MARKETS FOR ENERGY AND LOCAL FOOD

By

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Abstract

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This dissertation investigates consumer preferences and willingness to pay (WTP) for renewable energy and local food in three separate papers. The first paper analyzes the results of a survey conducted in major Korean cities to estimate consumer preferences for second-generation lignocellulosic bioethanol. I use information treatments on positive effects of this type of advanced fuel on the environment, food prices, and fuel supply security and compare results with a group of respondents who don't receive any information. Using a double-bounded dichotomous choice contingent valuation methodology, I find that consumers in Korea are willing to pay a premium over second-generation bioethanol compared to conventional fuel and that the mean premium is highest in the group treated with positive environmental information. The second paper focuses on comparative analysis of consumer preferences for second-generation ethanol in Korea and the United States. I estimate WTP for the product in the combined sample and separately for each country, and find that the mean premium for the second-generation ethanol was higher in the U.S. than in Korea. The results also suggest that attitudinal and demographic variables have unidirectional marginal effects on WTP in the two countries, while the magnitudes differ. Compared to the U.S. sample, the consumers from Korea

were less responsive to positive information treatment. In the third paper, I analyze data from field experiments on various aspects of consumer demand for oysters to estimate WTP for locally harvested oysters in two distinct groups of respondents - local residents of Delaware and tourists. I find that consumers in both samples are less likely to purchase oysters if they are offered oysters of non-local origin and that their WTP for local oysters is higher than for oysters harvested more than 100 miles away. The price of the product, as expected, has a significant negative effect on the decision to purchase oysters, while the frequency of oyster consumption increases the likelihood of making a purchase. These papers provide new insights on how information treatments and consumer differentiation elicit consumer preferences for renewable energy and local food in new and established markets.

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Dedication

I dedicate this dissertation to my parents, my spouse and children who have always encouraged me to go the extra mile.

CHAPTER ONE

INTRODUCTION

This dissertation investigates consumer preferences and willingness to pay (WTP) for renewable energy and local food. Recent years have shown the increase in interest of consumers in renewable energy options and local food products. Consumers become more and more aware of environmental benefits of biofuels and that the choices they make in favor of local food can also reduce environmental degradation and carbon footprint of agriculture and aquaculture. At the same time, when making their everyday purchasing decisions, consumers may require additional information about comparative environmental benefits of a particular type of renewable energy or a local food product available on the market. When designing their advertising campaigns, producers may wish to underline environmental benefits associated with their product. In the case of bioethanol, the advantages of the second-generation fuel over traditional ethanol should be communicated. In the context of developing shellfish aquaculture, consumers should be informed about benefits of local oyster farming for water quality and habitat restoration. In addition, it is important to estimate preferences across different groups of consumers to draw up tailor made information campaigns. Development of new energy sources and local seafood industries requires substantial investments, thus calling for studies about potential markets and willingness to pay a premium for such products. In this dissertation, I use contingent valuation (CV) and field experiment methodology to quantify consumer WTP for second generation bioethanol and locally grown oysters. Both methods are well established

economic valuation techniques and are used widely to elicit consumer preferences for market and non-market goods.

While there are a lot of studies investigating consumer WTP for biofuels, I am not aware of any article about consumer preferences for second-generation bioethanol in Korea, which uses information treatments about environmental, food prices and fuel supply security benefits of this advanced liquid fuel. The same is true about the availability of any comparative studies between Korea and the United States about consumer preferences for second-generation bioethanol. The first paper (Chapter Two) examines consumer preferences in Korea towards advanced lignocellulosic ethanol. A double-bounded dichotomous-choice model is utilized to estimate WTP of consumers for second-generation ethanol and analyze factors affecting purchasing decisions. The sample was partitioned into four approximately equal groups. In three groups, participants were treated with positive information about the product related to its environmental benefits, effects on food prices, and on fuel supply security. The last fourth group was not treated with any information. In the overall sample, female participants were significantly more likely to purchase the product than male respondents. Such demographic variables as education and income, though insignificant, had parameters with positive sign, which is consistent with other studies. Consumers who were knowledgeable about renewable energy sources and who put more value to environmental friendliness of fuel over its price were also willing to pay a premium for the advanced bioethanol. The average respondent in the full investigated sample was willing to pay a 4.3% premium over second-generation bioethanol compared to conventional fuel. In the partitioned samples, the mean WTP was highest in the subsample with positive environmental information treatment and lowest in the group, which received information on food prices. The results show that respondents who received information about positive

environmental benefits from the advanced biofuels place the highest value on the product, suggesting that a policy maker could promote the product by focusing on such its characteristics as lower greenhouse gas emissions, water consumption, and pesticide and fertilizer use. The findings also point to a need for awareness raising campaigns specifically targeting males.

