



# Consumer preferences for second-generation bioethanol<sup>☆</sup>



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## ABSTRACT

This study investigates the consumer responses toward fuel from second-generation, nature-inspired lignocellulose processing systems. Data was collected via in-person consumer surveys across in three major U.S. cities with two different information treatments. A dichotomous-choice contingent valuation methodology is utilized to estimate consumers' willingness to pay for this product and analyze factors that affect consumer choice. The results suggest that the average respondent was willing to pay an 11% premium for second-generation nature-inspired bioethanol compared to conventional fuel. The willingness to pay was the highest in Portland, Oregon (17%), followed by Minneapolis (9%) and then Boston (8%). Driving distance was found to have a negative effect on consumer willingness to pay. Consumers who purchase more organic foods were more willing to pay a premium for the product. Risk attitude had heterogeneous effects in different locations. The effect of information regarding the second-generation, nature-inspired lignocellulose process was found to be significantly positive.

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## 1. Introduction

U.S. consumers use more petroleum fuel per capita than any other OECD country, and the transportation sector accounts for 70% of U.S. oil consumption and 30% of U.S. greenhouse gas (GHG) emissions (Knittel, 2012). Biofuels are gaining attention for seeking to reduce the consumption of petroleum-based liquid fuel. Many researchers have argued that consumer valuation of technologies needs to be studied in order to effectively develop the renewable energy market (e.g., Zarnikau, 2003; Collantes, 2010).

A major barrier to the growth of the biofuel industry is the lack of an effective process that transforms lignocellulosic biomass to simple sugar molecules for production of biofuel and bioproduct. First-generation bioethanol is produced from corn, rice, and other grains, and therefore, producing first-generation ethanol can increase food prices (Serra and Zilberman, 2013; de Gorter et al., 2015). Second-generation biofuel

has a lower impact on food prices because it is made from lignocellulosic biomass, woody crops and/or agricultural residues or waste,<sup>1</sup> which can be grown on marginal lands. Scientists are developing new sustainable energy systems through a biomimicry pathway inspired by biological systems that exist in nature. For example, termites are capable of breaking down the complex plant cell wall structure under ambient conditions, without input of additional chemicals (Ke et al., 2012). Thus, this line of inquiry can be called “nature-inspired” biofuels, which utilize new knowledge of reaction mechanisms and enzyme systems that exist in nature to provide insights for designing these systems. Preliminary tests suggest that nature-inspired lignocellulose processing systems are more energy efficient and environmentally sustainable than the existing thermochemically based technologies (Margeot et al., 2009).

This study investigated consumer preferences for fuel from nature-inspired lignocellulose processing systems compared to existing thermochemically based technologies. To this end, analyses of consumer acceptance and willingness to pay (WTP) for nature-inspired, second-generation biofuels were conducted in order to estimate profitability of the proposed biologically inspired energy system. A contingent valuation (CV) approach, a survey-based economic valuation technique, was utilized in order to quantify consumer's WTP for this product. In addition, an examination was conducted on whether the provision of information describing the advantages of nature-inspired lignocellulose processing systems had a significant effect on consumers' WTP.

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<sup>1</sup> This definition was provided by a reviewer.

In total, for the purpose of this study, 600 consumers were surveyed in Portland, Oregon; Minneapolis, Minnesota; and Boston, Massachusetts. The survey data included information about consumers' driving habits, attitudes, and demographic characteristics. It also contained the responses to dichotomous-choice questions that were intended to elicit the respondents' WTP. A double-bounded, dichotomous-choice model was then estimated with the data to evaluate the responses. The results of this study suggest that 66% of the surveyed consumers were willing to purchase second-generation bioethanol at a premium price and 12% more at the current market price of fuel. On average, consumers were willing to purchase this product with an 11% premium over conventional fuel.

## 2. Previous studies

There are a number of studies that have investigated consumer attitudes toward renewable fuels in different locations. Ulmer et al. (2004) conducted a mail survey in Oklahoma and qualitatively concluded that the factors that affect the decision to purchase an ethanol blend were, in descending order, the cost to consumers, environmental impact, and vehicle performance. Demographic variables, such as gender, education, income, age, and location of household, had no significant correlation with willingness to purchase an ethanol blend. Li et al. (2009) combined telephone survey data with online survey data to examine whether U.S. households were generally willing to fund research and development for renewable energy sources. The respondents' willingness to fund research was higher for females, those with liberal political beliefs, and those with higher incomes. Solomon and Johnson (2009) conducted a survey in Michigan, Minnesota, and Wisconsin to estimate WTP for cellulosic ethanol. They concluded that a large proportion of respondents were willing to pay a premium price for cellulosic ethanol compared to gasoline. Van de Velde et al. (2009) found that fuel price, quality, availability in fuel stations, and environmental friendliness were considered important in fuel choice by the respondents in Belgium. Giraldo et al. (2010) conducted a market survey in Spain. Their results suggested that consumers were willing to pay 5% extra for biodiesel than conventional diesel. Using data from face-to-face interviews in Greece, Savvanidou et al. (2010) found that half of the respondents believed that biofuel can effectively ameliorate climatic changes and energy problems. However, there was a lack of knowledge about biofuels, especially among younger people and those with lower levels of education.

