WTP for gal./100 miles among the eight vehicle classes.

Figure 4. Willingness-to-pay for one MPG across the class of next intended vehicle (error bars represent standard error)



Note: Consumers intending to purchase large SUVs were willing to pay the most for fuel economy, relative to all other vehicle classes, but that WTP value did not differ significantly from the other classes, likely due to the large standard error. Further research, with increased sample size, may be able to confirm this trend.

** WTP for fuel economy was statistically significantly higher among those planning to purchase a pickup truck (roughly $1,140 for one MPG), compared to those interested in purchasing a small car (about $450 for one MPG) or a small SUV (approximately $410 for one MPG) ($p < .05$). WTP was also significantly higher among those planning to acquire a mid-size SUV (about $850 for one MPG), compared to those interested in a small SUV or a small car ($p < .05$).*

 # The differences in WTP between those intending to purchase a pickup truck and those planning to purchase a mid-size car (roughly $590 for one MPG) or a large car (about $690 for one MPG) are borderline significant ($p < .1$).

Summary of Method

We recruited a nationally representative sample of 1,883 Americans with a valid driver's license who plan to purchase or lease a new or used vehicle within the next ten years.[5] The study consisted of a set of survey questions and a choice experiment. The choice experiment required participants to select the vehicles they would be most likely purchase from six sets of three vehicle options. Vehicle attributes consisted of price, fuel economy, safety, reliability, acceleration, and premium features/trim. Depending on the condition to which they were randomly assigned, researchers presented the fuel economy attribute in the choice experiment using different metrics (six possible fuel economy metrics or no fuel economy information in the control condition). Researchers strove to include all of the most critical attributes to vehicle decision-making in the experiment but nevertheless acknowledge that consumer willingness-to-pay for an attribute is strongly affected the context of the decision and the information provided to the consumer. The fuel economy metrics were as follows:

- Miles per gallon (MPG),
- Annual fuel cost,
- Five-year fuel cost,
- The average amount a customer would spend/save over five years compared to the average new vehicle,
- Lifetime fuel cost, and
- The full fuel economy label (as currently mandated by the EPA).

The current study had several advantages over previous research. It used both explicit (open-ended, multiple choice, and rank-ordering questions) and implicit (discrete choice experiment, DCE) measures of consumer preferences to converge on the same answer. It also embedded the DCE within a randomized experiment to systematically test whether the presentation of fuel economy can affect its valuation. The experiment evaluated demographic information with DCE results in order to allow for an in-depth examination of how different population segments value fuel economy. The experiment maximized external applicability by using a large national sample and tailoring the choice task based on participants' specific vehicle class preferences and intended purchase price for their next vehicle.

Implications

This study adds to the growing body of literature regarding consumer valuation of fuel economy. We found that our nationally representative sample of consumers greatly valued fuel efficiency, especially when it was presented using the familiar metrics of the full fuel economy label or MPG. We also determined that merely presenting fuel economy information to consumers had statistically significant effects on their attitudes and decisions. Findings suggest that consumers highly value fuel economy but that the presentation of different fuel economy metrics can significantly affect this valuation.

[5] Approximately 65% of respondents plan to buy a vehicle in the next two years

Introduction

How much does fuel economy matter to consumers when they choose new or used vehicles? This question has been examined in several ways, including economic modeling of revealed preferences, discrete choice modeling of stated preferences, interviews, surveys and general reviews of psychological purchase motivations. Another persistent question is whether the value that consumers place on fuel economy is dictated by what is presented to them, or by their pre-existing preferences and motivations. In other words, can consumers' perceived value of fuel economy change, based on how it is presented? Or is the value fixed and therefore immutable to changes in its presentation?

Economic Modeling of Consumer Preferences

Two extensive reviews from 2009 and 2010 summarized the economic modeling literature on consumer valuation of fuel economy (Helfand and Wolverton, 2009; Greene, 2010). Both reviews agreed that discrete choice modeling is the most commonly used method for assessing valuation of fuel economy relative to other attributes, and that the overall literature on the topic was inconclusive. To examine if consumers are willing to pay at least the value of what they receive from fuel efficiency, Greene (2010) reviewed 25 studies. He found a roughly equal number of studies (reviewed by Greene, 2010) showing that consumers undervalue fuel economy (12 studies), as that consumers overvalue (five studies) or fully value (eight studies) fuel economy. The difference in results could not be attributed to study timeframe, quality, or methods. More recently, Greene has updated his review of fuel economy valuation and expanded it to all vehicle characteristics (Greene, Hossain, and Beach, 2016; Greene, Hossain, Helfand, and Beach, 2017). These reviews again conclude that valuation of fuel economy varies greatly between, an even within, studies. Furthermore, the questions of which population segments value fuel economy most, and how different fuel economy metrics affect valuation remain open.

However, authors of the fuel economy reviews also raise important concerns about using economic modeling to understand actual car purchase behavior. For example, Helfand and Wolverton (2009) note that economic models based on purchase behavior may have been somewhat flawed because consumers did not have a sufficient variety of options of fuel-efficient vehicles to choose from. Auto producers at that time tended not to offer consumers fuel-efficient vehicles because they did not perceive the consumers' interest in fuel economy. Efficiency gains would be channeled into greater acceleration rather than increased fuel economy because that was assumed to be more valuable to consumers. Indeed, McManus and Kleinbaum (2009) point out that the collapse in the American auto industry in 2008-2010 was partially caused by American auto producers ignoring increasing interest in fuel economy.

One critique of relying on strict economic modeling of consumer car purchase behavior is that such models are built around the assumption that consumers are 'rational actors.' Unfortunately, consumers' purchasing behavior does not often align with economic theories when making car purchase decisions. Greene explains:

> "The consistency with which the literature has yielded widely varying, inconsistent estimates over a period of more than three decades suggests that there is either a

> fundamental empirical problem in estimating the value consumers place on fuel economy, or that the presumed theory of consumer behavior is incorrect, or both. Recent but very limited in-depth survey evidence indicates that the rational economic model of consumer behavior is very likely not an accurate description of consumers' decision making about fuel economy" (Greene, 2010).

An Approach Incorporating Behavioral Science

Researchers should use a more nuanced approach to understanding vehicle purchase behavior. Rational economic models should be augmented by decision-making theories derived from behavioral science, or they will fall short of accurately predicting behavior. One detailed account of an economists' analysis of his own car consumption behavior (purchase, maintenance, etc.) over 30 years reveals that his behavior is rarely explained by rational economic theories (Earl, 2012). The author goes through a number of relevant behaviors and compares the best economic explanation to his own interpretation of his actions. Indeed, this reflects the experience of most car buyers, few of whom are aware of the basic elements of knowledge assumed by rational economic decision-making models (Turrentine and Kurani, 2007).

Households do not track gasoline prices over time and cannot accurately estimate future gas prices or cost savings (Turrentine and Kurani, 2007). Instead, they typically purchase visibly fuel efficient vehicles for symbolic reasons (e.g., to show off their values of thriftiness or being green), attitudes (such as environmental or financial), lifestyle, personality, social norms, moral norms (e.g., feelings of moral obligation to protect the environment), or self-image (Turrentine and Kurani, 2007; Popp et al., 2009; Peters, de Haan, Scholz, 2015; Choo and Mokhtarian, 2004; Peters, Gutscher, and Scholz, 2011; Ozaki and Sevastyanova, 2011). Although this is especially true for hybrid or electric vehicles, it also applies to other fuel-efficient vehicles with traditional internal combustion engines (e.g., Peters, de Haan, Scholz, 2015).

Demographics and personal circumstances can also influence the desire for more fuel-efficient vehicles. For example, car buyers in larger homes tend to prefer larger vehicles (Choo and Mokhtarian, 2004). When it comes to vehicle purchase decisions, a host of factors work together to influence vehicle purchase, and studies of this behavior would benefit from taking into account research from behavioral science.

Cognitive Biases

Greene (2011) suggests that consumers' uncertainty about future fuel costs, paired with their natural loss aversion could be a reason for "irrational" car purchase behavior. A loss-aversion explanation would imply that car labels that reframe fuel economy in terms of losses (e.g., "you will spend $X more for this vehicle than the average vehicle over the next five years") should increase the attractiveness of efficient vehicles, more than labels without the loss-aversion framing. This is the case for appliance energy efficiency labels (Bull, 2012). Given that non-financial variables play into vehicle purchase decisions, a number of simple cognitive biases and heuristics may affect these choices. For example, when fuel economy is presented using large numbers (e.g., fuel costs over 100,000 miles), consumers may be more likely to choose a fuel-efficient option than when the same fuel economy is presented using smaller numbers (e.g., fuel costs over 100 miles or 15,000 miles; Camilleri and Larrick, 2014).

Although these cognitive aspects can have a negative role (distracting the consumer from making the optimal decision), they can also be used to draw attention to attributes that are necessary for optimal decision making – allowing them to make energy efficient purchase decisions when they want to.

Fuel Economy Labels

Research on the design of labels shows that simple changes in their design can affect how consumers perceive products. From a rational economic perspective, this should not occur. The form of the data does not affect its content and, therefore, should not affect consumers' perception of those products. Nevertheless, research on labels shows that this can happen (e.g., Ungemach, Camilleri, Johnson, Larrick, and Weber, 2017) and that fuel economy metrics in particular may affect consumer valuation (although this has yet to be tested in a randomized experiment; Greene, Hossain, and Beach, 2016).

How Labels Affect Perceptions

For consumers that care about energy efficiency, labels that present the information in a metric that matters to them increases their likelihood of purchasing efficient products. Metrics act as signposts that both activate the consumers' pre-existing values, attitudes and goals, and tell them how likely the product is to meet those goals (Ungemach et al., 2017). For example, vehicle fuel economy labels with greenhouse gas emission information allow readers who care about the environment to choose vehicles that emit less pollution (Ungemach et al., 2017).

Consumers will look for the information that is most relevant to their objectives and use that to make their decisions. Thus, labels that lack sufficient metrics may be less effective for encouraging energy efficient purchases (Newell and Siikamaki, 2013). Label readers look for the metric that matters most to them, and make their decision based primarily on that metric. For example, a broad-spectrum label, such as the current EPA label, allows those who are interested in environmental sustainability to use the CO_2 emissions or smog information, and those who are interested in financial considerations to use the annual or five-year fuel cost information.

Cost savings and financial motivations are among the most frequently mentioned reasons for consumers to invest in energy efficiency. This is the case for efficient vehicle purchases (e.g., Skinner, et al., 2006; Keeney 1996) and home efficiency upgrades (e.g., Sussman and Chikumbo, 2017). Therefore, one could argue that these metrics should be present on fuel economy labels. Although consumers that are very motivated can technically calculate costs using MPG or other metrics, they are not fluent at doing so (Larrick and Soll 2008). In the appliance domain, for example, consumers can be swayed to purchase energy efficient products if the labels include life-cycle costs (Kaenzig and Wustenhagen, 2010), greenhouse gas emissions (Bull, 2012; Newell and Siikamaki, 2013), or running costs (Anderson and Claxton, 1982, Bull, 2012; Newell and Siikamaki, 2013).

However, whether an item is *perceived* as efficient or not also affects whether this information is persuasive. Simply providing the information does not guarantee that the item will be chosen – it also has to appear efficient relative to others. Cognitive biases and heuristics can influence how information is perceived. This is one reason why presenting costs and savings using larger

numbers, such as lifetime costs or savings, can sometimes be more effective than smaller units (e.g., Bull, 2012; Heinzle, 2012). These make savings seem bigger than expected. The *absolute* difference between numbers are more often used as a heuristic for making decisions than the *relative* difference, as is the case when using larger units to represent the same information (Cadario, Parguel, and Benoit-Moreau, 2016). Large absolute differences between numbers were found to be persuasive in one previous study of fuel economy (Camilleri and Larrick, 2014) and a study of vehicle CO_2 emissions (Cadario, Parguel, and Benoit-Moreau, 2016), but those studies did not allow for tradeoffs between multiple vehicle attributes (only purchase price and fuel economy/emissions). Our study included a more realistic scenario in which consumers were able to make multiple tradeoff decisions.

Familiar Metrics

Although fuel economy metrics that present savings using larger numbers or a form that matters to consumers (e.g., CO_2 emissions ratings for some consumers) could potentially be effective, familiarity with metrics also matters. Again, this could be related to meaningfulness – familiar scales may be more meaningful. MPG is the most familiar fuel economy metric for vehicles, and familiarity can, in some cases, play a role in the perception and understanding of information. For example, Celsius may arguably be a more functional measure of temperature than Fahrenheit, but American audiences are less likely to be moved by information that uses The former metric. Audiences can more fluently process scales that are familiar to them, and therefore attributes that are presented on familiar scales may receive more weight than those that are unfamiliar (Lembregts and Pandelaere, 2013).

