Determinants of Consumer Choice for Biofuels
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FPTI Research Report Number 3

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Determinants of Consumer Choice for Biofuels

Abstract

We use data from a national survey to investigate consumers’ preference for cellulose- and corn-based ethanol using discrete choice modeling approach. Due to both positive and negative information about environmental footprints from the use of ethanol as a transportation fuel, consumers’ fuel choice becomes complicated. We investigate the relationship between consumers’ fuel choice (gasoline, cellulose-based and corn-based ethanol) and attributes (price, emissions, and service availability), and a set of behavioral and socio-demographic variables. The results indicate that economic incentives, such as cheaper prices and service availability exceed environmental incentives such as reduction in environmental emission levels. The price attribute influenced consumers’ choice decision making by 83% more than the emission levels attribute, and by 69% more than the service availability. We also find that the respondents with higher levels in proenvironmental norms not only prefer ethanol to gasoline, but they also prefer the environmentally cleaner alternative - cellulose-based ethanol. Increasing the extent to which individuals care about the future consequences from their current actions led to increased preference for environmentally cleaner fuels. Finally, we find that respondents’ sensitivity to fuel attributes varies across several individual characteristics, such as proenvironmental norms, the consideration of future consequences, income, as well as across geography. The findings contribute to predicting consumer’s behavior, which increasingly became important in determining consumer demand. The results also provide important policy implications for the effective marketing of next generation clean transportation fuels.

Keywords: biofuels, discrete choice analysis, value-belief-norm theory, stated preferences, proenvironmental behavior, consideration of future consequences.
INTRODUCTION AND BACKGROUND

“Ethanol is a magic elixir. It allows politicians and political operations to promise voters that America can achieve energy independence” (Bryce 2007). Counterintuitive to the common sense that biofuels are environmentally friendly fuels, several massive displays in Oklahoma City advertised ethanol-free gasoline (Galbraith 2008): “Why put corn in your tank? Increase MPG, buy 100% gas here!” Today, consumers face increasing misinformation and disinformation about environmental and economic cost-benefits of biofuels. However, regardless of the ongoing speculation and surrounding political climate, biofuels’ potential as an alternative to long-time dominated petroleum-based fuels has escalated. The Energy Independence and Security Act (EISA) of 2007 proposed to increase the Renewable Fuel Standard (RFS)\(^1\) to meet the 36 billion gallons target by 2022 (EISA 2007; Sissine 2007). If successful, this will replace roughly one third of the U.S. transportation sector’s fuel consumption. Further, to ensure sustainable energy and environmental future for the economy, starting in 2015, only advanced biofuels (i.e. those processed from cellulose\(^2\)) will be counted toward the RFS target (EISA 2007). Under these conditions, will consumer’s economic incentives (e.g., lower price or service availability) dominate environmental concerns (e.g., greenhouse gas emissions (GHG) or air pollution reduction) when choosing among different transportation fuels at the service station?

Consumers, including those considering themselves environmentally conscious, may have little or no knowledge about biofuels’ net energy balance or feedstock types (cellulose vs.

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\(^1\) For comparison, the Renewable Fuel Standards for 2008 were only 9 billion gallons (EISA 2007; Sissine 2007).

\(^2\) Cellulose refers to “non-food,” cellulosic feedstocks, including dedicated energy crops, such as switchgrass, algae, poplar, etc., woody biomass, such as agricultural crop residue, forest residue, or animal manure, municipal solid waste, to name a few.
corn) that are used for ethanol processing. What attributes and to what extent will make the consumer to prefer biofuel to conventional gasoline? This initiates a question, about the determinants of the behavioral process that influences consumers’ fuel choice decisions. Some of the past research investigating the environmental/economic cost-benefits argues about the positive aspects of biofuels (Farrell et al. 2006). In general, the proponents argue for biofuels’ positive net energy balance and the contribution to the GHG emissions and air pollution reduction, sometimes overstating the actual environmental benefits. Only a few studies have tried to investigate possible adverse impact on the environment (Doornbosch & Steenblik 2007; Zah 2007). The uncertainty from these bipolar research-based recommendations can be misleading at the policy decision making level, as well as for an average consumer facing fuel choices at the service station. Therefore, an important dimension of research around biofuels involves an investigation of the behavioral process that influences consumers’ fuel choice.

The primary objective of this paper is to investigate consumers’ preferences for two types of biofuels – corn- and cellulose-based ethanol using data from an online national survey. In particular, we quantify the influence of interactions of fuel attributes and behavioral/socio-demographic variables on consumer choice. In the online survey, we included the extended version of the consideration of future consequences scale, a measure which has been widely used in the peer reviewed research literature to measure the extent to which consumers care about the future consequences from their current choices. Additionally, we measure the weights that survey participants’ assign to fuel attributes, including their willingness-to-pay (WTP) premium for the ethanol fuel. A discrete choice analysis is conducted, which involves both socio-

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3 (Zah 2007) reports that current ethanol processing from several feedstocks including U.S. produced corn, Brazilian soy, and Malaysian palm oil can lead to worse environmental consequences compared to fossil fuels, when the impact of the entire supply chain is considered.

4 In this paper, ethanol refers to E85 fuel, which is a blend of 85 percent ethanol and 15 percent gasoline.
economic (i.e., price and fueling station availability) and environmental (i.e., GHG emissions) attributes of the fuel types under investigation – gasoline, corn- and cellulose-based ethanol). In contrast to the research investigating consumer’s preferences through the direct effects of product attributes on choice, this paper incorporates behavioral variables that help understanding the process of choice decision making. Those behavioral variables include value orientations, environmental concerns, awareness of consequences, and proenvironmental personal norms.

The transition from petroleum-based fuels to alternative fuel consumption involves some understanding or concern about potential adverse impacts on the environment. Thus far, dominated by economic feasibility studies (Doornbosch & Steenblik 2007; Stiles et al. 2008; U.S. Government Accountability Office 2007) and environmental cost-benefit analysis (Doornbosch & Steenblik 2007; Farrell et al. 2006; Toman et al. 2008; Zah 2007), an in-depth investigation of the determinants of consumers’ preferences for biofuels has been overlooked. A handful of studies investigated consumer preferences for alternative fuel vehicles (Ahn et al. 2008; Bhat & Sudeshna Sen 2006; Bhat et al. 2009; Fang 2008). In these studies that involved vehicle-specific attributes, the structure of consumers’ preference formation is fundamentally different. This is because the product attributes are mostly related to the vehicles, i.e., annual maintenance cost, acceleration, body type, single passenger HOV line usage incentive, etc. Consequently, the experimental designs that are dominated by vehicle-oriented attributes do not identify and isolate the link between consumers’ characteristics and fuel-specific attributes. Consumers may prefer a vehicle that has the capacity to consume both gasoline and ethanol fuel. But regardless of that initial decision to buy a flexible-fuel car, their fuel choice decision can still be influenced by speculations about the benefits of using ethanol.
Additionally, research efforts in which the central focus is on the relationship between corporate proenvironmental behavior and consumer expectations, leaves out nuances of consumer-level heterogeneous behaviors (Brown & Dacin 1997; Creyer & Ross Jr. 1997; Sankar Sen & Bhattacharya 2001; Trudel & Cotte 2009) such as consumer sensitivity for greenhouse emissions (from the use of transportation fuels) across different age, income groups, or geography. Thus, to the best of our knowledge, none of the previous research investigated the consumers’ heterogeneous preferences for biofuels by incorporating both economic and environmental attributes/incentives.

For purposes in this paper, the role of differentiating between the cellulose- and corn-based ethanol in the product choice set is essential. Besides its promising environmental benefits, the adoption of cellulosic feedstocks for ethanol processing provides potential to reduce the long-term economic feasibility issues. Driven by the global economic/financial crisis, the volatility in corn prices has recently caused many ethanol producers, including the biggest U.S. corn-based ethanol producer VeraSun Energy Corporation, to fill for bankruptcy (Biofuels Business 2008). Most notably, the use of cellulosic feedstocks for ethanol processing will enable flexibility to avoid some of the potential environmental problems related to substantive use of fertilizers for corn production (e.g. nitrogen runoffs into water sources). Finally, cellulosic feedstocks are resource abundant and do not contribute to the increasing food prices. Thus, with an increasing criticism for the use of corn as feedstock, cellulose-based ethanol gains considerable attention as a second-generation fuel, despite being under development stage. Given these different characteristics of the corn- and cellulose-based ethanol blends, the consumer choice decision requires considerations from both economic and environmental aspects, which presumably complicates the decision making process.
In addition to uncovering the behavioral process that leads to some choice outcome, the identification of important attributes and their interaction with individuals’ characteristics has managerial implications. Responsible marketing action requires better understanding of the characteristics of the socially and environmentally conscious consumer. Therefore, to develop successful marketing strategies for the new product – cellulose-based ethanol (which is not marketed yet), in-depth understanding of the weights that consumers assign to product attributes is imperative. Additionally, consumers’ environmental consciousness or an interest in environmental protection can be determined by their consideration of public consequences of current private consumption (Trudel & Cotte 2009; Webster 1975). The level of concern, or the way consumers treat current ecological problems can influence their actions to contribute or to further deteriorate the environment (Joireman et al. 2006; Kinnear & Taylor 1973). These considerations, coupled with the previous research findings disparity (arguing for both positive and negative economic/environmental consequences from the ethanol production and use) suggest an extra attention to investigating the consumer preferences for different alternative fuels. Additionally, at a macro level, a better understanding of consumers’ behavioral process may contribute to the development and viability of an emerging ethanol industry.