Recently, scientists linked conventional ethanol production to environmental damage. For example, Timilsina and Shrestha (2011) argued that biofuels reduce greenhouse gas emissions only if emissions related to land-use change are avoided. The environmental friendliness of biofuels varies based on inputs, and previous research suggested that consumers' WTP for renewable energy also differs by source (e.g., Borchers and Parsons, 2007). Petrolia et al. (2010) conducted a nationwide survey of consumer preferences for E10 and E85<sup>2</sup> in the United States. The estimated mean WTP over regular unleaded gasoline for E10 fuel ranged from 6.2 to 12.4 cents per gallon depending on the econometric method used, while the mean WTP over regular unleaded gasoline for E85 was from 13.1 to 15.2 cents per gallon. Jensen et al. (2010) showed that respondents' WTP for E85 made from switchgrass was nearly one cent per mile greater than their WTP for E10 made from corn. Concerns about land use had a negative impact on WTP for food-based ethanol, but concerns about fuel security had a positive impact.

This study focuses on U.S. consumers preferences toward nature-inspired bioethanol. The contribution to the existing literature is an

investigation of the effect of information provision on consumers' WTP, examining the correlation between electric/hybrid cars or organic food consumption and WTP for the nature-inspired bioethanol, and analyzing the heterogeneity among consumers across regions of the United States.

## 3. Data and methods

### 3.1. Survey methods

In-person consumer surveys were pre-tested with 100 subjects in May 2013. After revising the survey instrument, in-person consumer surveys were conducted in three major U.S. cities. The first one was completed in February 2014 in Portland, Oregon. The second one was carried out in July 2014 in Minneapolis, Minnesota, and the third one was conducted in January 2015 in Boston, Massachusetts. These cities were chosen in order to examine how preferences might vary across major cities located in different U.S. regions.<sup>3</sup>

The on-site interview process took nine days in total, with three days at each location. The same set-up and signs were used consistently throughout the study. With the assistance of banners and hardboard signs, three student interviewers randomly approached crowds from busy spots at each location and verbally recruited adult respondents. For each survey, ten to fifteen minutes were needed for completion, and each participant was paid \$5.

In total, 599 valid face-to-face interviews were analyzed (approximately 200 per city). The surveys solicited information regarding respondent's willingness to pay for nature-inspired, second-generation biofuels, driving habits, risk preferences, environmental attitudes, demographic information, and other factors that might influence their fuel purchase decisions.

The sample was split into equal groups to examine the information effects. In particular, before the consumers were asked about their preferences, half of the sample was provided a paragraph containing scientific information about nature-inspired second-generation biofuels. The paragraph is presented in the Appendix. The other half received no information.

Data regarding environmental attitudes were obtained via a question involving a trade-off situation between the importance of greater environment friendliness of fuel and the importance of buying fuel at the lowest price (please see the Appendix for the specific text). Eliciting these attitudes toward trade-off scenarios was an effective way of ensuring that survey information was informative as well as useful in an empirical modeling context. For example, without the trade-off, most respondents would likely say that they value the environment highly. This lack of variation in response owing to the omission of a frame of reference for the evaluation can lead to statistical insignificance of the effect of the environmental variable.

The demographic characteristics of the respondents for the overall sample are summarized in Table 1. The average age is approximately 42 years. Thirty-one percent of the respondents have at least one child less than 18 years living with them. There are 47% male and 53% female participants in the study sample, and there is diversity in terms of ethnic affiliations of the respondents interviewed during this survey. The study sample comprised of 72.2% Whites (non-Hispanic), 6.8% African-Americans, 10.8% Asians, 3.2% Hispanics, and 6.0% mixed/others ethnic groups. The education level of the respondents is higher than the national average with 21.3% of respondents holding graduate or professional degrees, 30.5% bachelors' degree holders, and 34.3% with some college degree. The employment status of the respondents indicate that 61.5% of the respondents are formally employed, 16.2% are self-employed, 4.3% are unemployed, 8.0% are retired, 8.7% are students,

<sup>2</sup> E10 is 10% ethanol and 90% unleaded gasoline and, according to the U.S. Department of Energy, E85 is a high-level ethanol-gasoline blends containing 51% to 83% ethanol, depending on geography and season.

<sup>3</sup> It is acknowledged that a trade-off for in-person surveys is that it could not arranged for studies in different locations to be conducted at the same time. Therefore, timing and location might have a compound effect.

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