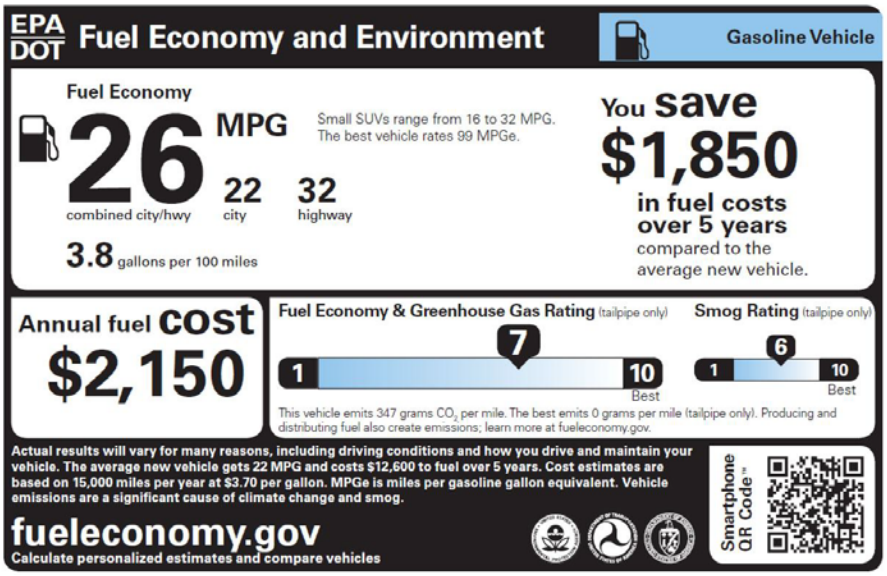
Discrete choice experiments (DCEs, measuring implicit or unconscious preferences), and surveys (measuring explicit preferences) can predict actual behavior to a certain degree. DCEs may be susceptible to a "hypothetical bias" (Loomis, 2011) in the form of overstatement of valuation, but they still have relatively good external validity (Lancsar & Swait, 2014) and can predict real-world travel choices (Wardman, 1988). Furthermore, surveying consumers about their intentions may be a valid approach to understanding their behavior because intentions, as suggested by the theory of planned behavior (Ajzen, 1991), are a good predictor of actual behavior (e.g., Armitage and Conner, 2001). Modeling consumer behavior using only real-world revealed preferences is also a valid approach, but it has drawbacks such not allowing consumers to choose potential options that do not yet exist.

EPA-Mandated Fuel Economy Label

The manner in which fuel efficiency is presented can have a considerable impact on fuel efficiency choices. With this understanding, the US Environmental Protection Agency (EPA) and Department of Transportation (DOT) conducted an in-depth assessment before redesigning their mandated fuel economy labels (EPA and DOT, 2010). This process involved a literature review, focus groups, an expert panel, and an internet survey of new vehicle buyers and intenders. The internet survey showed participants equivalent vehicle choices with different labels and asked which they think would be best for a trip of specified distances. The team considered and rejected hundreds of design options before deciding on the final option. The final label, depicted in Figure 5, consisted of several fuel economy metrics, as well as two environmental measures. Although the label is well designed and based on input from several

relevant sources, only a few elements (greenhouse gas emissions, MPG, and fuel costs) have been tested empirically to confirm their effectiveness for influencing decisions (Ungemach et al., 2017), and none of those tests allowed for tradeoffs between fuel economy and other attributes (except price).

Figure 5. Sample EPA-mandated fuel economy label.



The Current Study

The current study was designed to measure how much consumers value fuel economy when considering purchasing or leasing a vehicle, as well as testing whether this value can be modified using cognitive science research on fuel economy metrics. The study allowed participants to consider tradeoffs between fuel economy and other attributes, as well as testing if these tradeoffs could be affected by how fuel economy was presented to them. To do this, we designed an experiment in which a DCE was embedded within a randomized controlled trial (see method section for more detail). By focusing on *relative* effects across conditions, this approach helps to mitigate potential bias from overstatement of valuation (common in choice experiments). This novel design was also used by Newell and Siikamaki (2013) to assess how much consumers were willing to pay for hot water heater fuel efficiency, given different label styles and elements. Our experiment also improves on previous DCE studies by customizing the choice experiment to each respondent's actual purchase intentions (e.g., vehicle type and intended purchase price), thereby increasing the realism of the choice sets.

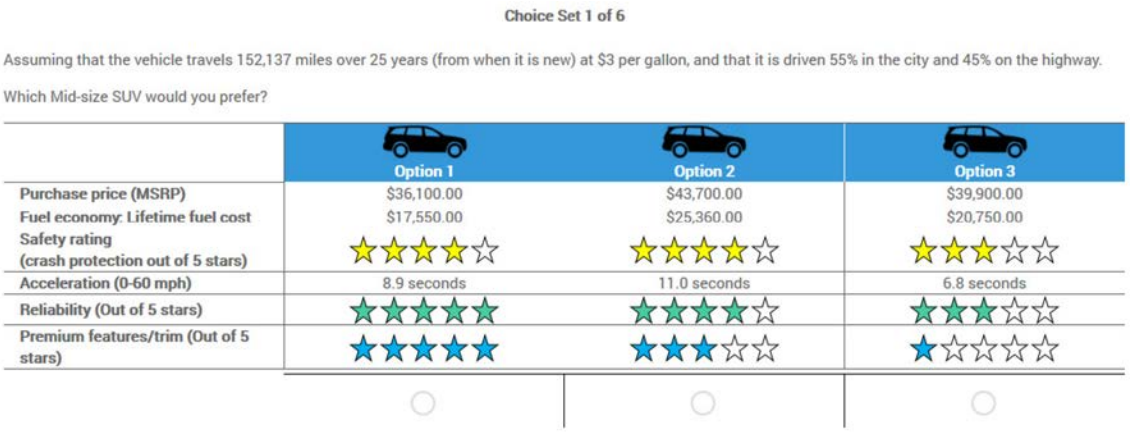
Research Questions

1. How much do consumers value fuel economy?
2. Does the presence of information on fuel economy affect consumers' valuation of fuel economy or stated vehicle choices?
3. Does valuation of fuel economy vary across consumer demographic characteristics or those of the vehicle they plan to buy/lease?

Method

This study consisted of an online survey-based experiment in which a nationally representative sample of participants answered questions about their demographics, their current vehicle (if they use one regularly), their next planned vehicle purchase, and their explicit preferences for various vehicle attributes. They also completed a discrete choice experiment (DCE) that was customized to their vehicle preferences (Figure 6). Depending on their random assignment to one of seven conditions, the fuel economy attribute in the DCE was presented to respondents as: (1) MPG, (2) annual fuel cost, (3) five-year fuel cost, (4) amount saved or spent in fuel cost over five years relative to the average vehicle, (5) lifetime fuel costs, (6) the full fuel economy label mandated by EPA, or (7) not presented at all (control). The DCE was used to measure implicit preferences for various vehicle attributes, including fuel economy, for each of the seven conditions as well as in relation to demographics and explicit preferences. We strove to include all of the most critical attributes to vehicle decision-making in the experiment but nevertheless acknowledge that consumer willingness-to-pay for an attribute is strongly affected the context of the decision and the information provided to the consumer. Full details of the study methods can be found in Appendix 1. Importantly, it should be noted that the values used in this study are window sticker values, which are approximately 30% lower than CAFE values.

Figure 6. Sample choice set (Condition 5: Lifetime fuel cost)



Sample

We sampled 1,883 participants from across the United States who had driver licenses and were planning to purchase or lease a vehicle within 10 years.[6] The sample was 51% male with a mean age of 49 years, and was 77% white or Caucasian. Almost half of the group had either some college credit and no degree (28%) or a bachelor's degree (20%), and household incomes between $25,000 and $75,000 per year (55%). The sample was drawn from across the U.S., with the largest number of respondents from Southern states (38%) and the rest distributed evenly among the Northeast (19%), Midwest (22%), and Western (21%) census regions.

The market research company's (ORC) "Census Balancer" tool was used to ensure that the initial intake of potential respondents mirrors the general population according to gender/age/race/ethnicity/education/region for the key demographics. The ultimate sample participants are nearly identical to the national census results for the general American population (see Appendix 3).

Almost the whole sample owned a vehicle (only 4% did not), and many owned two or more (47%). The two most commonly driven vehicle classes within the sample were mid-sized cars and mid-sized SUVs. On average, respondents estimated that they drove their primary vehicle slightly less than average (12,260 miles/year), and they generally claimed to use the vehicles for errands, leisure and sometimes commuting to work (the sample was roughly split between those who never used the vehicle to commute to work and those who always used it to commute to work). About one-quarter of the respondents used their primary vehicle to commute to school at least one day a week (25%), and over half of the sample used it to commute to work at least one day a week (57%).

Participants were also asked about the vehicle they planned to purchase next. Most participants are planning to acquire their next vehicle within two years (65%), and expect to spend an average of $26,360. Just over half (58%) of the respondents said they were more likely to buy a new vehicle than a used vehicle (at an average price of $33,654, as opposed to $16,355 for those planning to buy a used vehicle). Only 7% claimed they would lease their next vehicle as opposed to purchasing it. Respondents estimated their annual travel distance per year and weekly use of the planned vehicle, to be nearly identical to their current vehicle. Indeed, 75% claimed that this future vehicle would replace their currently most-driven vehicle.

Of the participants who owned vehicles and could remember the process of acquiring their current vehicle, 68% indicated that they actively learned about fuel economy information before they chose their current vehicle.

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[6] In addition to excluding participants who did not own a drivers' license or plan to purchase a vehicle within 10 years, respondents were automatically excluded from the study if they completed it in less than half of the median completion time, or if they failed three cheater-detection questions. Three hundred and twenty-three respondents were excluded for this reason. The remaining participants' responses were examined for suspicious answer patterns and none were found. The last question asked participants to indicate the understandability of the survey on a five-point scale and the majority (81%) indicated a four or five out of five (completely understandable). Only one participant indicated a one out of five and did not understand how to complete the task.

Results

Question #1: How much do consumers value fuel economy?

Three pooled multinomial logit (MNL) choice models were estimated across all of the experimental conditions using data from the stated choice experiment. The data reflected three different ways of representing the common metric for fuel usage for modeling purposes: 1) gallons/100 miles (gal./100 miles), 2) fuel cost per year (calculated using MPG, respondents' reported annual VMT, and fuel cost of $2.61/gallon for all conditions, except for $3/gallon for the lifetime fuel cost condition)[7], and 3) miles/gallon (MPG). In the three pooled models, all of the vehicle attribute coefficients were in the direction that we would expect and were highly significant. Specifically, participants preferred lower levels of purchase price, fuel consumption, and acceleration, but they preferred higher levels for safety, reliability, and premium features/trim (Table 1).

Gal./100 miles is used as the fuel consumption metric for the majority of the analyses because MPG is a ratio in which gas consumption is the inverse of the ratio, meaning that – although this fuel economy metric conveys which vehicles are generally more or less efficient – there is not a linear relationship between MPG values and gas consumption. Gal./100 miles is a more direct measure of gas consumption, and is thus better-suited for the analyses from the choice experiment, which test the association between respondents' perceived valuation of fuel economy levels assuming an underlying linear relationship.

In addition, WTP, which represents the ratio of the degree to which participants value an additional unit of a particular vehicle attribute in relation to an increase or decrease in purchase price, was calculated using coefficient estimates that were statistically significant at the 95% confidence level or higher (Table 1). In this sense, WTP is the average dollar amount in purchase price that the sample is willing to pay for an additional unit of a particular vehicle attribute (e.g., one gal./100 miles).

As shown in Table 1, the pooled model for fuel cost per year across the six experimental conditions revealed a WTP of $10.73 (*s.e.* = 0.83), which indicates that respondents would be willing to pay $10.73 more in purchase price to save $1/year in fuel costs (a value equivalent to more than a 10-year payback period). [8] By association, respondents would be willing to pay an extra $10,730 in purchase price to save $1,000/year in fuel costs.

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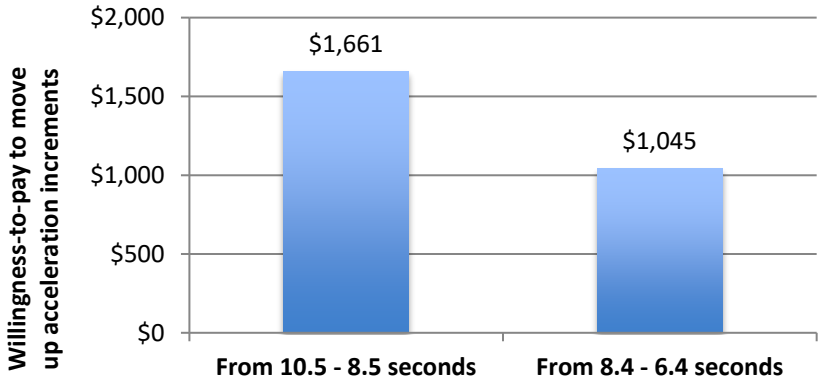
[7] Based on current EIA gas prices (Annual Energy Outlook 2018) and annual mileage used by EPA fuel economy labels, all respondents (except those assigned to the lifetime fuel cost condition) were instructed to assume a travel distance of 15,000 miles per year at $2.61 per gallon. Those in the lifetime fuel cost condition were asked to assume a 25-year VMT of 152,137 miles per vehicle for all 8 classes (based on the NHTSA's VMT Schedule for Passenger Cars) and $3.00/gallon, given that EIA projections predict higher gasoline prices. Those in all experimental conditions were asked to assume 55% driven in the city and 45% driven on the highway.