The rest of the paper is organized as follows. In the subsequent section, we review the relevant literature, by integrating them into the theoretical framework underlying this research. The section 2 discusses the elements of the Value-Belief-Norm theory (subsection 2.1) that are integrated into the model, and provides the foundations for constructing the model. Subsection 2.2 discusses how the extent to which people consider potential future outcomes of their current actions may influence fuel choice decisions. Subsection 2.3 briefly reviews the relationship between environmental concerns and consumer preferences. Subsection 2.4 integrates the
elements from the value-based theories with a random utility formulation for the consumer choice model. Section 3 describes the survey design, the empirical model, and the hypotheses. Section 4 discusses the results. We conclude by discussing the implications of the current research in section 5.

2 THEORETICAL FOUNDATIONS

2.1 Value-Belief-Norm Theory

Value-Belief-Norm (VBN) theory combines value and norm-activation theories, with the New Environmental Paradigm (NEP)\(^5\) to create a causal or mediation chain, which leads to different behavioral outcomes. In the context of our research, we consider choice for alternative fuels as one such outcome. In particular, values (e.g., egoistic, altruistic, or biospheric) influence beliefs (e.g., NEP, awareness of consequences, and ascription of responsibility), which in turn activate proenvironmental personal norms (Figure 1). Finally, those personal norms result in a particular behavioral outcome (Stern 2000).

Figure 1: VBN in the framework of current research

- Values Orientations
  - egoistic
  - altruistic
  - biospheric
- Environmental Concerns & Awareness of Consequences
- Proenvironmental Personal Norms
  - sense of obligation to self and for government
- Proenvironmental Behaviors
  - e.g., preference for environmentally clean fuels

Source: Adapted from (Stern 2000).

However, in this paper we are not testing the validity of the VBN theory. The purpose of our investigation is to understand consumer’s behavior when choosing among transportation fuel

\(^5\) For more information about the NEP scale used in the context of a social-psychological theory of attitude/behavior formation see (Stern et al. 1995)
types, further focusing our attention on the consumer sensitivity for fuel attributes across different characteristic groups (attribute-consumer characteristic interaction effects).

Under that framework, the primary role of the VBN theory for achieving our objectives is its well-established structure that we use to enrich the consumer choice model. For example, the VBN theory emphasizes that the proenvironmental behavior can be explained by a chain effect of individuals’ values, awareness of consequences, and personal norms. These considerations are parallel to our investigation of transportation fuel choice, which includes biofuels, such as cellulose- or corn-based ethanol. Consumers’ behavioral outcome in a form of a preference for biofuels vs. gasoline, or the choice between two different types of biofuels, may be influenced by the elements of the VBN theory.

2.2 Consideration of Future Consequences

Proenvironmental behavior has been found to be linked to the concept of a consideration of future consequences (CFC). Joireman et al. (2004) investigates preferences for commuting to work by different modes of transportation. The study reports higher preferences for public transportation among the survey participants with higher levels of environmental concern. The CFC scale was developed in Strathman et al. (1994), and refers to the extent to which people consider potential future outcomes of their current actions or behaviors. Generally, people scoring high in the CFC scale give high importance to the future consequences that might result from their current behavior, and low importance to immediate consequences. In contrast, those scoring low in the CFC are people who care less about the long-term consequences of their current behavior, but who give more importance to the immediate “payoffs.” Additionally, the CFC construct has been used in applications, such as understanding fiscal responsibility behavior.
(Joireman et al. 2005), and for persuasiveness of health-related communication (Orbell & Hagger 2006), to name a few.

Joireman et al. (2006) discusses the awareness and concern models within the CFC construct. The awareness model represents a mediation model, in which individual differences in CFC influence immediate vs. delayed consequences of an action as depicted in the Figure 2. In turn, those consequences influence the outcomes – preferences, intentions and behavior. So, the path (initially) going from CFC to behavioral outcome becomes statistically insignificant after introducing the immediate vs. delayed consequences mediator. In the context of our model of fuel choice, an individual scoring low in the CFC scale may be seeking immediate payoffs from the use of gasoline in the form of lower per gallon prices, thus ignoring the long-term consequences in the form of higher emissions level.

**Figure 2: Awareness and Concern Models of CFC**

![Figure 2: Awareness and Concern Models of CFC](image)

Source: Joireman et al. (2006)

Alternatively, the concern model of the CFC influences the effects of immediate vs. delayed consequences on the behavioral outcome. In other words, this moderation shows that the CFC can have influence on the relationship between the immediate vs. delayed consequences and preferences, intentions and behavior. In this case, both high and low in CFC individuals
may equally accept the negative effects from gasoline usage, but those high in CFC are less likely to use it, since they give more importance to long-term consequences of the air pollution. Both the awareness (mediation) and concern (moderation) models can work simultaneously as discussed Joireman et al. (2006).

2.3 Environmental Concerns and Consumer Preferences

Over years, the relationship between individuals’ value orientations and attitudes around environmental problems has been widely investigated (Joireman et al. 2004; Stern 2000; Stern et al. 1999; Stern & Dietz 1994; Stern et al. 1993; W. P. Schultz et al. 2005; P. Schultz 2001). A number of research papers in the field of environmental marketing that investigated consumer’s environmental consciousness, emphasized its influence on advertising and merchandising strategies for “green” food products (Smith & Haugtvedt 1955; Sheth & Parvatiyar 1995; Shrum & McCarty 1995).

Cellulose-based ethanol is currently not marketed, because of the absence of commercial-scale cellulose-based ethanol processing plants in the country. However, there are many reasons that the cellulose-based fuels industry may benefit from the research investigating consumer preferences for transportation fuels. The identification of environmentally concerned consumers’ characteristics or the identification of product attributes that consumers value most are some of the issues that the newly established industry may benefit from.

Discussions about biofuels’ potential to replace part of the petroleum-based fuels date back to several decades. The situation with cellulose-based biofuels in the current marketplace is directly comparable with that of the gasoline with an F-310 additive introduced by Standard Oil Company of California in 1970 (Kassarjian 1971). Current ethanol marketers face similar
conditions discussed in (Kassarjian 1971) – an introduction of pollution-reducing gasoline, population that is concerned with an increasing environmental pollution, substantial advertising campaigns, and considerable governmental support. Kassarjian (1971) examined the reactions of consumers to advertising for the gasoline with the new additive (F-310) that claimed to reduce automotive emissions. Counterintuitively, people with greater environmental awareness and receptivity for the emission-free fuel additive, and environmentally less concerned respondents revealed similar levels of WTP premium for the gasoline with the F-310 question. Advertising with promise of some mitigation of the environmental pollution was found to be an important factor for environmentally concerned consumers (Kassarjian 1971).

Webster (1975) analyzed the relationship between a socially conscious consumer index (CCI) and attitudinal, personality, social activity, socioeconomic, and demographic independent variables through the social involvement model. The CCI included questions about the usage of low-lead or lead-free gasoline, low-phosphate detergent, and beverages in returnable bottles. Findings revealed the possibility that the socially conscious consumer scores low on the measures of social responsibility. Using lead-free gasoline and boycotting certain products as examples, the results showed that the social consciousness and social responsibility measure two distinct phenomena. While, personality and attitude measures revealed a stronger relationship with the CCI than socioeconomic and demographic variables, the study found that the social involvement model was inadequate to explain the variation in socially conscious consumer behavior.

2.4 Discrete Choice Modeling Approach

Discrete choice experiments are broadly used to analyze consumer’s preference structure in a number of disciplines, including marketing, applied economics, and transportation
economics (Jordan J. Louviere et al. 2008; Small et al. 2005; Train & Wilson 2008). The underlying theory for discrete choice experiments is based on the random utility theory. Random utility models were developed for predicting individual-level choices, and assume that individuals prefer choices that maximize their utility. In the discrete choice modeling framework, the factors that influence consumers’ utility and thus their choices, include attributes of the product, as well as individuals’ characteristics represented by a set of behavioral and socio-economic variables.

One of the widely used discrete choice approaches to measure consumers’ attitude toward environmental values is the contingent valuation method (Hanemann 1994). Contingent valuation allows capturing uncertainty measure in consumer attitude and perception for a product that has not been marketed before. Despite the wide use of discrete-choice methods for investigating preferences for both public and private goods, a number of relatively recent studies indicated possibility of bias between WTP responses and the actual purchasing behavior. It is natural (and is one the major limitations of the contingent valuation approach) that a survey participant will indicate a certain level of WTP, but will deviate from his/her “hypothetical commitment” when an actual purchase decision is made. As an alternative, the use of choice-based conjoint analysis (Jordan J. Louviere et al. 2008; Caparros et al. 2008) mitigates the deviations from respondents’ “hypothetical commitment” by offering more realistic representation of market situation (Adamowicz et al. 1994).