[8] Without the fuel economy label condition and the control condition, which had the highest WTP, valuation of fuel cost was $9.16, *s.e.* = 0.81 (respondents would be willing to forgo $9.16 in purchase price to save $1/year in fuel costs).

We found high, significant WTP values for fuel economy, which indicates that respondents highly value improved fuel economy. Specifically, on average, participants were willing to pay $685 for one MPG. Averaged across the eight vehicle classes, one second of acceleration had a WTP of $847 (*s.e.* = 215.35); however, as shown in Figure 7 this is not a static trade-off. Valuation of acceleration decreased as acceleration time decreased, when evaluated across the eight vehicle classes.

Figure 7. Willingness-to-pay to increase acceleration by two seconds.



MPG is perceived to be relatively more valuable than acceleration or premium features/trim, but not as valuable as safety or reliability. Assuming a vehicle purchase price of $30,000, consumers valued a 25% increase in: acceleration (i.e., a decrease of 1.75 seconds) as much as a 4.9% increase in purchase price; premium features/trim rating (i.e., an increase of 1 star out of 5) as much as a 8.1% increase in purchase price; MPG (i.e., an increase of 5 MPG) as much as a 11.4% increase in purchase price; safety rating (i.e., an increase of 1 star out of 5) as much as a 15.8% increase in purchase price; and reliability rating (i.e., an increase of 1 star out of 5) as much as a 16.8% increase in purchase price (Figure 8).

Figure 8. Willingness-to-pay for MPG relative to other vehicle attributes (assuming a $30,000 base vehicle purchase price)

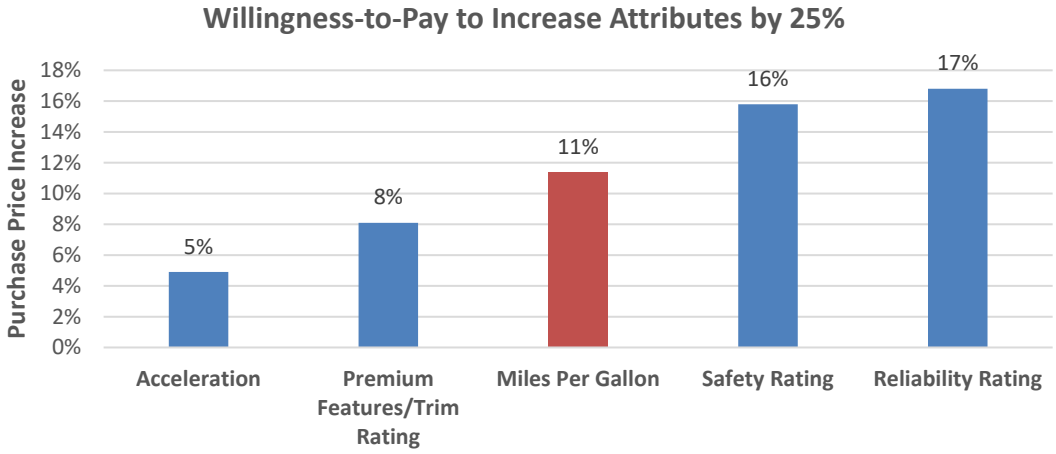
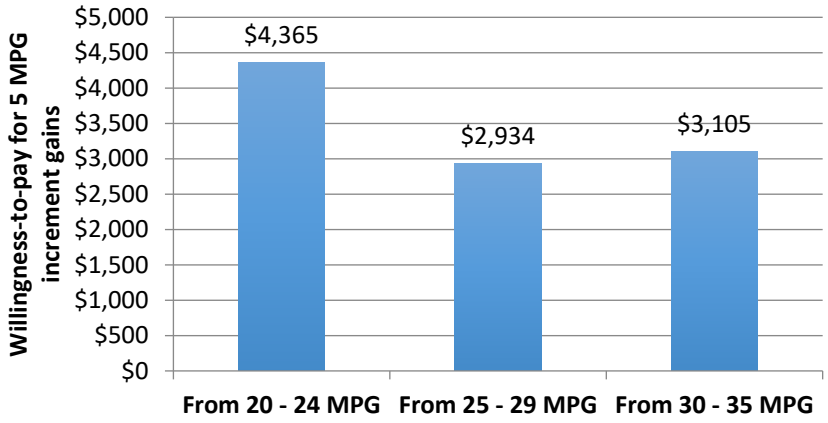


Table 1. Pooled choice model results - when fuel usage is represented as the common metric of gal./100 miles, fuel cost per year, and MPG.

	Fuel usage represented as: gal./100 miles			Fuel usage represented as: Fuel cost/year			Fuel usage represented as: MPG		
Attributes	**Coefficient**	***p*-value**	**WTP [*s.e.*]**	**Coefficient**	***p*-value**	**WTP [*s.e.*]**	**Coefficient**	***p*-value**	**WTP [*s.e.*]**
Purchase price	-0.0001	$p < .001$	-	-0.0001	$p < .001$	-	-0.0001	$p < .001$	-
Fuel consumption (gal./100 miles)	-0.3561	$p < .001$	-$5,052.00 [351.52]						
Fuel costs ($1 per year)				-0.0007	$p < .001$	-$10.73 [0.83]			
Fuel Economy (MPG)							0.0482	$p < .001$	$685.34 [48.04]
Safety rating (1 star)	0.3353	$p < .001$	$4,757.30 [306.56]	0.3337	$p < .001$	$4,797.89 [312.44]	0.3331	$p < .001$	$4,739.98 [307.43]
Acceleration (1 second)	-0.0684	$p < .001$	-$970.66 [214.61]	-0.0916	$p < .001$	-$1,316.31 [220.37]	-0.0596	$p < .001$	-$847.62 [215.35]
Reliability (1 star)	0.3538	$p < .001$	$5,019.10 [331.98]	0.3543	$p < .001$	$5,094.21 [337.79]	0.3544	$p < .001$	$5,042.97 [332.34]
Premium features/trim (1 star)	0.3417	$p < .001$	$2,423.70 [297.40]	0.3449	$p < .001$	$2,479.46 [301.26]	0.3416	$p < .001$	$2,429.94 [296.16]

Respondents particularly valued increasing the fuel economy of the least efficient vehicles. Trends in respondent WTP for increases of 5-MPG increments (i.e., from the average MPG amounts for each level in the DCE) are shown in Figure 9. Tables depicting WTP for MPG increment gains for each vehicle class are included in the Appendix 3.

Figure 9. Willingness-to-pay in purchase price for increases of five MPG



Explicit preferences matched implicit preferences. We assessed explicit preference for fuel economy by asking participants to (1) write "what they look for in a vehicle" (open-ended, Figure 10), (2) select six of 19 possible attributes that are important to them, and (3) rank order the six attributes that the research team deemed most important based on previous research and consultation with experts. All three measures triangulated on the same result: the most important features that participants mentioned explicitly were reliability, safety, purchase price, and fuel economy. These vehicle attributes, along with acceleration and premium features/trim, were included in the DCEs.

Figure 10. Attributes that participants stated were "most important"

Question #2: Does the presence of information on fuel economy affect consumers' valuation of fuel economy?

To assess whether the presentation of *any* fuel economy information in the experimental conditions (versus *none* in the control condition) impacts consumer vehicle choices, a variable was created for each respondent to reflect the average ranking of vehicles selected across the six choice sets, where "1" is the least efficient vehicle in the choice set and "3" is the most efficient vehicle in the choice set. Thus, higher scores for *average fuel efficiency rank* indicate a greater frequency of selecting more fuel-efficient vehicles across the choice experiment. In the control condition, vehicles were identical except for the absence of fuel efficiency information. We compared participants' vehicle ranks in the control condition against those in the six experimental conditions (combined).

The presence of fuel economy information was found to affect vehicle decision-making. Respondents who were presented with fuel economy information chose vehicles that were statistically different than those who did not see fuel economy information, $t(409.07) = 6.09$, $p < .001$. They tended to choose the vehicle options that were ranked higher in fuel-efficiency.

Each vehicle choice set had three vehicle options (see Figure 6), and when fuel economy information was presented, consumers chose the option that was ranked an average of 2.19 out of 3 ($SD = .39$). When vehicle fuel economy was not presented, consumers chose the equivalent vehicle option only an average of 2.06 out of 3 ($SD = .33$) – a statistically significant difference. The finding that respondents rank ordered the vehicles significantly differently in the control versus experimental conditions corresponds with our explicit findings and suggests that consumers use fuel economy information when they are provided with it.

Using the same dependent variable of ranked vehicle choice, an analysis of variance (ANOVA) was performed to evaluate whether certain types of fuel economy metrics have a larger impact than others on consumer vehicle choices. Results revealed an overall significant difference among the means of the conditions, $F(6, 1791.20) = 10.71$, $p < .001$. Follow-up tests revealed that four of the experimental conditions resulted in significantly more frequent selection of fuel-efficient vehicles compared to the control condition: MPG ($M = 2.27$ out of 3, $p < .001$), the fuel economy label ($M = 2.26$ out of 3, $p < .001$), lifetime fuel cost ($M = 2.20$ out of 3, $p < .001$), and five-year fuel cost ($M = 2.15$ out of 3, $p < .05$). Results suggest that **when participants saw fuel economy information in the randomized choice experiment presented as MPG or the full EPA-mandated fuel economy label, they were especially likely to select a fuel-efficient vehicle**.[9]

A previous study of decision making in Ford dealerships (between 2012 and 2014) found that customers who were given fuel economy information did not purchase more efficient vehicles

[9] Additional significant post-hoc comparisons were also detected among the conditions. Specifically, participants who saw MPG information selected vehicles ranked as significantly more fuel-efficient ($M = 2.27$), than those who saw annual fuel cost ($M = 2.14$, $p < .001$), five-year fuel cost ($M = 2.15$, $p < .01$), and spend/save comparisons ($M = 2.15$, $p < .01$). Similarly, participants selected significantly more efficient vehicles if they saw the full fuel economy label ($M = 2.26$), than if they saw annual fuel cost ($M = 2.14$, $p < .01$), five-year fuel cost ($M = 2.15$, $p < .01$), and or the spend/save comparison ($M = 2.15$, $p < .01$).

(Allcott and Knittel, 2017). However, during that time, Ford was arguably the producer of America's most inefficient vehicles[10] and, as such, the sample of consumers that were included in the study may not have been nationally representative. Additionally, the authors of that study presented efficiency as annual and lifetime fuel costs, as opposed to the full label or MPG, which could have diminished their intervention's effectiveness. Studies of revealed preference are also limited by the options that consumers can purchase. Participants cannot choose options that are not available. Thus, although the study illuminates a potential difference between stated and revealed preferences, it also has important limitations.

With respect to the influence of fuel economy information on explicit preferences, consumers who were exposed to fuel economy information later indicated a higher interest in fuel economy than consumers who were not exposed to fuel economy information. Participants were asked to rank order six vehicle attributes (purchase price, fuel economy, reliability, safety, premium features/trim, and acceleration). Those who were randomly assigned to complete a DCE that included a fuel economy attribute, later ranked fuel economy as statistically significantly more important to their real-life purchase decisions (3.3 out of 6 attributes) than those who completed a DCE that did not include some form of fuel economy metric (3.1 out of 6 attributes). The MPG metric was particularly likely to increase participants' ranking of fuel economy (2.9 out of 6). In terms of polling, this suggests that if consumers indicate that they do not consider fuel economy important in a poll, it could be that exposure to fuel efficiency information or fuel-efficient vehicle options would increase their valuation.

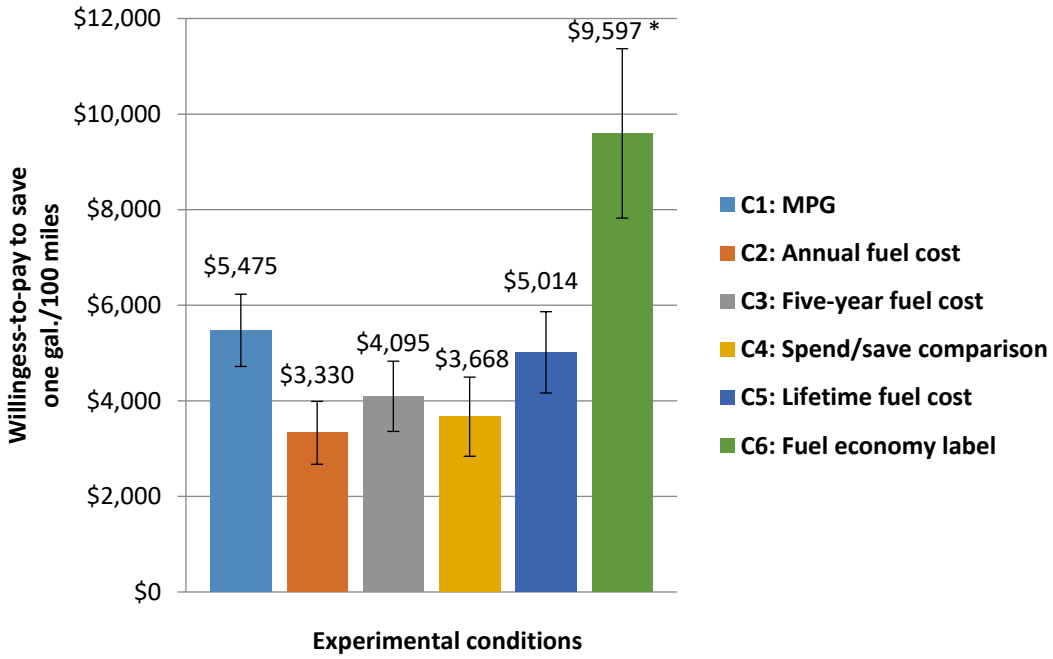
Additional MNL choice models were estimated for each of the conditions for the three ways to represent the common metric of fuel economy: gal./100 miles, fuel cost per year, and MPG. These analyses reveal consumer valuation of the vehicle attributes within each condition, and they also allow for a comparison of WTP for fuel economy across the conditions (Table 2). We were able to examine WTP values across attributes because the key variables of gal./100 miles and purchase price were significant in every experimental condition.

[10] The EPA trends report (US EPA, 2018) notes that in 2012-2014, while average fuel economy across all manufacturers increased, Ford's remained static at 22.7mpg. In 2014, this was 1.4mpg lower than average. Furthermore, in each year between 2012 and 2014, greenercars.org posted lists of the most and least efficient vehicles in their classes. In those years, Ford only had one vehicle in the "greenest" list, and consistently had the most vehicles on the "meanest" list (four each year), https://greenercars.org/news-resources/resources.

As shown in Table 2 and Figure 11, the WTP in purchase price for each fewer gallons of gas (required to travel 100 miles) was highest for participants who saw the full fuel economy label: $9,596.50 (*s.e.* = 1,773.5). Consistent with the above results, the choice model findings revealed that **when participants saw fuel economy information in the randomized choice experiment presented as the full EPA-mandated fuel economy label, they were willing to pay significantly more for fuel efficiency compared to the compared to the annual fuel cost, five-year fuel cost, and the spend/save comparison conditions ($p < .05$).[11] Thus, valuation of fuel economy can significantly increase when more information is provided, but not all fuel economy metrics are equal.**

Again, we can use this data to compare conditions, and we have accounted for potential hypothetical bias by randomly assigning respondents to conditions. That is, by conducting the study on six experimental conditions (with random assignment), we have effectively standardized possible hypothetical bias across our conditions, such that our approach allows for controlled experimental manipulation of the presentation of fuel economy information as well as an examination of trade-offs among vehicle attributes.

Figure 101. Willingness-to-pay in purchase price to save one gal./100 miles across the six experimental conditions (error bars represent standard error)



** When participants saw fuel economy information presented as the full EPA-mandated fuel economy label, they were willing to pay significantly more for fuel efficiency compared to the compared to the annual fuel cost, five-year fuel cost, and the spend/save comparison conditions ($p < .05$).*

[11] Determined by multiplying the standard error by 1.96, and then adding and subtracting that resulting confidence interval value from the WTP value. If the two confidence intervals did not overlap, then the WTP values for two conditions were found to differ significantly at a level of $p < .05$.

Table 2. Willingness-to-pay for each additional gallon of gas to travel 100 miles, to save $1 per year in fuel costs, and for one MPG in the six experimental conditions

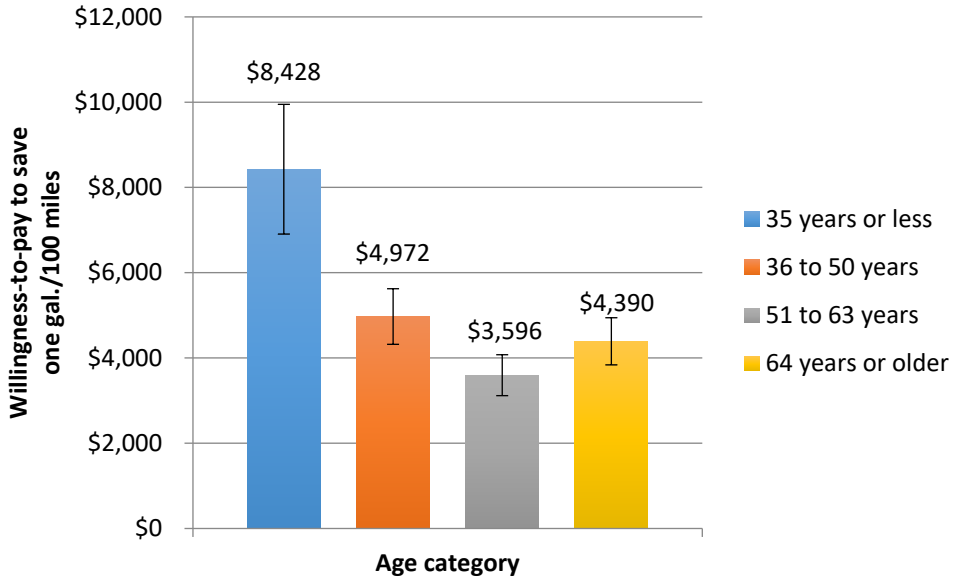
Condition	WTP to save one gal./100 miles (Pooled WTP: $5,052)	*s.e.*	WTP to save $1/year in fuel costs (Pooled WTP: $10.73)	*s.e.*	WTP for one MPG (Pooled WTP: $685)	*s.e.*
C1: MPG	$5,475.20	756.05	$11.80	1.81	$767.90	103.75
C2: Annual fuel cost	$3,330.40	658.39	$8.16	1.73	$448.32	89.86
C3: Five-year fuel cost	$4,094.50	734.74	$8.26	1.75	$561.62	103.29
C4: Spend/save comparison	$3,668.00	827.83	$5.79	1.78	$430.85	108.83
C5: Lifetime fuel cost	$5,014.30	851.45	$11.33	2.03	$733.47	121.77
C6: Fuel economy label	$9,596.50	1772.5	$21.94	4.21	$1,216.40	225.05

Question #3: Does valuation of fuel economy vary across consumer demographic characteristics or features of the vehicle they plan to buy/lease?

Several additional MNL choice models were estimated, with the file split according to various characteristics of the respondent and of their next intended vehicle purchase/lease. WTP values were consulted for all models because the price and fuel economy attributes were both significant in all analyses (see Appendix 3 for WTP for fuel economy across respondent demographics and intended vehicle characteristics).

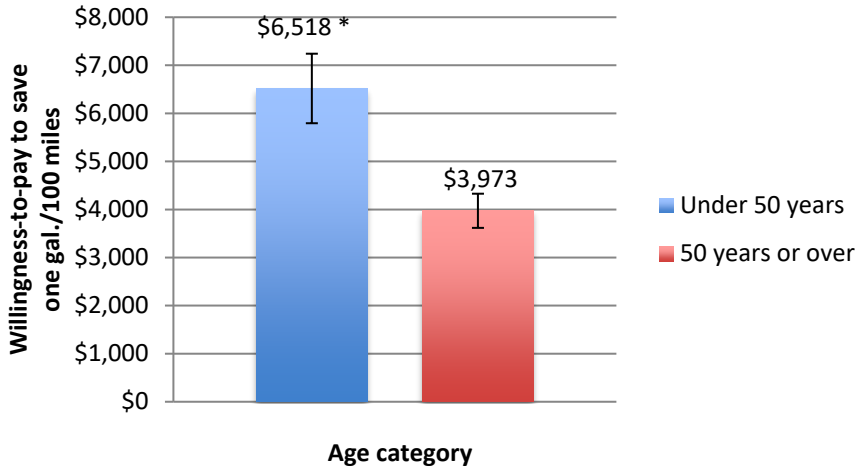
Valuation of fuel economy varied statistically significantly across age and household income.[12] Although no significant differences were detected among the age sub-categories (Figure 12), respondents under the sample median age of 50 ($6,518 for one gal./100 miles, *s.e.* = 723.25) were willing to pay statistically significantly more for fuel economy compared to those 50 years of age or older ($3,973 for one gal./100 miles (*s.e.* = 355.53), $p < .05$ (Figure 13).

Figure 112. Willingness-to-pay for one gal./100 miles across age categories (error bars represent standard error)



[12] Determined by multiplying standard error by 1.96, and then adding and subtracting that resulting confidence interval value from the WTP value. If the two confidence intervals did not overlap, then the two demographic groups were found to differ significantly at a level of $p < .05$.

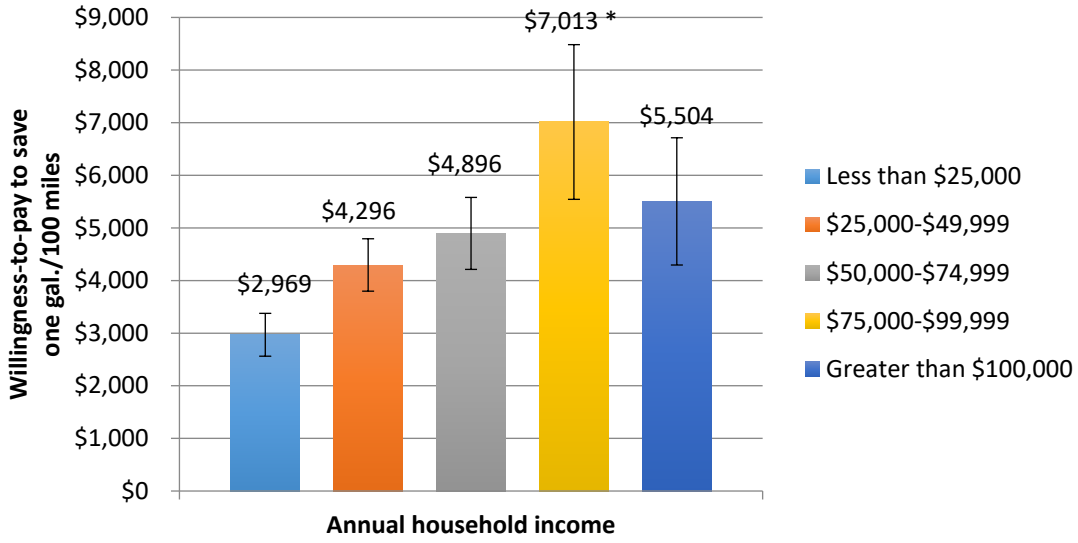
Figure 123. Willingness-to-pay for one gal./100 miles split by median age of sample (error bars represent standard error)



** Respondents under the sample median age of 50 were willing to pay statistically significantly more for fuel economy compared to those 50 years of age or older ($p < .05$).*

Respondents with household incomes between $75,000-$99,999 ($7,013.00 for one gal./100 miles, *s.e.* = 1,470.70) had a WTP statistically significantly greater than those with incomes less than $25,000 ($2,969.40 for one gal./100 miles, *s.e.* = 407.31), $p < .05$, but no other significant differences were present (Figure 14). Respondents with household incomes under $25,000 also statistically significantly valued fuel economy, being willing to pay an additional $2,969 in purchase price for each less gal./100 miles.

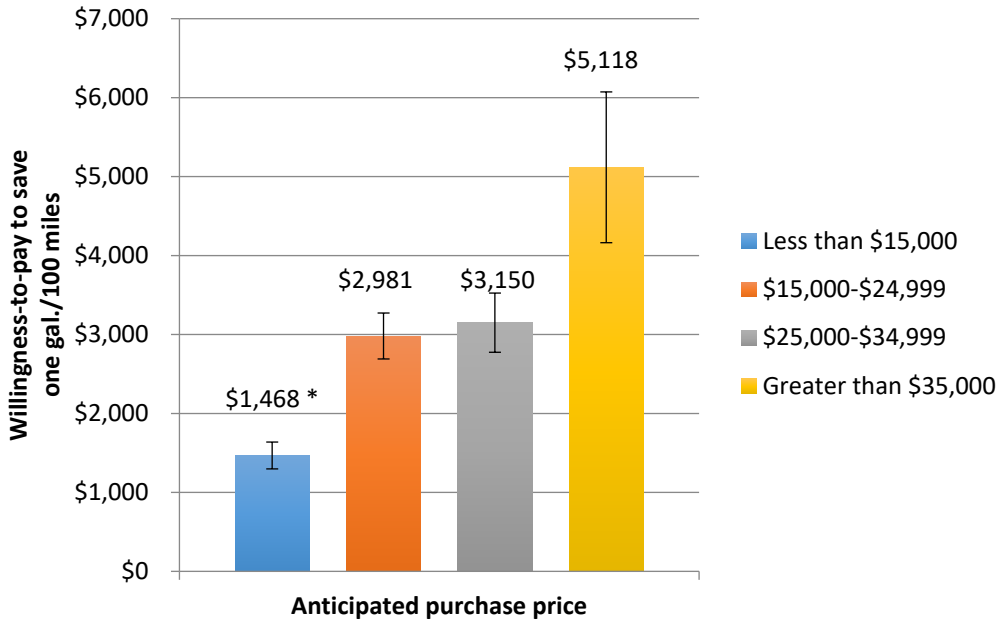
Figure 134. Willingness-to-pay for one gal./100 miles across annual household income categories. (Error bars represent standard error.)