The choice-based conjoint analysis refers to a method that estimates the structure of consumer’s preferences by decomposing product attributes and valuing the utilities of each of those attributes (Green & Srinivasan 1978). Full profile, adaptive, self-explicated, and choice-based conjoint classes (same as discrete choice model) are some of the methodological variations
of the conjoint analysis. The prevailing agreement is that the choice-based conjoint analysis provides improvement over contingent valuation method, making it an attractive alternative for measuring preference structures (Adamowicz et al. 1998).

3 METHODOLOGY

3.1 Survey Design

The data were collected using online survey services provided by Qualtrics.com. The survey was conducted in November 2009, and responses from 463 participants were collected from different U.S. regions. After screening, 300 full responses were chosen for the analysis in this paper. The geographic distribution of the responses is shown in Figure 3. The full online survey questionnaire is provided in the Online Survey Template subsection of the Appendix.

The participants of the online survey were asked to consider a scenario in which they are at a service station and have to choose between the three types of fuels – gasoline, cellulose-based ethanol, and corn-based ethanol. The participants were then asked to select their preferred fueling option from each of the 8 choice scenarios presented one after another on separate webpages. Each choice scenario contained a different combination of prices, emissions and service availability for the cellulose- and corn-based ethanol fuels. The price, emissions and service availability for gasoline, which is the reference fuel option, were the same in every choice scenario.

Figure 3: Survey participants’ geographic distribution
The levels for the price attribute were based on retail gasoline sales data from 2007 – 2009 (Table 1). The emissions (carbon dioxide) attribute was developed based on Environmental Protection Agency’s (EPA) transportation fuel emissions estimates (EPA 2009). The emission levels for cellulose- and corn-based ethanol were discounted from gasoline’s CO2 emissions estimates by EPA. The service attribute shows the frequency of the service stations that own ethanol dispensing pumps.

Table 1: Attributes of Cellulose- and Corn-based Ethanol

<table>
<thead>
<tr>
<th>Fuel Attributes</th>
<th>Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>2.50</td>
<td>3.00</td>
</tr>
<tr>
<td>Emissions</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>

6 Emissions and service attribute values for gasoline are constant at 20lb/gallon, and every gas station respectively.
Following fractional factorial design procedures in (Kuhfeld 2009), 8 choice sets with orthogonal design were derived. Further, the respondents were asked to fill the rest of the questions in the survey. Demographic characteristics of the sample are shown in Table 2. The full summary statistics and variable descriptions are provided in the Data subsection of the Appendix (Table 6).

Table 2: Survey Sample Socio-Demographic Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Freq. (%)</th>
<th>Mean</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Male</td>
<td>50.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Female</td>
<td>50.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Age</td>
<td>-</td>
<td>50</td>
<td>13</td>
</tr>
<tr>
<td>Under 25 years</td>
<td>3.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>25 to 44 years</td>
<td>26.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>45 to 59 years</td>
<td>44.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>60 to 78 years</td>
<td>24.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Annual Income</td>
<td>-</td>
<td>4.44</td>
<td>2.59</td>
</tr>
<tr>
<td>Below $20,000</td>
<td>15.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$20,000 - $29,999</td>
<td>14.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$30,000 - $39,999</td>
<td>12.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$40,000 - $49,000</td>
<td>12.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$50,000 - $59,999</td>
<td>10.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$60,000 - $69,999</td>
<td>9.7</td>
<td>-</td>
<td>-</td>
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<td>$70,000 - $79,999</td>
<td>5.4</td>
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<td>$80,000 - $89,999</td>
<td>14.7</td>
<td>-</td>
<td>-</td>
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<tr>
<td>$90,000 and more</td>
<td>5.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Occupation</td>
<td>-</td>
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<td>2.02</td>
</tr>
<tr>
<td>Full-time employed</td>
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<td>-</td>
</tr>
<tr>
<td>Part-time employed</td>
<td>12.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Self employed</td>
<td>9.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Education</td>
<td>-</td>
<td>3.89</td>
<td>1.38</td>
</tr>
<tr>
<td>Less than High School</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>High School</td>
<td>-</td>
<td>15.7</td>
<td>-</td>
</tr>
<tr>
<td>Some College</td>
<td>-</td>
<td>30.1</td>
<td>-</td>
</tr>
<tr>
<td>2-year College</td>
<td>-</td>
<td>14.1</td>
<td>-</td>
</tr>
<tr>
<td>4-year College</td>
<td>-</td>
<td>26.1</td>
<td>-</td>
</tr>
<tr>
<td>Master's Degree</td>
<td>-</td>
<td>11.4</td>
<td>-</td>
</tr>
<tr>
<td>Doctoral Degree</td>
<td>-</td>
<td>1.0</td>
<td>-</td>
</tr>
<tr>
<td>Professional Degree</td>
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<td>-</td>
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<tr>
<td>Marital Status</td>
<td>-</td>
<td>2.16</td>
<td>1.3</td>
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<tr>
<td>Married with children</td>
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<td>-</td>
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<tr>
<td>Married without child</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Divorced</td>
<td>-</td>
<td>15.1</td>
<td>-</td>
</tr>
<tr>
<td>Single</td>
<td>-</td>
<td>18.4</td>
<td>-</td>
</tr>
<tr>
<td>Widowed</td>
<td>-</td>
<td>4.0</td>
<td>-</td>
</tr>
<tr>
<td>Race</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>African American</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Asian American</td>
<td>-</td>
<td>2.7</td>
<td>-</td>
</tr>
<tr>
<td>Caucasian</td>
<td>-</td>
<td>91.9</td>
<td>-</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-</td>
<td>2.0</td>
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<tr>
<td>Pacific Islander</td>
<td>0.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>2.0</td>
<td>-</td>
</tr>
</tbody>
</table>
### 3.2 Empirical Model for Discrete Choice Analysis

This section describes the discrete choice model and the VBN theory components that were incorporated into the model of consumer preferences for fuels. The use of VBN theory strengthens the model of consumer choice by providing better underlying behavioral rule that individuals use to make their choices. In doing so, it alleviates one of the maintained controversial assumptions made in discrete choice modeling that consumers act rationally. The VBN elements enter our model with the following components:

- Values with egoistic, altruistic and biospheric orientations; a 12-item scale adapted from de Groot & Steg (2008),
- Environmental Concerns with egoistic, altruistic and biospheric orientations; a 12-item scale from Schultz (2001),
- Awareness of Consequences with egoistic, altruistic and biospheric orientations; a 6-item scale adapted from (Stern et al. 1999),
- Proenvironmental Personal Norms (beliefs) with orientations related to self, to government, and to businesses; a 6-item scale adapted from (Stern et al. 1999).

In addition to these four constructs, the extended, 14-item version of the consideration of future consequences was used in the model. (The initial scale was developed in Strathman et al. (1994).)
In our model, consumers face with a set of fuel choice scenarios from which they have to select their preferred option. Attributes of the alternatives – per gallon prices, emissions levels and service availability varies over alternatives. Gasoline is the reference category and its attributes do not vary across choice scenarios. Additionally, the characteristics of the decision maker do not vary over alternatives. In other words, the model includes alternative-specific and case-specific variables. The alternative-specific variables are fuel attributes – per gallon prices, per gallon emissions and service availability. Case-specific variables include individuals’ characteristics, which include behavioral and other socio-demographic variables.

Consider an individual $i$ who faces a choice among $j$ fuel alternatives (gasoline, cellulose-based ethanol and corn-based ethanol). By specifying the observed part of utility to be linear in parameters, the utility of individual $i$ obtained from consuming alternative $j$ can be represented as

$$U_{ij} = V_{ij}(w_{ij}) + \varepsilon_{ij}$$

where $V_{ij}$ represents observed part of the utility, $w_{ij}$ includes $x_{ij}$ attributes for the $j^{th}$ alternative for individual $i$, and $z_i$ characteristics for individual $i$, i.e., $w_{ij} = [x_{ij}, z_i]$. The $\varepsilon_{ij}$ is the unobserved term, and is independently, identically distributed (iid) extreme value. Variables in $z_i$ do not change across alternatives (e.g., individual’s age or race is the same across the choice alternatives). The attribute variables in $x_{ij}$ have different values for each alternative, i.e., the fuel prices, emission levels and service availability is different across the choice alternatives (except for the reference category – gasoline). The probability of an individual $i$ choosing alternative $j$ from the choice set $C_i$ can be modeled as conditional logit probabilities (McFadden 1974)
\[ Pr(y_i = j) = \frac{e^{v_{ij}}}{\sum_j e^{v_{ij}}}, \quad j \in C_i \]

where \( y_i \) represents the choice outcome selected by individual \( i \). Considering the observed part of the utility as a function of the product attributes \( (x_{ij}) \), the choice-specific constant \( (\alpha_j) \), and assuming the \( V_{ij} \) to be linear in parameters, we can specify the following model

\[ V_{ij} = \alpha_j + \beta' x_{ij} \]

The choice probability of an individual \( i \) choosing alternative \( j \) shown above becomes

\[ Pr(y_i = j) = \frac{e^{\alpha_j + \beta' x_{ij}}}{\sum_j e^{\alpha_j + \beta' x_{ij}}}, \quad j \in C_i \]

This model in equation (3) allows investigating the effects of the product attributes - price, emissions, and service availability on consumers’ choice decision (Model 1). The parameters of this specification can be estimated with conditional logit regression. Using this model we investigate whether the economic incentives such as lower prices and service convenience exceed environmental incentives such as GHG emissions reductions (Hypothesis 1).

Additionally, the WTP for emissions reduction and service availability attributes can be calculated as the ratio of a given attribute to price attribute coefficient (Hensher et al. 2005; Revelt & Train 1998). The WTP premium for a reduction in emissions or an increase in service availability quantifies the importance of each attribute that the consumers “assign” when making their choice decisions. Then the per gallon WTP premiums that consumers are willing to pay for the emissions reductions and service availability can be compared with each other.
Additionally, we are interested in determining whether the sensitivity to a particular fuel attribute varies across individuals with different behavioral and socio-demographic characteristics. For instance, if we are interested in examining whether price sensitivity of consumers varies across income levels, we need to include an interaction of the income variable with the price attribute. Thus, to account for these possible associations between individuals’ characteristics and their fuel choices/attributes in a greater detail, we introduce interaction terms between attributes and individual characteristics (Model 2) and interactions between individual characteristics and fuel types (Model 3). To estimate these two models, we use a combination of conditional and multinomial logit models respectively. For Model 2, we specify the representative utility equation shown above as a function of fuel attributes \( x_{ij} \) and interactions between fuel attributes and individual characteristics \( x_{ij} \times z_i \). The representative utility function becomes

\[
V_{ij} = \gamma' \left( x_{ij} \times z_i \right)
\]

where \( \gamma \) is a vector of coefficients for the interaction terms. This specification allows estimating how individual demand for each attribute varies based on consumers’ characteristics. By replacing \( V_{ij} \)'s from equation (5) into (2) the probability of an individual \( i \) choosing alternative \( j \) becomes

\[
Pr(y_i = j) = \frac{e^{\gamma' \left( x_{ij} \times z_i \right)}}{\sum_j e^{\gamma' \left( x_{ij} \times z_i \right)}}, \quad j \in C_i
\]

The probability estimates can also be treated as market shares for the fuel types under investigation. In a similar fashion, Model 3 can be estimated and choice probabilities can be
derived by including interaction terms (this time between individual characteristics and fuel choices) into the equations (5) and (6).

3.3 Summary of Hypotheses

In Model 1 we test whether the economic incentives such as lower prices and service availability (i.e., convenience) exceed environmental incentives such as GHG emissions reductions (Hypothesis 1). In Model 2 we test whether consumers’ sensitivity to price attribute varies across egoistic, altruistic and biospheric proenvironmental norms (Hypothesis 2). Under the framework of Model 2 we also test whether consumers’ sensitivity to emissions varies across different levels of proenvironmental norms (Hypothesis 3), and whether consumers’ sensitivity to price attribute varies across different income groups (Hypothesis 4). Lastly, in Model 3 we test whether consumers with higher levels in personal proenvironmental norms prefer biofuels over gasoline (Hypothesis 5), and whether consumers scoring high in the consideration of future consequences prefer biofuels over gasoline (Hypothesis 6).

4 Model Estimation and Results

4.1 Model 1 – the effects of attributes on consumer preferences for fuel

First we estimate Model 1, which specifies consumers’ utility of a chosen fuel option as functions of the fuel attributes described in Table 1. The estimates for the alternative-specific attributes – price, emissions and service availability represent multiplicative effects of a unit change in that attribute variable on the probability of a given fuel alternative (i.e., either of the two types of biofuels). The estimates for the alternative-specific constants Cell (cellulose-based ethanol) and Corn (corn-based ethanol) represent, ceteris paribus, the relative likelihood of choosing cellulose- and corn-based ethanol versus gasoline – the reference group.
The results of the Model 1 are shown in Table 3. Increasing the price for a given fuel by one unit (the increment in our case is $0.25; see Table 1), decreases the probability of choosing that fuel by a factor of 0.005 (i.e., by 99.5%), holding the emissions and service attribute values constant for the other fuels. Similarly, increasing service availability by a unit for a given fuel (i.e., from every station to every 3-rd station), decreases the odds of using that fuel by a factor of 0.692, or by 30.8%.\footnote{Because the service attribute is ordered as 1) every station, 2) every 3\textsuperscript{rd} station, in this case a unit increase in service attribute actually means less fuel availability. Thus, the negative sign/relationship between service availability and preference for that fuel is consistent with our expectations.} In contrast, increasing the emissions levels by one unit (2 lbs/gallon) for a given fuel, decreases the probability of choosing that option by a factor of 0.838, or by only 16.2%. All of the attribute coefficients are statistically significant at $p < 0.01$ level.

Table 3: Conditional Logit Estimation Results (Model 1) - the effects of attributes on choice

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coeff.</th>
<th>z-value</th>
<th>p-value</th>
<th>$e^\beta$</th>
<th>WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell</td>
<td>-0.29</td>
<td>-1.24</td>
<td>0.214</td>
<td>0.746</td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>-0.48</td>
<td>-2.11</td>
<td>0.035</td>
<td>0.617</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-5.30</td>
<td>-30.62</td>
<td>0.000</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>Emiss</td>
<td>-0.18</td>
<td>-4.00</td>
<td>0.000</td>
<td>0.838</td>
<td>$0.03$</td>
</tr>
<tr>
<td>Serv</td>
<td>-0.37</td>
<td>-9.88</td>
<td>0.000</td>
<td>0.692</td>
<td>$0.07$</td>
</tr>
</tbody>
</table>

| Number of observations | 7,161 | LR $\chi^2$ (5) | 1714.2 |
| Log-likelihood         | -1,765.3 | Prob $>\chi^2$ | 0.000 |
| Pseudo R2              | 0.33  |                  |       |

Dependent variable is the choice for fuels with gasoline as a base alternative.

The results indicate that the economic incentive – the price attribute, influenced consumers’ choice decision making by about 83% more than the emissions level attribute did, and by about 69% more than service availability. Further, the service availability influenced consumers’ choice twice as much as the emissions levels. According to these results, we reject
H_{0} (Hypothesis 1) that the economic incentives in the form of price and service availability do not exceed environmental incentives such as decreased emissions levels. Other factors, such as the relationship between consumers’ environmental concerns or awareness and fuel preferences will be discussed in the next two models, but these results indicated that the (low) prices have the most influence on consumers’ preference for fuel.

Another support for rejecting the Hypothesis 1 can be observed by comparing the WTP estimates for emissions reduction and service availability attributes. The WTP estimates show that for every unit of reduction in emissions level, the consumers are willing to pay 3 cents premium. Meanwhile, for every unit increase in the service availability WTP premium is 7 cents, which is more than twice the premium for the emissions attribute. According to the coefficient results reported in Table 3, the most important fuel attribute is the price, followed by the service attribute, and the least important attribute was found to be the emissions level. Consistent with those results, the WTP premium estimates showed that the emissions attribute was the least valued by the survey respondents, thus providing additional support for the Hypothesis 1. Although, higher weights assigned to service availability can be directly linked to consumers’ preference for convenience, fuel service availability can also be associated with search costs, in terms of both time and money.

The estimates for the alternative-specific constants Cell and Corn indicate the relative likelihood of choosing cellulose- and corn-based ethanol versus gasoline, the reference group, assuming all of the attributes are constant. This means if the prices, emissions and service availability were the same for all fuels, the consumers would be 0.617 times (i.e., less) likely to purchase corn-based ethanol than gasoline. The same interpretation applies to the cellulose-based fuel coefficient. However, its coefficient is statistically significant at only \( p < 0.3 \) level.
The Likelihood Ratio (LR) statistics tests the hypothesis that all of the coefficients are statistically not significant from zero. The result \( \chi^2 (5) = 1714.2, \text{ prob} < 0.01 \) provides support for the overall significance of the model.

### 4.2 Model 2: the effects of attribute-individual characteristics interactions on consumers’ fuel preference

Model 2 includes attribute interactions with value orientations, environmental concerns, awareness of consequences, proenvironmental norms (beliefs), the consideration of future consequences, income, and political orientation. Additionally, interactions with regional dummy variables were included for testing the extent to which consumers’ preferences vary across U.S. regions. Values, environmental concerns and awareness of consequences variables were further divided into egoistic, altruistic and biospheric orientations. The proenvironmental norms variable was separated into personal (Bpers), for-government (Bgov), and for-businesses categories (Bbus).

The results in Table 4 show that the sensitivity to fuel attributes varies across several individual characteristics. In particular, respondents’ with higher scores in personal beliefs (Bpers) category of proenvironmental norms showed more sensitivity to price attribute, thus supporting Hypothesis 2. Although in Model 1 we found that the prices had the biggest influence among the fuel attributes, this result provides evidence to argue that the influence of prices can be “fine-tuned” further by differentiating between different belief orientations. The coefficients for interactions of emissions with Bpers and Bgov belief orientations are statistically significant, with a negative sign indicating less sensitivity to the prices. The positive coefficient of the Bbus category of the same interaction indicates more sensitivity to emissions levels.
These results support Hypothesis 3 that consumers’ sensitivity to emission levels does vary across different levels of proenvironmental norms. Among the interactions with the service availability, only the Bpers category showed statistically significant results, with a negative sign indicating more sensitive to service availability.