** Respondents with household incomes between $75,000-$99,999 had a WTP statistically significantly greater than those with incomes less than $25,000 ($p < .05$).*

Additional analysis revealed that **valuation of fuel economy varied statistically significantly according to two characteristics of the next intended vehicle: anticipated purchase price and purchase timeframe.** Respondents planning to spend less than $15,000 on their next vehicle have statistically significantly lower valuation of fuel economy ($1,467.80 for one gal./100 miles, *s.e.* = 170.25), compared those planning to spend between $15,000-$24,9999 ($2,981.20 for one gal./100 miles, *s.e.* = 290.72), $25,000-$34,999 ($3,149.90 for one gal./100 miles, *s.e.* = 375.17), and greater than $35,000 ($5,117.80 for one gal./100 miles, *s.e.* = 954.88), all $p < .05$ (Figure 15).[13]

Figure 145. Willingness-to-pay for one gal./100 miles across anticipated purchase price categories (error bars represent standard error)

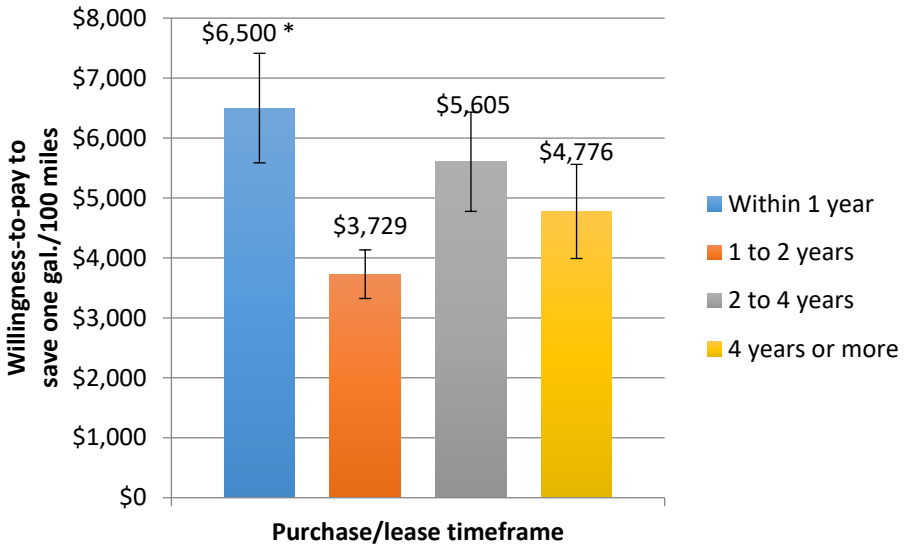


** Respondents planning to spend less than $15,000 on their next vehicle have statistically significantly lower valuation of fuel economy, compared those in the other three categories of anticipated purchase price (all p < .05).*

[13] The average new-car price was $36,113 at the end of 2017, while the average used-car price was $19,400 at that time, according to data from Kelley Blue Book and Edmunds

Analysis also revealed that valuation of fuel economy among those who intend to purchase/lease a vehicle within the next year ($6,500 for one gal./100 miles, *s.e.* = 914.54) was statistically significantly higher than those who intend to purchase/lease a vehicle within one to 2 years ($3,729 for one gal./100 miles, *s.e.* = 404.97), $p < .05$ (Figure 16).

Figure 156. Willingness-to-pay for one gal./100 miles based on purchase/lease timeframe (error bars represent standard error)



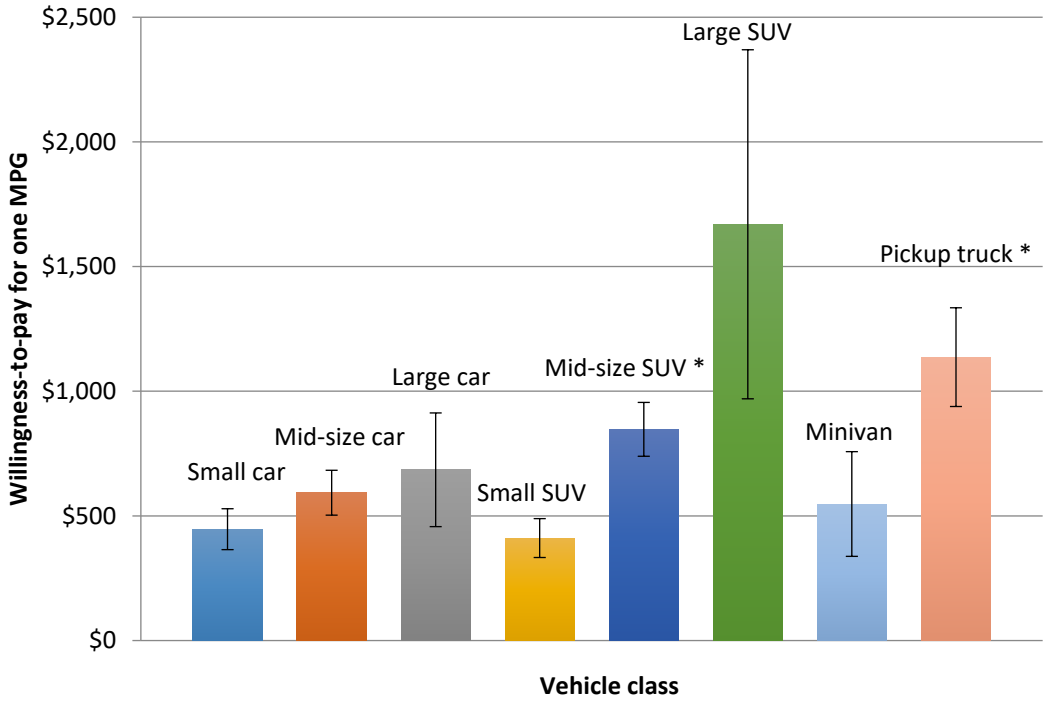
** Valuation of fuel economy among those who intend to purchase/lease a vehicle within the next year was statistically significantly higher than those who intend to purchase/lease a vehicle within one to 2 years (p < .05).*

Valuation of fuel economy did *not* vary statistically significantly based on: gender, level of education, intention to purchase a new or used vehicle, anticipated vehicle miles traveled (VMT) of next vehicle, or intention to purchase, lease, or finance the vehicle. This lack of significance may partly be because these variables were latent in the vehicle type and vehicle purchase price that we used as a filter. A future study with a larger sample size may be better able to detect significant differences in valuation according to these variables.

An examination of WTP for MPG across the eight vehicle classes, based on separate choice models for each class, revealed the highest WTP among those planning to purchase a large SUV ($1,670 for one MPG, *s.e.* = 108), followed by a pickup truck ($1,137 for one MPG, *s.e.* = 198). WTP was statistically significantly higher among those planning to purchase/lease a mid-size SUV ($847 for one MPG, *s.e.* = 108) or a pickup truck, compared to a small SUV ($411 for one MPG, *s.e.* = 78), $p < .05$. WTP was also statistically significantly higher among those planning to purchase/lease a pickup truck, compared to a mid-size SUV or a small car ($447 for one MPG, *s.e.* = 82), $p < .05$ (Figure 17).[14] See Appendix 3 for WTP for each vehicle class as well as WTP for increasing increments of MPG.

[14] Analyses using gal./100 miles did not detect statistically significant differences among valuation of fuel economy for the different vehicle classes.

Figure 167. Willingness-to-pay for one MPG across class of next intended vehicle (error bars represent standard error)



Note: Consumers intending to purchase large SUVs were willing to pay most for fuel economy, relative to all other vehicle classes, but their WTP did not differ significantly from the other classes, likely due to the large standard error. Further research, with increased sample size, may be able to confirm this trend.

** WTP for fuel economy was statistically significantly higher among those planning to purchase a pickup truck (roughly $1,140 for one MPG), compared those interested in purchasing a small car (about $450 for one MPG) or a small SUV (approximately $410 for one MPG) ($p < .05$). WTP was also significantly higher among those planning to acquire a mid-size SUV (about $850 for one MPG) compared to those interested in a small SUV or a small car ($p < .05$).*

Discussion

We found that our nationally representative sample of consumers greatly valued fuel efficiency, especially when it was presented using the familiar metrics of the full fuel economy label or MPG. We also determined that merely presenting fuel economy information to consumers had statistically significant effects on their attitudes and decisions. Findings suggest that consumers highly value fuel economy but that presentation of different fuel economy metrics can significantly affect this valuation.

The current study had several advantages over previous research. It used both explicit (open-ended, multiple choice, and rank-ordering questions) and implicit (discrete choice experiment, DCE) measures of consumer preferences to converge on the same answer. It also embedded the DCE within a randomized experiment to systematically test whether the presentation of fuel economy can affect its valuation. The experiment evaluated demographic information with DCE results in order to allow for an in-depth examination of how different population segments value fuel economy. The experiment maximized external applicability by using a large national sample and tailoring the choice task based on participants' specific vehicle class preferences and intended purchase price for their next vehicle.

Key Findings

We found high, statistically significant WTP values for fuel economy, which suggests that consumers are willing to pay a premium for improved fuel economy. On average across all experimental conditions, consumers were willing to pay about $690 for each additional MPG – or roughly $5,050 for each gallon saved per 100 miles. Similarly, they were willing to pay almost $10,730 more to save $1,000/year in fuel costs across experimental conditions, and respondents particularly valued increasing the fuel economy of the least efficient vehicles. **Consumer valuation of fuel economy (MPG) is relatively greater than valuation of acceleration and premium features/trim, but less than safety and reliability.**

Self-reported findings also revealed that fuel economy is important to consumers. Using both open-ended questions and a list of 19 possible vehicle attributes, four primary vehicle attributes emerged as most important: fuel economy, safety, reliability, and price.

The presence of fuel economy information affects vehicle decision-making. With all attributes held constant, respondents who were presented with fuel economy information made different vehicle choices than those who were not – they chose vehicles that are more efficient.

The presence of fuel economy information affects attitudes about fuel economy. When respondents were presented with fuel economy information during the first part of the study, they subsequently ranked it higher in importance at the end of the study (relative to other attributes).

Not all fuel economy metrics are equal: Full fuel economy label and MPG resulted in the highest WTP for fuel economy. Consumers who saw fuel economy information presented as MPG or the full EPA-mandated fuel economy label were statistically more likely than consumers

who saw other fuel economy metrics to select fuel-efficient vehicles and to rank fuel economy as important, relative to other attributes.

Consumers who saw fuel economy presented as the full EPA-mandated fuel economy label were willing to pay the most for fuel economy (roughly $1,200 for one MPG). This was significantly more than consumers who saw fuel economy presented as annual fuel cost (approximately $450 for one MPG), five-year fuel cost (about $560 for one MPG), and amount spent/saved over five years relative to the average vehicle in that class (more than $430 for one MPG).

Consumers who saw fuel economy information presented as the full fuel economy label or as MPG were more likely to select most fuel-efficient vehicles and to rank fuel economy as important, relative to other attributes. **Taken together, these findings reveal that valuation of fuel economy can vary depending on the information provided.**

Valuation of fuel economy varies across age and household income. Respondents under the age of 50 were willing to pay statistically more for fuel economy ($6,518 for one gal./100 miles) compared to those 50 years of age or older ($3,973 for one gal./100 miles). Follow-up analyses revealed no statistically significant differences among the age sub-categories. For household income, the only statistically significant difference was between those earning $75,000-$99,000 ($983 for one MPG) and those earning less than $25,000 ($383 for one MPG). Nevertheless, consumers in the lowest income bracket still statistically significantly valued fuel economy ($383 for one MPG).

Valuation of fuel economy varies based on some characteristics of the vehicle that consumers plan to buy/lease. Respondents planning to spend $15,000 or more on their next vehicle had statistically significantly higher valuation of fuel economy, compared to those anticipating a purchase price of less than $15,000 for their next vehicle ($182 for one MPG). This suggests that consumers looking for more expensive vehicles may be more willing to pay more for fuel economy when making purchase decisions.

Miles per Gallon

In this study, we found that MPG and the full fuel economy label (which contains MPG, among other metrics) led consumers to make the most fuel-efficient vehicle choices. This is both compelling and reassuring because these forms of presentation are currently the most well-known and frequently used. Previous research suggests that this particular metric may be susceptible to systematic misunderstandings, but our current study casts doubt on this conclusion.

In a landmark study published in *Science*, Larrick and Soll (2008) describe an “MPG Illusion” in which they found that consumers in their study assumed that fuel consumption (and associated costs) increase linearly as MPG decreases. For example, consumers falsely believed that an increase from 34 MPG to 50 MPG saved more gas than an increase from 16 MPG to 20 MPG. They concluded that consumers assessed the size of the difference between the two numbers rather than assuming a curvilinear relationship between MPG and fuel consumption. A similar illusion was reported for appliance energy consumption (Waechter, Sütterlin, and Siegrist, 2015).