**Table 4: Mixed Logit Estimation Results (Model 2) – the effects of attribute×individual characteristic interactions on choice**

<table>
<thead>
<tr>
<th>Interaction Variables</th>
<th>Coeff.</th>
<th>Std. Err.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRICE X</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFC-F</td>
<td>-0.976*** (0.32)</td>
<td>-62.3</td>
<td></td>
</tr>
<tr>
<td>CFC-I</td>
<td>-0.123 (0.16)</td>
<td>-11.6</td>
<td></td>
</tr>
<tr>
<td>Vego</td>
<td>-0.551* (0.31)</td>
<td>-42.4</td>
<td></td>
</tr>
<tr>
<td>Valt</td>
<td>0.540 (0.42)</td>
<td>71.7</td>
<td></td>
</tr>
<tr>
<td>Vbio</td>
<td>1.002** (0.44)</td>
<td>172</td>
<td></td>
</tr>
<tr>
<td>ECego</td>
<td>-0.388 (0.31)</td>
<td>-32.1</td>
<td></td>
</tr>
<tr>
<td>ECalt</td>
<td>-0.782* (0.45)</td>
<td>-54.2</td>
<td></td>
</tr>
<tr>
<td>ECbio</td>
<td>-0.804** (0.38)</td>
<td>-55.3</td>
<td></td>
</tr>
<tr>
<td>ACego</td>
<td>0.546 (0.37)</td>
<td>72.7</td>
<td></td>
</tr>
<tr>
<td>ACalt</td>
<td>0.277 (0.56)</td>
<td>31.9</td>
<td></td>
</tr>
<tr>
<td>ACbio</td>
<td>-0.970** (0.51)</td>
<td>-62.1</td>
<td></td>
</tr>
<tr>
<td><strong>EMISS X</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFC-F</td>
<td>-0.017 (0.02)</td>
<td>-1.7</td>
<td></td>
</tr>
<tr>
<td>CFC-I</td>
<td>0.005 (0.01)</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Vego</td>
<td>0.110*** (0.02)</td>
<td>11.7</td>
<td></td>
</tr>
<tr>
<td>Valt</td>
<td>0.003 (0.03)</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Vbio</td>
<td>-0.041 (0.03)</td>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>ECego</td>
<td>0.030 (0.02)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ECalt</td>
<td>-0.024 (0.03)</td>
<td>-2.4</td>
<td></td>
</tr>
<tr>
<td>ECbio</td>
<td>0.044 (0.03)</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>ACego</td>
<td>0.073** (0.03)</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>ACalt</td>
<td>-0.088** (0.04)</td>
<td>-8.4</td>
<td></td>
</tr>
<tr>
<td>ACbio</td>
<td>0.005 (0.03)</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td><strong>SERV X</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFC-F</td>
<td>0.016 (0.07)</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>CFC-I</td>
<td>-0.049 (0.03)</td>
<td>-4.8</td>
<td></td>
</tr>
<tr>
<td>Vego</td>
<td>-0.039 (0.06)</td>
<td>-3.8</td>
<td></td>
</tr>
<tr>
<td>Valt</td>
<td>-0.068 (0.08)</td>
<td>-6.6</td>
<td></td>
</tr>
<tr>
<td><strong>PRICE X</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bpers</td>
<td>1.929*** (0.26)</td>
<td>588.5</td>
<td></td>
</tr>
<tr>
<td>Bgov</td>
<td>-0.481 (0.31)</td>
<td>-38.2</td>
<td></td>
</tr>
<tr>
<td>Bbus</td>
<td>-0.270 (0.28)</td>
<td>-23.6</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>0.035 (0.08)</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Polit</td>
<td>-0.133 (0.14)</td>
<td>-12.5</td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>-2.950*** (0.65)</td>
<td>-94.8</td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>-0.242 (0.58)</td>
<td>-21.5</td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>-0.113 (0.59)</td>
<td>-10.6</td>
<td></td>
</tr>
<tr>
<td><strong>EMISS X</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bpers</td>
<td>-0.097*** (0.02)</td>
<td>-9.2</td>
<td></td>
</tr>
<tr>
<td>Bgov</td>
<td>-0.073*** (0.02)</td>
<td>-7</td>
<td></td>
</tr>
<tr>
<td>Bbus</td>
<td>0.053*** (0.02)</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>-0.014** (0.01)</td>
<td>-1.4</td>
<td></td>
</tr>
<tr>
<td>Polit</td>
<td>0.031*** (0.01)</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>0.012 (0.05)</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>0.044 (0.04)</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>0.012 (0.04)</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td><strong>SERV X</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bpers</td>
<td>0.196*** (0.05)</td>
<td>21.6</td>
<td></td>
</tr>
<tr>
<td>Bgov</td>
<td>-0.048 (0.06)</td>
<td>-4.6</td>
<td></td>
</tr>
<tr>
<td>Bbus</td>
<td>-0.025 (0.05)</td>
<td>-2.5</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>-0.017 (0.02)</td>
<td>-1.7</td>
<td></td>
</tr>
</tbody>
</table>
Vbio 0.103 (0.09) 10.8  Polit 0.014 (0.03) 1.4  
ECego -0.042 (0.06) -4.1  West 0.024 (0.13) 2.5  
ECalt 0.006 (0.09) 0.6  East -0.041 (0.12) -4  
ECbio -0.064 (0.08) -6.2  Midwest -0.089 (0.13) -8.5  
ACego 0.009 (0.08) 0.9  
ACalt 0.016 (0.11) 1.6  
ACbio -0.084 (0.10) -8.1  

Log-likelihood -1,240  Number of observations 6,132  
LR $\chi^2$ (57) 2,010  Pseudo R2 0.45  
Prob $> \chi^2$ 0.00

Table:  

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vbio</td>
<td>0.103</td>
<td>0.09</td>
<td>10.8</td>
</tr>
<tr>
<td>ECego</td>
<td>-0.042</td>
<td>0.06</td>
<td>-4.1</td>
</tr>
<tr>
<td>ECalt</td>
<td>0.006</td>
<td>0.09</td>
<td>0.6</td>
</tr>
<tr>
<td>ECbio</td>
<td>-0.064</td>
<td>0.08</td>
<td>-6.2</td>
</tr>
<tr>
<td>ACego</td>
<td>0.009</td>
<td>0.08</td>
<td>0.9</td>
</tr>
<tr>
<td>ACalt</td>
<td>0.016</td>
<td>0.11</td>
<td>1.6</td>
</tr>
<tr>
<td>ACbio</td>
<td>-0.084</td>
<td>0.10</td>
<td>-8.1</td>
</tr>
</tbody>
</table>

Dependent variable is the choice for fuels with gasoline as a base alternative.

The coefficient for sensitivity to price and service attributes across different income levels is statistically not significant. We fail to reject Hypothesis 4 that there is no price sensitivity variation across different income groups. Only the interaction of income with emissions attribute was found to be statistically significant – those in the higher income groups are less sensitive to emissions level/attribute when making fuel choice decision. Egoistic value orientation variable was found to be statistically significant with price (less sensitive) and emissions (more sensitive) interactions at $p < 0.05$ and $p < 0.01$ levels respectively.

Respondents with the CFC-future orientation are less sensitive or less concerned about prices when choosing among the fuel types. The CFC-future orientation with emissions and service interactions did not show statistical significance, indicating that the respondents’ sensitivity for emissions and service attributes does not vary across individuals with different CFC orientations. In addition to the effects of interactions between fuel attributes and the CFC measure, we discuss the relationship between the CFC and biofuel choices using the estimates derived from Model 3 below.

The only geographic variation was found with the price attribute interaction with West regional dummy variable. Respondents from the West were found to be less sensitive to the
price attribute. This spatial variation in the sensitivity to prices suggests that further investigation may be needed to analyze geographic patterns for consumer demand for fuels, as well as for several key variables included in the model.

4.3 Model 3: the effects of individual characteristics-fuel choice interactions

In Model 2 we estimated the influence of the interactions between fuel attributes and individual characteristics on choice. The purpose of the Model 3 is to understand whether respondents’ fuel preference vary across different levels of consumer characteristics. To achieve that purpose, Model 3 incorporates interactions between fuel choices and individual characteristics such as values, environmental concerns, awareness of consequences, proenvironmental norms, the consideration of consequences, likelihood of purchasing flexible-fuel vehicle in the next 5 years, modal choices, and political orientations. In the initial model we also controlled for education, age, gender and race. However, none of these variables showed statistically significant results. The results of the Model 3 are shown in Table 5.