Interestingly, participants in our study were willing to pay considerably more for increases in fuel economy in the lowest-efficiency vehicles than in vehicles with higher base efficiency levels (see Figure 2). Given that low-efficiency vehicles indeed benefit most from a bump in MPG, this result suggests that consumers may have some intrinsic understanding of the curvilinear relationship between MPG and fuel consumption. If the "MPG Illusion" explained behavior, then we would expect an equal valuation of fuel economy across all three equally leveled increases in MPG. We hypothesize that this lack of an apparent MPG Illusion could be a result of our more realistic experimental method. By tailoring our study for each participant, we focused consumers on a narrow band of MPG options (vehicle class) that they would realistically consider (and may already have experience with), rather than forcing comparisons between radically different levels of MPG. We believe this is an interesting potential avenue for further study, but recognize that there could also be several alternative explanations for this finding.

Limitations, Future Research, and Action

While this study used realistic choices, allowed respondents to trade off among the most important attributes, triangulated multiple methodologies, and was conducted with a nationally-representative sample, DCEs are not immune to "hypothetical bias." While recent research has shown that stated preferences, assessed via DCEs, demonstrate high external validity of revealed preferences (Lancsar & Swait, 2014), hypothetical bias is an unavoidable potential limitation of using DCEs in that findings may suggest a greater WTP than what respondents' actual choices may reveal that they are willing-to-pay (i.e., in real dollars; Loomis, 2011). This is a limitation that is common to all DCEs and which we have controlled for as much as possible. DCEs are commonly relied on to forecast consumer decisions and influence policy-making (e.g., Greene, 2010).

Furthermore, by conducting the study on six experimental conditions (with random assignment), we have effectively standardized hypothetical bias across our conditions. Our approach therefore allows for controlled experimental manipulation of the presentation of fuel economy information and a relative comparison of WTP values across the conditions. Unlike other DCEs, we tend not to rely solely on individual WTP values, but rather on the *relative difference* between values. We also reduced the potential for bias by tailoring the DCEs more than is often done (and thereby increasing their realism and relevance for each respondent). Last, we have attempted to mitigate potential for bias in our results by triangulating the choice modeling results with participants' responses to explicit measures from three survey questions.

Although Greene's (2010) review indicates lots of variation in consumers' valuation of fuel economy across studies the present WTP results for annual fuel cost are higher than would be expected based on the literature (e.g., Axsen, Mountain, & Jaccard, 2009). Due to the possibility of hypothetical bias, WTP values from the choice experiment may exceed what a consumer would actually be willing-to-pay. Hypothetical bias is not always present in stated choice experiments, although it can result in WTP values that exceed the actual value by a factor of two to three (Loomis, 2011). Thus, it is necessary to use caution in interpreting these pooled valuation findings, as these findings may not translate directly into real-world WTP values.

Implications and Conclusions

This study adds to the growing body of literature regarding consumer valuation of fuel economy. We found that our nationally-representative sample of consumers greatly valued fuel efficiency, especially when it was presented using the familiar metrics of the full fuel economy label or MPG. We also determined that merely presenting fuel economy information to consumers had statistically significant effects on their attitudes and decisions. When the information was available, consumers relied on it to make purchase intention decisions and subsequently rated it as a more important attribute. This implies that consumers may have an underlying preference for fuel-efficient vehicles and, when these options are made available (and their efficiency is emphasized), they may purchase them.

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Appendix 1: Detailed Methods

Study Design

Respondents completed a 15-minute, web-based survey consisting of three parts. The overall flow of the survey is depicted in Figure 18.

Part 1

In Part 1 (pre-experiment survey), respondents were asked a series of background questions, as follows:

- **Demographic information:** e.g., gender, age and income.
- **Current vehicle information:** e.g., current vehicles and usage patterns, and approximate annual distance driven.
- **Next intended vehicle information:** e.g., whether they intend to purchase or lease, when they plan to acquire their next vehicle, whether they plan to buy new or used, what type of vehicle they plan to acquire, estimated purchase price, how much they plan to drive, and the intended uses of the vehicle.
    - Importantly, the participants' estimated purchase price, their preference for new or used vehicles, and their preferred vehicle class were used to customize elements of the DCE in Part 2.
    - The eight potential vehicle classes were: small car, mid-sized car, large car, small SUV, mid-sized SUV, large SUV, minivan, and pickup truck.

Part 2

Part 2 of the survey was designed to assess consumers' implicit preferences for various vehicle features and valuation of fuel economy. Respondents completed a randomized, controlled and customized DCE experiment to model their preferences.

Discrete Choice Experiment

The DCE consisted of an unlabeled experiment in which respondents were presented with six vehicle choice sets, each comprised of three vehicle alternatives with systematically varied vehicle attributes. Participants were asked to select the one vehicle in each set that they would be most likely to purchase/lease. There were systematically varied levels of vehicle attributes, based on the array of potential attributes and levels outlined in Table 3, as follows. Vehicle attributes and levels were derived based on previous literature and interviews with experts at Consumers Union. They were tested for plausibility and realism in an initial small-scale launch with 217 pilot participants from the target population, four of whom also provided researchers with one-on-one interview data. Notably, safety, luxury, and reliability are represented by five-point scales whereas acceleration and fuel economy are represented by continuous values, which is realistic, but nevertheless a limitation for comparison.

1) Purchase price, where the four level values were pivoted around the base of each respondent's self-reported intended purchase price (i.e., $[85%], $[95%], $[105%], or $[115%] the stated price).

2) Fuel economy was tailored based on each respondent's preferred vehicle class (of the eight possible classes) for their next purchase/lease. The form of presentation was varied using a randomized control experiment to determine if the type of metric could affect consumers' valuation. The metrics that were used are presented in the next section, under *Randomization*.

3) Acceleration (0-60 mph) was also tailored based on each respondent's preferred vehicle class (of the eight classes) for their next purchase/lease. Acceleration was included in the DCE using three equally-spaced levels, which as a group were centered on the mid-point of acceleration for each respondent's desired vehicle class. The range we used was based closely on a range provided by experts at Consumer Reports such that the lowest and highest values of the range were 25% lower and higher, respectively, from the mid-point. (Note that that the percentage differences were the same across the levels, regardless of the vehicle class that each respondent selected.)

4) Safety rating (crash protection) was presented as one of three levels (3, 4, or 5 stars).

5) Reliability was also presented as one of three levels (3, 4, or 5 stars).

6) Premium features/trim was presented as one of three levels (1, 3, or 5 stars).

Table 3. Attribute levels for choice experiment (6 choice sets per respondent).

Attributes	Small car	Mid-size car	Large car	Small SUV	Mid-size SUV	Large SUV	Minivan	Pickup truck
Purchase price (MSRP) *Pivoted around each respondent's intended purchase price*	$[85% stated price] $[95% stated price] $[105% stated price] $[115% stated price]							
Condition 1: Fuel economy - MPG (combined city/highway) *25% difference*	28 mpg 34 mpg 41 mpg 47 mpg	25 mpg 31 mpg 36 mpg 42 mpg	20 mpg 24 mpg 29 mpg 33 mpg	22 mpg 27 mpg 32 mpg 37 mpg	18 mpg 22 mpg 26 mpg 30 mpg	16 mpg 20 mpg 23 mpg 27 mpg	18 mpg 22 mpg 26 mpg 30 mpg	16 mpg 20 mpg 23 mpg 27 mpg
Condition 2: Annual fuel cost	$1,400 $1,140 $960 $840	$1,560 $1,270 $1,080 $930	$1,970 $1,610 $1,360 $1,180	$1,770 $1,450 $1,230 $1,060	$2,180 $1,780 $1,510 $1,310	$2,430 $1,990 $1,680 $1,460	$2,180 $1,780 $1,510 $1,310	$2,430 $1,990 $1,680 $1,450
Condition 3: Five year fuel costs	$6,990 $5,690 $4,820 $4,180	$7,790 $6,370 $5,390 $4,670	$9,850 $8,060 $6,820 $5,910	$8,850 $7,240 $6,130 $5,310	$10,880 $8,900 $7,530 $6,530	$12,140 $9,930 $8,400 $7,280	$10,880 $8,900 $7,530 $6,530	$12,140 $9,930 $8,400 $7,250

Attributes	Small car	Mid-size car	Large car	Small SUV	Mid-size SUV	Large SUV	Minivan	Pickup truck
Condition 4: "What you save or spend over 5 years compared to the average new vehicle"	Spend $1,570 Spend $270 Save $600 Save $1,240	Spend $1,740 Spend $320 Save $670 Save $1,390	Spend $2,190 Spend $400 Save $840 Save $1,750	Spend $1,970 Spend $360 Save $750 Save $1,570	Spend $2,420 Spend $440 Save $930 Save $1,930	Spend $2,700 Spend $490 Save $1,040 Save $2,160	Spend $2,420 Spend $440 Save $930 Save $1,930	Spend $2,710 Spend $500 Save $1,030 Save $2,180
Condition 5: Lifetime fuel cost	$16,300 $13,280 $11,230 $9,740	$18,170 $14,860 $12,580 $10,900	$22,960 $18,790 $15,900 $13,780	$20,630 $16,880 $14,280 $12,380	$25,360 $20,750 $17,550 $15,210	$28,300 $23,160 $19,600 $16,980	$25,360 $20,750 $17,550 $15,210	$28,300 $23,160 $19,600 $16,900
Condition 6: Full label image	28 mpg 34 mpg 41 mpg 47 mpg	25 mpg 31 mpg 36 mpg 42 mpg	20 mpg 24 mpg 29 mpg 33 mpg	22 mpg 27 mpg 32 mpg 37 mpg	18 mpg 22 mpg 26 mpg 30 mpg	16 mpg 20 mpg 23 mpg 27 mpg	18 mpg 22 mpg 26 mpg 30 mpg	16 mpg 20 mpg 23 mpg 27 mpg
Condition 7: No fuel economy information (control condition)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Attributes	Small car	Mid-size car	Large car	Small SUV	Mid-size SUV	Large SUV	Minivan	Pickup truck
Acceleration (0-60 mph)	7.0 sec.	6.5 sec.	5.9 sec.	6.8 sec.	6.8 sec.	6.2 sec.	7.0 sec.	5.4 sec.
25% difference	9.2 sec.	8.6 sec.	7.8 sec.	9.0 sec.	8.9 sec.	8.2 sec.	9.3 sec.	7.2 sec.
	11.3 sec.	10.6 sec.	9.6 sec.	11.2 sec.	11.0 sec.	10.1 sec.	11.5 sec.	8.9 sec.
Safety rating (crash protection)	3 stars							
	4 stars							
	5 stars							
Reliability	3 stars							
	4 stars							
	5 stars							
Premium features/trim	1 star							
	3 stars							
	5 stars							

Randomization

Fuel economy information was presented differently depending on which of seven conditions to which each respondent was randomly assigned: one of six conditions that include various presentations of fuel economy information, or a control condition that lacks fuel economy information. The specific values in the choice experiment were tailored based on which of eight vehicle classes each respondent indicated they are likely to purchase/lease as their next vehicle.[15] Importantly, the conditions differed only in *form* and not in *content.* Fuel economy was always included in the DCE using four equally-spaced levels, which as a group were centered on the mid-point of fuel economy for each respondent's desired vehicle class. The range we used was based closely on a range provided by experts at Consumer Reports such that the lowest and highest values of the range were 25% lower and higher, respectively, from the mid-point.[16] These levels of fuel economy presented using one of the following metrics:

- ***Condition 1: MPG*** (combined city/highway); for example, "*24 MPG*."
- ***Condition 2: Annual fuel cost*** (assuming annual mileage of 15,000, 55% under city conditions and 45% under highway conditions, and assuming $2.61/gallon for regular gasoline based on the EPA's use of this value for 2018 model year vehicles on fuel economy labels); for example, "*$1,610*."
- ***Condition 3: Five-year fuel cost*** (assuming five-year mileage of 75,000, 55% under city conditions and 45% under highway conditions, and assuming $2.61/gallon for regular gasoline based on the EPA's use of this value for 2018 model year vehicles on fuel economy labels); for example, "*$8,060*."
- ***Condition 4: What you save/spend over five years*** (compared to the average new vehicle); for example, "*You save $400 in fuel costs over 5 years*."
- ***Condition 5: Lifetime fuel cost*** (assuming 25-year VMT of 152,137 miles per vehicle for all 8 classes) from the NHTSA's VMT Schedule for Passenger Cars, and assuming $3.00/gallon, as EIA projections predict higher gasoline prices; for example, "*$18,790*."
- ***Condition 6: Full fuel economy label***, including mpg (combined city/highway), amount saved/spent over 5 years compared to the average new vehicle, annual fuel cost, fuel economy and greenhouse gas rating, and smog rating.[17]
- ***Condition 7: Control condition*** (lacks fuel economy information).