Table 5: Mixed Logit Estimation Results (Model 3) – the effects of fuel type × individual characteristic interactions on choice

<table>
<thead>
<tr>
<th>Interaction Variables</th>
<th>Coeff.</th>
<th>Std. Err.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose-based ethanol X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vego</td>
<td>-0.414***</td>
<td>(0.104)</td>
<td>-33.9</td>
</tr>
<tr>
<td>Valt</td>
<td>-0.321**</td>
<td>(0.140)</td>
<td>-27.5</td>
</tr>
<tr>
<td>Vbio</td>
<td>0.364***</td>
<td>(0.139)</td>
<td>43.9</td>
</tr>
<tr>
<td>ECego</td>
<td>-0.032</td>
<td>(0.100)</td>
<td>-3.2</td>
</tr>
<tr>
<td>ECalt</td>
<td>0.301**</td>
<td>(0.135)</td>
<td>35.1</td>
</tr>
<tr>
<td>ECbio</td>
<td>-0.312**</td>
<td>(0.124)</td>
<td>-26.8</td>
</tr>
<tr>
<td>ACego</td>
<td>-0.317**</td>
<td>(0.140)</td>
<td>-27.1</td>
</tr>
<tr>
<td>ACalt</td>
<td>0.187</td>
<td>(0.175)</td>
<td>20.6</td>
</tr>
<tr>
<td>ACbio</td>
<td>0.078</td>
<td>(0.144)</td>
<td>8.1</td>
</tr>
<tr>
<td>Corn-based ethanol X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vego</td>
<td>-0.494***</td>
<td>(0.107)</td>
<td>-39</td>
</tr>
<tr>
<td>Valt</td>
<td>-0.321**</td>
<td>(0.143)</td>
<td>-27.4</td>
</tr>
<tr>
<td>Vbio</td>
<td>0.233*</td>
<td>(0.142)</td>
<td>26.3</td>
</tr>
<tr>
<td>ECego</td>
<td>0.087</td>
<td>(0.103)</td>
<td>9.1</td>
</tr>
<tr>
<td>ECalt</td>
<td>0.284**</td>
<td>(0.139)</td>
<td>32.8</td>
</tr>
<tr>
<td>ECbio</td>
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<td>(0.127)</td>
<td>-16.5</td>
</tr>
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<td>-0.263*</td>
<td>(0.143)</td>
<td>-23.1</td>
</tr>
<tr>
<td>ACalt</td>
<td>0.088</td>
<td>(0.181)</td>
<td>9.2</td>
</tr>
<tr>
<td>ACbio</td>
<td>0.265*</td>
<td>(0.150)</td>
<td>30.3</td>
</tr>
</tbody>
</table>
The estimates for Bpers showed statistically significant results with a positive sign, thus supporting the Hypothesis 5. The positive sign of Bpers and Bgov categories for both cellulose- and corn-based fuels indicates that the higher is the score for the proenvironmental norms (both personal and for-government) the higher is the probability for those respondents to choose biofuels relative to the reference alternative – gasoline. Additionally, we observe that the magnitude of the coefficients for fuels differ between corn- and cellulose-based fuels. The coefficients of Bpers (0.28) and Bgov (0.28) for cellulose-based fuel are relatively higher than those for the corn-based fuel – Bpers (0.25) and Bgov (0.26). This result provides evidence to argue that respondents with higher levels in proenvironmental norms (personal and for-government) not only prefer biofuels to gasoline in general, but they also give relatively more preference to environmentally cleaner alternative (cellulose-based). The same relationship is observed for the respondents with higher levels in the biospheric value orientation (Vbio) and altruistic environmental concerns (ECalt) variables. The coefficients are greater when interacted
with the cellulose-based ethanol option for both variables (Table 5). The Bbus category showed negative relationship for both cellulose-based (-0.16, p < 0.1), and corn-based fuels (-0.25, p < 0.01).

Egoistic value orientations were found to be statistically significant with a negative sign for both cellulose- and corn-based fuels. As expected, the respondents with higher levels in egoistic value orientations care less about environmentally clean transportation fuels. The coefficients of the interactions between cellulose-based fuel and the CFC show statistically significant results for both future (0.27, p < 0.05) and immediate (-0.12, p < 0.05) orientations. Increasing the extent to which individuals care about the future consequences from their current actions (CFC-F category) leads to increased preference for environmentally cleaner fuels, thus supporting Hypothesis 6.

Another statistically significant positive relationship for both cellulose- and corn-based fuels was observed with the respondents’ likelihood of purchasing a flexible fuel vehicle in the next 5 years variable. The respondents who indicated likelihood of purchasing a flexible fuel vehicle prefer both biofuel options to gasoline. Among modal choice variables, only “driving for daily errands” variable showed statistically significant negative relationship for both cellulose- and corn-based fuel interactions. Respondents who indicated that they drive their vehicles for daily errands versus walking, using public transportation or riding a bicycle, do not prefer biofuel options to gasoline. Political orientation variable showed statistically significant negative relationship when interacted with the cellulose-based ethanol variable. Respondents with more conservative political orientation tend to prefer gasoline to ethanol fuels.
Investigation of factors that influence individual choice behavior remains as one of the fundamental concerns in many disciplines (McFadden 1974). Research efforts around the characteristics of environmentally conscious consumer date back to the early 1970’s (Kinnear & Taylor 1973; Kassarjian 1971). Around the mid 1980’s, contributions to understanding consumers’ ecological awareness started to progress in several other disciplines, including sociology (Buttel 1987; van Liere & Dunlap 1981), education (Hines et al. 1987) and psychology (Maloney et al. 1975; Arbuthnot 1977).

The primary focus of this paper was to investigate the link between consumers’ environmental and socio-economic characteristics and their heterogeneous preferences for transportation fuels. We used data from the national online survey in which the participants were asked to consider a fuel choice scenarios, including gasoline, cellulose-based and corn-based ethanol options. Following the fuel choice scenarios, the respondents were asked to complete a set of behavioral and socio-demographic questions.

Findings from the Model 1 indicate that despite recent rise in public awareness about environmental issues, the economic incentives such as cheaper fuel prices and service availability exceeded environmental incentives such as reduction in the environmental emissions levels. The influence of the price attribute on consumers’ choice during their decision making is 83% more than that of emissions level attribute. The Model 2 allowed isolating the effects of different orientations in proenvironmental norms, values, and the consideration of future consequences on the choice behavior. The sensitivity to fuel attributes varies across several individual characteristics, such as proenvironmental norms, the consideration of future consequences, income, as well as across the geography.
Today, companies are incurring additional costs to provide ethically produced goods, knowing that consumers “award” socially responsible marketers (Trudel & Cotte 2009). The results of the Model 3 showed that the respondents with higher levels in proenvironmental norms (personal; for-government), values (biospheric orientation) and environmental concerns (altruistic) not only prefer ethanol to gasoline in general, but they also prefer the environmentally cleaner alternative - cellulose-based ethanol. Corn-based ethanol has recently been criticized for its adverse impacts to the environment (through increased nitrogen fertilizers used in corn production), and for its contribution to the increasing food prices. It is possible that the choices of the respondents with above mentioned characteristics was influenced by the consideration that corn-based ethanol contributes to the national energy security in the short run, but harms the environment in the long run.

The consideration of future consequences concept is relevant in consumer choice for transportation fuels research context in a sense that it can be used to understand the structure of the thought (from the temporal point of view) that influences consumers’ intentions. In turn, these intentions lead to a behavioral outcome – choice for a specific type of fuel. In the Model 3 we found that increasing the extent to which individuals care about the future consequences from their current actions (CFC-F orientation) leads to increased preference for environmentally cleaner fuels. In contrast to corn-based ethanol, cellulosic biofuels are promising in terms of not interfering with the “food” feedstocks. (Cellulosic feedstocks are derived mainly from bio-waste - municipal, agricultural, or forest sources.) Essentially, cellulosic biofuels are beneficial for both short- and long-run. Thus, our findings are consistent with what we hypothesized – those respondents scoring high in the CFC scale, i.e., those more concerned in the future consequences from current actions will prefer ethanol to gasoline.
The possible link between consumers’ environmental concerns and political interests has been often underestimated in the research literature (Torgler & Garcia-Valinas 2007). The results of the current research also showed that the respondents with conservative political orientation preferred gasoline to ethanol fuels. In examining consumer reactions to an advertising campaign for gasoline with a special additive that was claimed to reduce air pollution, Kassarjian (1971) found no significant results for political party preference variable. However, over time the situation with U.S. energy dependence on foreign sources may fundamentally change public views. Certainly, phrases, such as “energy security and independence” are keywords that are frequently heard during political debates. Additionally, politically active people tend to be better informed about the issues frequently discussed by the political world, including alternative transportation fuel policies. This may directly influence (positively or negatively) the level of their knowledge or concern about the current environmental problems.

These findings shed some light on the complexity of human choice behavior, by breaking down individual characteristics measuring environmental concerns or proenvironmental norms, etc., into egoistic, altruistic, and biospheric orientations. Predicting consumer’s behavior increasingly became important in determining consumer demand for products yet to be marketed (e.g., cellulose-based ethanol). These results may also provide important policy implications for the alternative fuel marketers by revealing the consumer preference heterogeneity or geographic patterns of the sensitivity to prices that we found in Model 2.
REFERENCES


Joireman, J., Sprott, D. & Spangenberg, E., 2005. Fiscal responsibility and the consideration of


Schultz, W.P. et al., 2005. Values and their Relationship to Environmental Concern and


## 6 Appendix

### 6.1 Data

Table 6: Full Sample Summary Statistics (Number of respondents = 300)

<table>
<thead>
<tr>
<th>Variable Notation</th>
<th>Variable Description</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Min</th>
<th>Max</th>
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<td>Values (Likert-scale, 0-6)</td>
<td></td>
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<tr>
<td>Vego</td>
<td>Egoistic orientation</td>
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<td>0.8</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Valt</td>
<td>Altruistic orientation</td>
<td>4.9</td>
<td>0.8</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Vbio</td>
<td>Biospheric orientation</td>
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<td>1.0</td>
<td>1</td>
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<td>1</td>
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<td>Altruistic orientation</td>
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<td>6</td>
</tr>
<tr>
<td>ECbio</td>
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<td>4.9</td>
<td>1.0</td>
<td>1</td>
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<tr>
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<td>Egoistic orientation</td>
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<td>Perceptions about Prices (Likert-scale, 1-7)</td>
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<tr>
<td>Drerr Equals 1 if drives for daily errands, 0 otherwise</td>
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<td>0.3</td>
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<td>Fullt Full-time employed, 1= yes, 0 = no</td>
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<td>0.48</td>
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<td>Partt Part-time employed, 1= yes, 0 = no</td>
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<td>Retd Retired, 1= yes, 0 = no</td>
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<td>0.40</td>
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<td>Education</td>
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<tr>
<td>Lesshs Education: less then high school , 1= yes, 0 = no</td>
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<td>Scollg Education: some college, 1= yes, 0 = no</td>
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<td>Gender</td>
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<td></td>
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</tr>
<tr>
<td>Gender Equals 1 if male, 0 otherwise</td>
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<td>Marital Status</td>
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</tr>
<tr>
<td>Mchld Equals 1 if married with child, 0 otherwise</td>
<td>0.48</td>
<td>0.50</td>
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</tr>
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<td>Mnochld Equals 1 if married with no child, 0 otherwise</td>
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<td>0.35</td>
<td>-</td>
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<tr>
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<td>0.36</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>East</td>
<td>Responses from East, 1= yes, 0 = no</td>
<td>0.32</td>
<td>0.47</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Midwest</td>
<td>Responses from Midwest, 1= yes, 0 = no</td>
<td>0.22</td>
<td>0.41</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Northeast</td>
<td>Responses from Northeast, 1= yes, 0 = no</td>
<td>0.23</td>
<td>0.42</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
6.2 Online Survey Template

Webpage 1

Note: This page of the online survey included Washington State University Consent Form.
Webpage 2
Introduction

Do you currently own a vehicle?
- Yes
- No

Webpage 3

Do you use ethanol fuel (of any grade) in your vehicle?
- Yes
- No
- Don't know

How knowledgeable are you about corn-based ethanol fuel?

<table>
<thead>
<tr>
<th>Not Knowledgeable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Very Knowledgeable</th>
</tr>
</thead>
</table>

How knowledgeable are you about cellulose-based ethanol fuel?

<table>
<thead>
<tr>
<th>Not Knowledgeable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Very Knowledgeable</th>
</tr>
</thead>
</table>

How likely is it that you will consider purchasing a flexible fuel vehicle in the next 5 years? (i.e., one that uses both gasoline and/or biofuel)

<table>
<thead>
<tr>
<th>Very Unlikely</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Very Likely</th>
</tr>
</thead>
</table>
Webpage 4

What is your perception about the advantages and disadvantages of gasoline vs. corn-based ethanol when considering 1) per gallon prices, 2) environmental emissions, and 3) service availability for each fuel?

<table>
<thead>
<tr>
<th></th>
<th>Gasoline is much better</th>
<th></th>
<th>Corn-based ethanol is much better</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Price</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental emissions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Availability</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Webpage 5

What is your perception about the advantages and disadvantages of gasoline vs. cellulose-based ethanol when considering 1) per gallon prices, 2) environmental emissions, and 3) service availability for each fuel?

<table>
<thead>
<tr>
<th></th>
<th>Gasoline is much better</th>
<th></th>
<th>Cellulose-based ethanol is much better</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Price</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental emissions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Availability</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What is your perception about the advantages and disadvantages of corn-based ethanol vs. cellulose-based ethanol when considering 1) per gallon prices, 2) environmental emissions, and 3) service availability for each fuel?

<table>
<thead>
<tr>
<th></th>
<th>Corn-based ethanol is much better</th>
<th>Cellulose-based ethanol is much better</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td><img src="image.png" alt="Score" /></td>
<td><img src="image.png" alt="Score" /></td>
</tr>
<tr>
<td>Environmental emissions</td>
<td><img src="image.png" alt="Score" /></td>
<td><img src="image.png" alt="Score" /></td>
</tr>
<tr>
<td>Service Availability</td>
<td><img src="image.png" alt="Score" /></td>
<td><img src="image.png" alt="Score" /></td>
</tr>
</tbody>
</table>

Introduction to fuel choice scenarios

On the next several slides, we will be asking you about your preference for three different forms of transportation fuels (gas, cellulose-based ethanol, and corn-based ethanol). Some of these fuels are widely available today, while others are less available or still under development.

In today's study, we will be asking you to imagine eight future "fuel-choice scenarios" and indicate your preference for the three types of fuels in these scenarios. Before presenting the scenarios, we would like to provide some background information on the two ethanol-based fuels. Please read this information carefully before moving on.

**Cellulose-based ethanol** is processed from cellulose, which is extracted from such sources as forest biomass, wood chips, agricultural crop residue, animal manure, or municipal solid waste.

**Corn-based ethanol** is processed from corn.

After production, the pure ethanol is blended with gasoline to create different grades of motor fuels. In this study, both cellulose-based and corn-based ethanol fuels refer to E85 grade (a blend of 85% ethanol and 15% gasoline).

Both cellulose-based and corn-based biofuels contribute to U.S. oil independence.
Webpage 8
Quiz questions

Please answer the following multiple choice questions before proceeding to the next section.

Cellulose-based ethanol can be produced from:
- a. Corn
- b. Agricultural crop residue
- c. Forest biomass
- d. B and C above

Webpage 9
(Pop-up message for wrong answers to the previous question)

Wrong Answer!
Cellulose-based ethanol can be produced from Agricultural crop residue or Forest biomass

Webpage 10

Corn-based ethanol can be produced from:
- a. Forest biomass
- b. Animal manure
- c. Corn
- d. Wood chips
Webpage 11

(Pop-up message for wrong answers to the previous question)

Wrong Answer!
Corn-based ethanol is produced from Corn

Webpage 12

E85 is a blend of ethanol and gasoline with the following proportions:
- a. 85% ethanol and 15% gasoline
- b. 85% gasoline and 15% ethanol
- c. 80% ethanol and 20% gasoline
- d. 20% gasoline and 80% ethanol

Webpage 13

(Pop-up message for wrong answers to the previous question)

Wrong Answer!
E85 is a blend of 85% ethanol and 15% gasoline

Next
Webpage 14
Choice Sets

Instructions

In this part of the survey, we would like you to imagine that you are at a service station and you have a choice between the three types of fuels shown below.

1. Gasoline
2. Cellulose-based ethanol
3. Corn-based ethanol

On each of the following eight pages, we will present a fuel-choice scenario. In each scenario, you will find a table listing the price, environmental emissions and service availability for each type of fuel.

Each table contains a different combination of price, emissions and service availability for cellulose-based and corn-based ethanol fuels. The emissions and service availability for gasoline are the same in every table.

Please read each table carefully before selecting your preferred fuel type.
Here is an example. In this fuel choice scenario, we would like you to imagine:

- Gas costs $2.75/gallon, while cellulose-based and corn-based ethanol cost $2.50/gallon.
- Gas has an emissions rating of 20 (lbs. per gallon)*, while cellulose-based ethanol has an emissions rating of 16, and corn-based ethanol has an emissions rating of 14.
- Gas is available at every fueling station; cellulose-based and corn-based ethanol are available at every third fueling station.

This is an example. On the following eight pages, we would like you to select your preferred fueling option after carefully reviewing the information provided in the table on that page. *Please note that the information in each table will change from page to page.*

<table>
<thead>
<tr>
<th></th>
<th>GASOLINE</th>
<th>CELLULOSE-BASED ETHANOL</th>
<th>CORN-BASED ETHANOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRICE/GALLON</td>
<td>2.75</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>EMISSIONS (IN LBS/GALLON)</td>
<td>20*</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>SERVICE AVAILABILITY</td>
<td>every fueling station</td>
<td>every 3rd fueling station</td>
<td>every 3rd fueling station</td>
</tr>
</tbody>
</table>

*One gallon of gasoline weights only 6.3 pounds. However, according to U.S. Department of Energy calculations, 1 gallon of gasoline can produce 20 pounds of carbon dioxide (most of the weight of the CO2 doesn't come from the gasoline itself, but the from the oxygen in the air). This occurs because burned gasoline produces carbon and hydrogen, which after interacting with the oxygen in the air, increases its weight to 20 pounds of carbon dioxide (CO2) per gallon.
### Scenario 1

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Cellulose-based Ethanol</th>
<th>Corn-based Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price/Gallon</strong></td>
<td>2.75</td>
<td>3.00</td>
<td>2.50</td>
</tr>
<tr>
<td><strong>Emissions (in LBS/Gallon)</strong></td>
<td>20</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td><strong>Service Availability</strong></td>
<td>every fueling station</td>
<td>every 3rd fueling station</td>
<td>every 3rd fueling station</td>
</tr>
</tbody>
</table>

### Scenario 2

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Cellulose-based Ethanol</th>
<th>Corn-based Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price/Gallon</strong></td>
<td>2.75</td>
<td>2.50</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>Emissions (in LBS/Gallon)</strong></td>
<td>20</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td><strong>Service Availability</strong></td>
<td>every fueling station</td>
<td>every fueling station</td>
<td>every fueling station</td>
</tr>
</tbody>
</table>
### Scenario 3