These data were then used to create six vehicle choice sets containing customized versions of three vehicle options. Those randomly assigned to Condition 1 – 6 viewed all six attributes, and those assigned to Condition 7 viewed five attributes because they were not shown fuel economy. An "efficiency" design was used to allocate the total full factorial of potential combinations of these attributes and levels to choice sets, where the final D-efficiency of the design was 90.95%, which is higher than the general guideline of 80% needed to indicate a

[15] Participants were aware that their DCE was customized because of the purchase price and the small graphic representing the vehicle class they selected

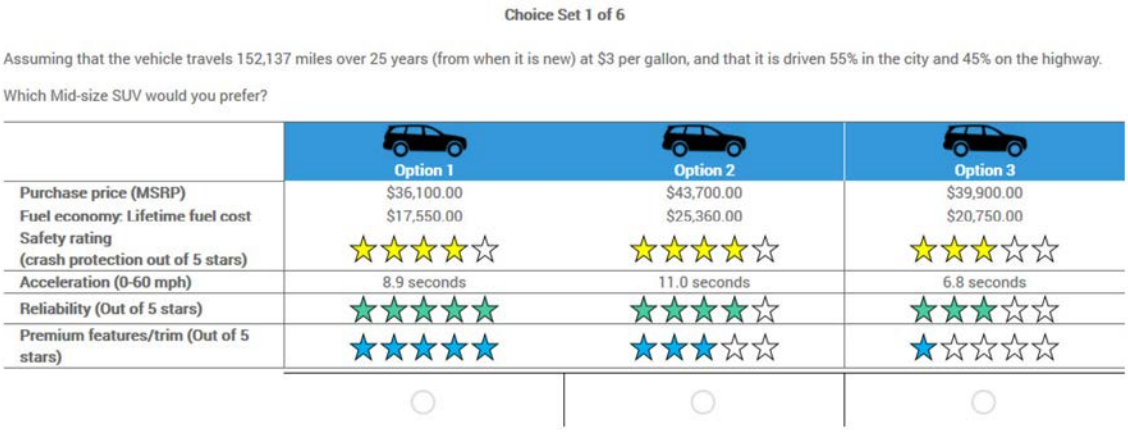
[16] Note that that the percentage differences were the same across the levels, regardless of the vehicle class that each respondent selected

[17] Note: All the metrics in the fuel economy label varied in tandem, except smog rating which was independent and remained at 6/10 for all vehicles.

"good" design that is balanced and orthogonal (Bliemer and Rose, 2011). As part of generating the design, we ensured that unrealistic attribute combinations were not created and that all choice sets were different. In particular, we used two constraints to prevent the inclusion of an unrealistic alternative in our choice sets, as follows: 1) highest acceleration cannot occur with highest fuel economy, and 2) level 2 and 3 for premium features/trim cannot exist with the lowest price. The design was checked to ensure that there were not any issues with duplicates, violated constraints, other anomalies, that there were no identical attributes displayed across all three alternatives, and that the DCEs contained adequate variation in alternative levels.

This series of 48 choice sets were then divided into eight blocks of six choice sets. Respondents were then randomly assigned to receive one block, in which each respondent was presented with six choice sets from which to choose one of three vehicles. For the control condition, we use an exact replica of the design file – to be able to compare respondents' choices in choice sets that are otherwise identical except for fuel economy information (relative D-efficiency = 60%). Figure 17 depicts how the vehicle choice set appeared to respondents, and Appendix 2 shows screenshots from each of the seven conditions.

Figure 17. Example of choice experiment (Condition 5: Lifetime fuel cost).



Choice Set 1 of 6

Assuming that the vehicle travels 152,137 miles over 25 years (from when it is new) at $3 per gallon, and that it is driven 55% in the city and 45% on the highway.

Which Mid-size SUV would you prefer?

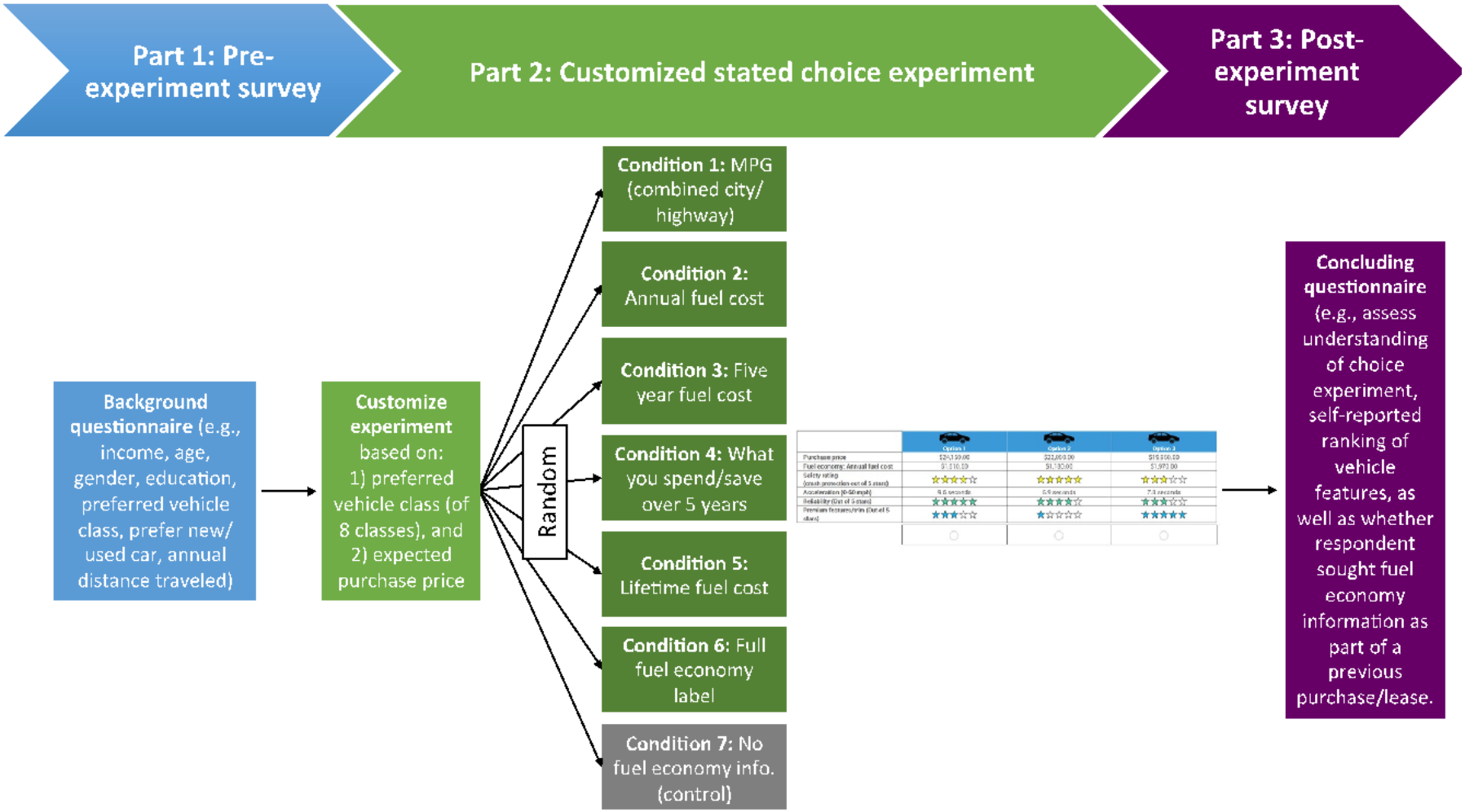
	Option 1	Option 2	Option 3
Purchase price (MSRP)	$36,100.00	$43,700.00	$39,900.00
Fuel economy: Lifetime fuel cost	$17,550.00	$25,360.00	$20,750.00
Safety rating (crash protection out of 5 stars)	★★★★☆	★★★★☆	★★★☆☆
Acceleration (0-60 mph)	8.9 seconds	11.0 seconds	6.8 seconds
Reliability (Out of 5 stars)	★★★★★	★★★★☆	★★★☆☆
Premium features/trim (Out of 5 stars)	★★★★★	★★★☆☆	★☆☆☆☆

Part 3

In Part 3 of the experiment (post-choice experiment survey), participants were asked concluding questions to assess:

- **Self-reported (explicit) importance of vehicle features:** including open-ended qualitative listing of features, rank order of the six vehicle attributes from the choice experiment, and selection of up to six vehicle features that are most important to each participant from a broad list of 19 attributes.
- **Initiative to seek out fuel economy information:** i.e., whether or not the respondent sought out fuel economy information (e.g., online or in a magazine) as part of their previous vehicle purchase or lease.
- **Respondents' understanding of the choice experiment:** i.e., on a 5-point scale assessing extent to which task was clear and understood.
- **Opportunity to provide comments, thoughts, or suggestions regarding the survey:** open-ended response.

Figure 18. Overview of survey flow.



Data Collection

A market research company (ORC) was contracted to recruit a cross-national sample of Americans with a valid driver's license and who plan to purchase/lease a vehicle (new or used) in the next ten years.

After excluding participants for failing all three quality control questions (n = 323), not meeting screening criteria (n = 1,295), or not meeting other quota requirements (n = 214), the researchers were left with 1,883 car consumers from across the U.S. on which to conduct the analyses.

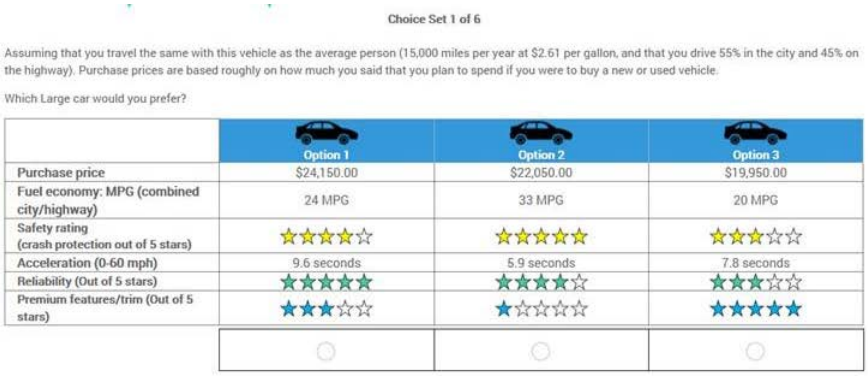
Data Analysis

We conducted a range of analyses on our dataset, using a variety of methods to analyze the data. Here, we provide brief summaries of the main types of analyses used in this report:

- **Descriptive and frequency analyses:** used to quantify basic counts and distributions of data (e.g., a count of the number of participants who intend to purchase or lease each type of vehicle class, or mean intended purchase price for their next vehicle).
- **Analysis of variance (ANOVA) and independent-samples *t*-test:** used to evaluate whether or not a statistically significant difference exists in the vehicle choices made by respondents among the various experimental conditions, as well as between those who received the control versus experimental conditions.
- **Discrete choice models:** used to analyze data from the choice experiment, which statistically quantifies consumer preferences for (and trade-offs among) vehicle attributes as well as consumer WTP for each attribute. We compared WTP for fuel economy across conditions.

Appendix 2: Randomized Discrete Choice Experiment Examples

Condition 1: MPG



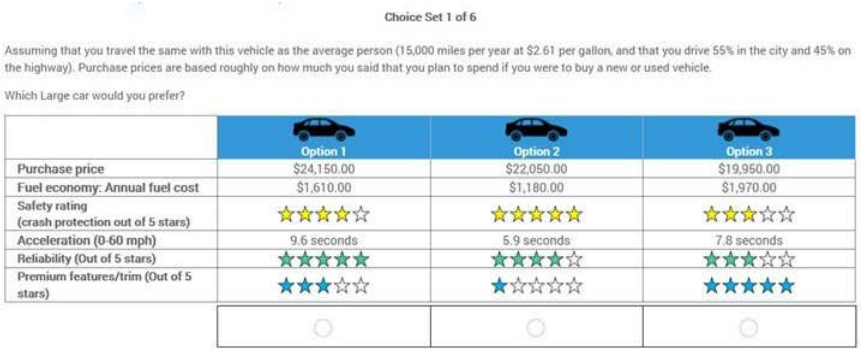
Choice Set 1 of 6

Assuming that you travel the same with this vehicle as the average person (15,000 miles per year at $2.61 per gallon, and that you drive 55% in the city and 45% on the highway). Purchase prices are based roughly on how much you said that you plan to spend if you were to buy a new or used vehicle.

Which Large car would you prefer?

	Option 1	Option 2	Option 3
Purchase price	$24,150.00	$22,050.00	$19,950.00
Fuel economy: MPG (combined city/highway)	24 MPG	33 MPG	20 MPG
Safety rating (crash protection out of 5 stars)	★★★★☆	★★★★★	★★★☆☆
Acceleration (0-60 mph)	9.6 seconds	5.9 seconds	7.8 seconds
Reliability (Out of 5 stars)	★★★★★	★★★★☆	★★★☆☆
Premium features/trim (Out of 5 stars)	★★★☆☆	★☆☆☆☆	★★★★★
	○	○	○

Condition 2: Annual Fuel Cost



Choice Set 1 of 6

Assuming that you travel the same with this vehicle as the average person (15,000 miles per year at $2.61 per gallon, and that you drive 55% in the city and 45% on the highway). Purchase prices are based roughly on how much you said that you plan to spend if you were to buy a new or used vehicle.

Which Large car would you prefer?

	Option 1	Option 2	Option 3
Purchase price	$24,150.00	$22,050.00	$19,950.00
Fuel economy: Annual fuel cost	$1,610.00	$1,180.00	$1,970.00
Safety rating (crash protection out of 5 stars)	★★★★☆	★★★★★	★★★☆☆
Acceleration (0-60 mph)	9.6 seconds	5.9 seconds	7.8 seconds
Reliability (Out of 5 stars)	★★★★★	★★★★☆	★★★☆☆
Premium features/trim (Out of 5 stars)	★★★☆☆	★☆☆☆☆	★★★★★
	○	○	○

Condition 3: Five-year Fuel Cost

Choice Set 1 of 6

Assuming that you travel the same with this vehicle as the average person (15,000 miles per year at $2.61 per gallon, and that you drive 55% in the city and 45% on the highway). Purchase prices are based roughly on how much you said that you plan to spend if you were to buy a new or used vehicle.

Which Large car would you prefer?

	Option 1	Option 2	Option 3
Purchase price	$24,150.00	$22,050.00	$19,950.00
Fuel economy: Five-year fuel cost	$8,060.00	$5,910.00	$9,850.00
Safety rating (crash protection out of 5 stars)	★★★★☆	★★★★★	★★★☆☆
Acceleration (0-60 mph)	9.6 seconds	5.9 seconds	7.8 seconds
Reliability (Out of 5 stars)	★★★★★	★★★★☆	★★★☆☆
Premium features/trim (Out of 5 stars)	★★★☆☆	★☆☆☆☆	★★★★★
	○	○	○

Condition 4: Spend or Save Relative to Average

Choice Set 1 of 6

Assuming that you travel the same with this vehicle as the average person (15,000 miles per year at $2.61 per gallon, and that you drive 55% in the city and 45% on the highway). Purchase prices are based roughly on how much you said that you plan to spend if you were to buy a new or used vehicle.

Which Large car would you prefer?

	Option 1	Option 2	Option 3
Purchase price	$24,150.00	$22,050.00	$19,950.00
Fuel economy: What you save or spend over 5 years compared to the average new vehicle	You save $400.00 in fuel costs over 5 years	You spend $1,750.00 in fuel costs over 5 years	You save $2,190.00 in fuel costs over 5 years
Safety rating (crash protection out of 5 stars)	★★★★☆	★★★★★	★★★☆☆
Acceleration (0-60 mph)	9.6 seconds	5.9 seconds	7.8 seconds
Reliability (Out of 5 stars)	★★★★★	★★★★☆	★★★☆☆
Premium features/trim (Out of 5 stars)	★★★☆☆	★☆☆☆☆	★★★★★
	○	○	○

Condition 5: Lifetime Fuel Cost

Choice Set 1 of 6

Assuming that the vehicle travels 152,137 miles over 25 years (from when it is new) at $3 per gallon, and that it is driven 55% in the city and 45% on the highway. Purchase prices are based roughly on how much you said that you plan to spend if you were to buy a new or used vehicle.

Which Large car would you prefer?

	Option 1	Option 2	Option 3
Purchase price	$24,150.00	$22,050.00	$19,950.00
Fuel economy: Lifetime fuel cost	$18,790.00	$13,780.00	$22,960.00
Safety rating (crash protection out of 5 stars)	★★★★☆	★★★★★	★★★☆☆
Acceleration (0-60 mph)	9.6 seconds	5.9 seconds	7.8 seconds
Reliability (Out of 5 stars)	★★★★★	★★★★☆	★★★☆☆
Premium features/trim (Out of 5 stars)	★★★☆☆	★☆☆☆☆	★★★★★
	○	○	○

Condition 6: Full Fuel Economy Label

Choice Set 1 of 6

Assuming that you travel the same with this vehicle as the average person (15,000 miles per year at $2.61 per gallon, and that you drive 55% in the city and 45% on the highway). Purchase prices are based roughly on how much you said that you plan to spend if you were to buy a new or used vehicle.

Which Large car would you prefer?

	Option 1	Option 2	Option 3
Purchase price	$54,050.00	$49,350.00	$44,650.00
Fuel economy: Full label information			
Safety rating (crash protection out of 5 stars)	★★★☆☆	★★★★★	★★★★☆
Acceleration (0-60 mph)	7.8 seconds	5.9 seconds	5.9 seconds
Reliability (Out of 5 stars)	★★★☆☆	★★★★☆	★★★★★
Premium features/trim (Out of 5 stars)	★☆☆☆☆	★★★★★	★★★☆☆
	○	○	○

Condition 7: No Fuel Economy Information (Control)

Choice Set 1 of 6

Assuming that you travel the same with this vehicle as the average person (15,000 miles per year at $2.61 per gallon, and that you drive 55% in the city and 45% on the highway). Purchase prices are based roughly on how much you said that you plan to spend if you were to buy a new or used vehicle.

Which Large car would you prefer?

	Option 1	Option 2	Option 3
Purchase price	$24,150.00	$22,050.00	$19,950.00
Safety rating (crash protection out of 5 stars)	★★★★☆	★★★★★	★★★☆☆
Acceleration (0-60 mph)	9.6 seconds	5.9 seconds	7.8 seconds
Reliability (Out of 5 stars)	★★★★★	★★★★☆	★★★☆☆
Premium features/trim (Out of 5 stars)	★★★☆☆	★☆☆☆☆	★★★★★
	○	○	○

Appendix 3: Demographics and Descriptive Statistics

Respondent Characteristics

Characteristic		Study Sample	US Census (2017)
Sex			
	Male	50.9%	48.2%
	Female	49.1%	51.8%
Age			
	18-24	8.1%	11.9%
	25-34	16.2%	17.9%
	35-44	16.8%	16.2%
	45-54	17.5%	17.1%
	55-64	19.0%	16.8%
	65+	22.5%	20.1%
Region			
	Northeast	18.9%	17.8%
	Midwest	22.3%	20.9%
	South	38.2%	37.6%
	West	20.7%	23.7%
Education			
	Some college or less	67.6%	68.6%
	College Graduate	20.4%	20.0%
	Advanced Degree	11.8%	11.4%
Race			
	White/Caucasian	77%	79.1%
	Black/African American	10%	12.3%
	Other, including Mixed Race	13%	8.6%

Characteristic	**Study Sample**	**US Census (2017)**
Income		
<$25,000	17.3%	
$25k to $49,999	30.9%	
$50k to $74,999	24.2%	
$75k to $99,999	12.9%	
$100k to $149,999	10.0%	
$150k to $249,999	3.6%	
$250k to $499,999	.9%	
$500k or more	.3%	
Searched for fuel economy information before buying current vehicle		
Yes	54.4%	
No	32.6%	
Can’t remember	11.0%	
Never owned	2.0%	

Current Vehicle Ownership

Characteristic		Study sample
Number of Vehicles Owned		
	0	4.0%
	1	48.2%
	2	36.4%
	3+	11.4%
Vehicle Class (currently owned vehicle that is driven most often)		
	Small Car	11.6%
	Mid-Sized car	32.6%
	Large car	5.5%
	Small SUV	8.0%
	Mid-Size SUV	18.1%
	Large SUV	5.0%
	Minivan	4.2%
	Pickup Truck	9.6%
	Other	1.3%
	Don't drive a vehicle	4.1%
Vehicle miles travelled (estimated by participants for current vehicle)		
	Mean	12,260 miles (SD = 8874.2)
	Median	12,000 miles

Characteristic		**Study sample**
Uses of current vehicle (that is driven most often)		
	Commuting to work	0 days = 43%, 1 day = 4% 2-4 days =13%, 5-7 days = 37%, missing = 4%
	Commuting to school	0 days = 75%, 1 day = 4%, 2-4 days = 9%, 5-7 days = 9%, missing = 4%
	Running errands	0 days = 1%, 1 day = 12%, 2-4 days = 56%, 5-7 days = 28%, missing = 4%
	Leisure	0 days = 6%, 1 day = 21%, 2-4 days = 44%, 5-7 days = 25%, missing = 4%

Intended Vehicle Purchase or Lease

Characteristic		Study sample
Purchase date of intended vehicle		
	In one year	32.0%
	In two years	32.7%
	In four years	20.5%
	In six years	8.7%
	In eight years	2.7%
	In ten years	3.5%
Purchase price of intended vehicle ($USD)		
	Overall mean	$26,360 (SD = $15,043)
	Overall median	$25,000
	New vehicle mean	$33,654 (SD = $13,814)
	New vehicle median	$30,000
	Used vehicle mean	$16,355 (SD = $10,100)
	Used vehicle median	$15,000
Payment method		
	Purchase	29%
	Finance	52%
	Lease	7%
	Don’t know yet	12%

Characteristic		**Study sample**
Vehicle Class intended to purchase or lease		
	Small Car	9.9%
	Mid-Sized car	28.2%
	Large car	5.2%
	Small SUV	24.5%
	Mid-Size SUV	6.0%
	Large SUV	3.2%
	Minivan	3.2%
	Pickup Truck	11.6%
Drivetrain of intended vehicle		
	Gasoline	76%
	Hybrid	13%
	Diesel	2%
	Unsure/Don’t know	7%

Willingness-to-pay for fuel economy across respondent demographics and characteristics of next intended vehicle.

Characteristics		WTP to save one gal./100 miles	*s.e.*
Gender			
	Male	$5,252	537.71
	Female	$4,720	439.18
Age*			
	35 years or less	$8,428	1,521.30
	36 to 50 years	$4,972	652.77
	51 to 63 years	$3,596	480.01
	64 years or older	$4,390	553.37
	Less than 50 (median split)*	$6,518	723.25
	50 years or more (median split)*	$3,973	355.53
Education			
	Some college or less education	$4,113	373.89
	Associate/college degree or more education	$6,032	638.32
Household income*			
	Less than $25,000*	$2,969	407.31
	$25,000-$49,999	$4,296	498.62
	$50,000-$74,999	$4,896	684.49
	$75,000-$99,999*	$7,013	1,470.70
	Greater than $100,000	$5,504	1,209.00

Characteristics	**WTP to save one gal./100 miles**	***s.e.***
Vehicle type		
Small car	$5,882	1091
Mid-size car	$6,243	944
Large car	$4,745	1542
Small SUV	$3,338	627
Mid-size SUV	$4,505	578
Large SUV	$7,271	3063
Minivan	$2,773	1124
Pickup truck	$4,952	877
Small SUVs and smaller	$5,306	514.77
Mid-size SUVs and larger	$4,936	492.92
Anticipated purchase price*		
Less than $15,000*	$1,468	170.25
$15,000-$24,999*	$2,981	290.72
$25,000-$34,999*	$3,150	375.17
Greater than $35,000*	$5,118	954.88
How plan to obtain next vehicle		
Cash	$5,847	951.78
Lease	$4,483	1359.60
Loan	$4,465	356.66
I don't know	$6,547	1545.10

Characteristics	**WTP to save one gal./100 miles**	***s.e.***
Purchase/lease timeframe*		
Within 1 year*	$6,500	914.54
1 to 2 years*	$3,729	404.97
2 to 4 years	$5,605	827.66
4 years or more	$4,776	785.24
New/used		
New	$4,930	483.20
Used	$3,414	307.17

Note: Variables denoted with an asterisk (*) in the table yielded statistically significant differences in valuation.

Fuel Economy (MPG) of vehicles selected in choice experiment for each of eight classes

Vehicle class	*n*	Average MPG of class	Average MPG of vehicles selected in choice experiment	SD of MPG of vehicles selected in choice experiment	% of sample with average selected MPG lower than class average
Small car	186	37	38.77	3.40	32.3%
Mid-size car	531	34	34.32	2.39	31.6%
Large car	97	27	26.97	2.02	29.9%
Small SUV	217	30	30.19	2.18	33.2%
Mid-size SUV	461	24	24.71	1.98	30.4%
Large SUV	113	22	22.00	1.75	39.8%
Minivan	60	24	24.60	2.17	33.3%
Pickup truck	218	22	22.45	1.81	26.1%

Willingness-to-pay for one MPG per vehicle class as well as to move up MPG increments for each class.

Vehicle class	MPG range	WTP (MPG)	*s.e.*
Small car		**$446.62**	**82.24**
	28 to 34 MPG	$3,212	
	34 to 41 MPG	$3,117	
	41 to 47 MPG	$2,168	
Mid-size car		**$592.92**	**89.58**
	25 to 31 MPG	$4,499	
	31 to 36 MPG	$3,111	
	36 to 42 MPG	$2,414	
Large car		**$684.91**	**227.74**
	20 to 24 MPG	$7,933	
	24 to 29 MPG	$164	
	29 to 33 MPG	$2,516	
Small SUV		**$411.03**	**77.85**
	22 to 27 MPG	$3,146	
	27 to 32 MPG	$1,348	
	32 to 37 MPG	$1,938	
Mid-size SUV		**$847.10**	**107.87**
	18 to 22 MPG	$3,938	
	22 to 26 MPG	$2,783	
	26 to 30 MPG	$3,699	
Large SUV		**$1,669.50**	**700.16**
	16 to 20 MPG	$12,484	
	20 to 23 MPG	-$182	
	23 to 27 MPG	$8,573	
Minivan		**$547.65**	**210.04**
	18 to 22 MPG	-$767	
	22 to 26 MPG	$4,075	
	26 to 30 MPG	$2,344	
Pickup truck		**$1,136.70**	**198.03**
	16 to 20 MPG	$4,812	
	20 to 23 MPG	$4,097	
	23 to 27 MPG	$3,495	