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Cellulose-based Ethanol</th>
<th>Corn-based Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price/Gallon</strong></td>
<td>2.75</td>
<td>3.00</td>
<td>2.50</td>
</tr>
<tr>
<td><strong>Emissions (in lbs/gallon)</strong></td>
<td>20</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td><strong>Service Availability</strong></td>
<td>every fueling station</td>
<td>every fueling station</td>
<td>every fueling station</td>
</tr>
</tbody>
</table>

Gasline: ![Gasoline](image1)
Cellulose-based Ethanol: ![Cellulose-based Ethanol](image2)
Corn-based Ethanol: ![Corn-based Ethanol](image3)

### Scenario 4

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Cellulose-based Ethanol</th>
<th>Corn-based Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price/Gallon</strong></td>
<td>2.75</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>Emissions (in lbs/gallon)</strong></td>
<td>20</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td><strong>Service Availability</strong></td>
<td>every fueling station</td>
<td>every 3rd fueling station</td>
<td>every fueling station</td>
</tr>
</tbody>
</table>

Gasline: ![Gasoline](image4)
Cellulose-based Ethanol: ![Cellulose-based Ethanol](image5)
Corn-based Ethanol: ![Corn-based Ethanol](image6)
### Scenario 5

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Cellulose-Based Ethanol</th>
<th>Corn-Based Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price/Gallon</td>
<td>2.75</td>
<td>2.50</td>
<td>3.00</td>
</tr>
<tr>
<td>Emissions (in lbs/gallon)</td>
<td>20</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Service Availability</td>
<td>every fueling station</td>
<td>every 3rd fueling station</td>
<td>every 3rd fueling station</td>
</tr>
</tbody>
</table>

### Scenario 6

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Cellulose-Based Ethanol</th>
<th>Corn-Based Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price/Gallon</td>
<td>2.75</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Emissions (in lbs/gallon)</td>
<td>20</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Service Availability</td>
<td>every fueling station</td>
<td>every fueling station</td>
<td>every 3rd fueling station</td>
</tr>
</tbody>
</table>
### SCENARIO 7

<table>
<thead>
<tr>
<th></th>
<th>GASOLINE</th>
<th>CELLULOSE-BASED ETHANOL</th>
<th>CORN-BASED ETHANOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRICE/GALLON</td>
<td>2.75</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>EMISSIONS (IN LBS/GALLON)</td>
<td>20</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>SERVICE AVAILABILITY</td>
<td>every fueling station</td>
<td>every 3rd fueling station</td>
<td>every fueling station</td>
</tr>
</tbody>
</table>

Gasoline: ![Gasoline]
Cellulose-based Ethanol: ![Cellulose-based Ethanol]
Corn-based Ethanol: ![Corn-based Ethanol]

### SCENARIO 8

<table>
<thead>
<tr>
<th></th>
<th>GASOLINE</th>
<th>CELLULOSE-BASED ETHANOL</th>
<th>CORN-BASED ETHANOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRICE/GALLON</td>
<td>2.75</td>
<td>2.50</td>
<td>3.00</td>
</tr>
<tr>
<td>EMISSIONS (IN LBS/GALLON)</td>
<td>20</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>SERVICE AVAILABILITY</td>
<td>every fueling station</td>
<td>every fueling station</td>
<td>every 3rd fueling station</td>
</tr>
</tbody>
</table>

Gasoline: ![Gasoline]
Cellulose-based Ethanol: ![Cellulose-based Ethanol]
Corn-based Ethanol: ![Corn-based Ethanol]

Next
Using the following scale, please indicate how important each statement is as a guiding principle in YOUR life. Please place your response in the space provided to the right of each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Opposed</th>
<th>Not at all Important</th>
<th>Slightly Important</th>
<th>Somewhat Important</th>
<th>Rather Important</th>
<th>Extremely Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influential: having an impact on people and events</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A world at peace: free of war and conflict</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protecting the environment: preserving nature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wealth: material possessions, money</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equality: equal opportunity for all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social power: control over others, dominance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using the following scale, please indicate how important each statement is as a guiding principle in YOUR life. Please place your response in the space provided to the right of each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Opposed</th>
<th>Not at all important</th>
<th>Slightly Important</th>
<th>Somewhat Important</th>
<th>Rather Important</th>
<th>Extremely Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventing pollution: protecting natural resources</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respecting the earth: harmony with other species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authority: the right to lead or command</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helpful: working for the welfare of others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social justice: correcting injustice, care for the weak</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unity with nature: fitting into nature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
People around the world are generally concerned about environmental problems because of the consequences that result from harming nature. However, people differ in the consequences that concern them the most. Please rate each of the following items from 1 (not important) to 7 (very important) in response to the question:

I am concerned about environmental problems because of the consequences for ____

<table>
<thead>
<tr>
<th></th>
<th>Opposed 0</th>
<th>Not at all Important 1</th>
<th>Slightly Important 3</th>
<th>Somewhat Important 4</th>
<th>Rather Important 5</th>
<th>Extremely Important 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>My lifestyle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People in my community</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Me</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All people</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future generations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My future</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Awareness of Consequences

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change will be a very serious problem for me and my family in the next 30 years.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change will be a very serious problem for the country as a whole in the next 30 years.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change will be a very serious problem for other species of plants and animals in the next 30 years.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic substances in the air due to automobile emissions will be a very serious problem for me and my family in the next 30 years.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic substances in the air due to automobile emissions will be a very serious problem for the country as a whole in the next 30 years.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic substances in the air due to automobile emissions will be a very serious problem for other species of plants and animals in the next 30 years.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To ensure that you are reading the statements, please choose strongly agree as your answer to this statement.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Webpage 28
Proenvironmental Norms/Beliefs (personal, for government and for businesses)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel a personal obligation to purchase ethanol instead of gasoline to prevent climate change.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>I feel a sense of personal obligation to take action to stop oil drilling that causes harmful environmental consequences.</td>
<td></td>
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</tr>
<tr>
<td>The U.S. government should take stronger action to encourage public use of biofuels, such as ethanol, to reduce environmental emissions and prevent global climate change.</td>
<td></td>
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</tr>
<tr>
<td>The U.S. government should increase tariffs on Brazilian ethanol imports in order to exert pressure on Brazil to prevent deforestation of Amazon rainforests (which are used for ethanol production).</td>
<td></td>
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<tr>
<td>The U.S. Department of Transportation should encourage the use of biofuels for industrial heavy truck fleets and buses to reduce harmful environmental emissions.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Business and industry should reduce their environmental emissions to help prevent climate change.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Please use the scale below to provide the extent to which you agree with the following statements.
Consideration of Future Consequences

For each of the statements below, please indicate whether or not the statement is characteristic of you.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Extremely Uncharacteristic</th>
<th>Moderately Uncharacteristic</th>
<th>Slightly Uncharacteristic</th>
<th>Neither</th>
<th>Slightly Characteristic</th>
<th>Moderately Characteristic</th>
<th>Extremely Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>I consider how things might be in the future, and try to influence those things with my day to day behavior.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Often I engage in a particular behavior in order to achieve outcomes that may not result for many years.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>I only act to satisfy immediate concerns, figuring the future will take care of itself.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>My behavior is only influenced by the immediate (i.e., a matter of days or weeks) outcomes of my actions.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>My convenience is a big factor in the decisions I make or the actions I take.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

For each of the statements below, please indicate whether or not the statement is characteristic of you.

<table>
<thead>
<tr>
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<th>Moderately Uncharacteristic</th>
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<th>Slightly Characteristic</th>
<th>Moderately Characteristic</th>
<th>Extremely Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>I think it is more important to perform a behavior with important distant consequences than a behavior with less important immediate consequences.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>I generally ignore warnings about possible future problems because I think the problems will be resolved before they reach crisis level.</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>
Webpage 33
*(If the respondents selected drive own vehicle or drive in carpool options above)*

How many miles (round-trip) do you drive each day to work?

Webpage 34

Webpage 35
*(If the respondents selected drive own vehicle or drive in carpool options above)*

How many miles (round-trip) do you drive each day to school?
Webpage 36

What mode of transportation do you usually use for your daily errands?

- Walk
- Public transportation
- Ride a bicycle
- Drive own vehicle
- Drive in carpool

Webpage 37

(If the respondents selected drive own vehicle or drive in carpool options above)

How many miles (round-trip) do you drive each day to do your daily errands?

Webpage 38

How many cars does your household own?

Webpage 39

What is the year of the car that you drive most?

(IF YOUR HOUSEHOLD OWNS ONE VEHICLE, JUST SELECT THE YEAR)

Click to select the year
Socio-Demographics

Which of the following best describes you?
- Full-time employed
- Part-time employed
- Self employed
- Unemployed
- Student
- Retired
- Other

What is the highest level of education you have completed?
- Less than High School
- High School / GED
- Some College
- 2-year College Degree
- 4-year College Degree
- Master’s Degree
- Doctoral Degree
- Professional Degree (JD, MD)

Please indicate your age.

Please indicate your gender.
- Male
- Female
Webpage 42

Please select the region where you live now.
- West
- South
- Midwest
- Northeast

Next

Webpage 43

Please type your zip code below. This information will help us evaluate geographical variations in preference for biofuels.

Next

Webpage 44

End-of-Survey Message

We thank you for your time spent taking this survey. Your response has been recorded.