Comparative studies are usually conducted to provide insights to consumer acceptance of new products across cultures. The second paper (Chapter Three) investigates differences and similarities between consumer preferences for second-generation ethanol in Korea and the United States. The comparisons are facilitated by analyzing the marginal effects of different factors on WTP, calculated separately for both countries to assess consumer attitudes towards second-generation ethanol, since the estimated coefficients are not directly interpretable in a double-bounded logit regression model. I also estimate mean WTP in the Korean and U.S. samples separately, as well as jointly in a combined sample. In the combined sample, an indicator variable corresponding to information treatment had a significant positive effect. A higher level of education also significantly increased WTP for the product, while the presence of a child in the household had a negative effect. Finally, the variable indicating that a respondent is from the United States had a strongly positive effect on the WTP. By analyzing two countries separately, I find that the mean premium for second-generation bioethanol over conventional fuel is significantly higher in the United States (11.0%) compared to Korea (4.4%). The findings suggest that on the global scale, more effort should be made to educate population about renewable energy sources. In addition, policy makers should focus on positive effects of second-generation bioethanol on food prices and the environment when introducing this product to the market and when designing information campaigns.

Recent years have shown the increase in consumers' preferences for locally produced foods. Consumers choose local foods because of different motivations, including environmental benefits and perceived quality and freshness. The third paper (Chapter Four) examines consumer preferences of local oysters in two distinct samples – local residents in Delaware and tourists. The analysis of preferences for locally grown oysters in different groups of consumers is critical to predicting demand for oysters, drawing up of marketing strategies targeting different types of consumers and informing local businesses about opportunities to offer local oysters to tourists and local clients. The findings show that both local residents and tourist respondents have a higher WTP for locally grown oysters than for oysters originating more than 100 miles away from the consumer. The difference in WTP for those two types of oysters is more pronounced in the sample containing tourists and they had a higher WTP for local oysters than local residents. Analyzing the impact of demographic characteristics on the decision to purchase oysters, I find that in both samples, being a frequent oyster consumer significantly increased the likelihood of making the purchase. In the local residents' sample, the age of a respondent had a significantly negative effect. In the tourists' sample the likelihood of buying oysters increased with the level of education of a participant. In both samples the offer of non-local oysters significantly decreased the likelihood of saying "yes". The results show that the tourists appear to care more about the origin of oysters than local population. This could be explained by the general inclination of tourists to prefer local food when traveling. The findings provide additional arguments for the development of oyster aquaculture in Delaware as both local residents and tourists in our study value the origin of oysters. Adequate branding of local oysters, once they became available, would be important to underline their origin. The results also suggest that with the growth in oyster farming, local businesses could supply local oysters to arriving tourists at a

premium price. Additional information campaigns might be necessary in Delaware to raise awareness about economic and environmental benefits of shellfish aquaculture.

These papers provide new insights on how contingent valuation and field experiments can help elicit consumer preferences for renewable energy and local food in new and established markets by introducing information treatments and consumer differentiation. The findings can be useful in understanding market potential for advanced biofuel and local oysters.

CHAPTER TWO

WILLINGNESS TO PAY FOR A SECOND-GENERATION BIOETHANOL: CASE STUDY OF KOREA

Abstract: This study investigates consumer preferences in Korea towards second-generation lignocellulosic bioethanol. We utilize a dichotomous-choice contingent valuation methodology in a double-bounded model to quantify willingness to pay for the product. In total, 471 consumers divided into four groups were surveyed in major Korean cities. We used three types of information treatments related to positive effects of second-generation bioethanol on the environment, food prices and fuel supply security and compared responses with the fourth group which didn't receive any information. We find that the average respondent in the full investigated sample was willing to pay a 4.3% premium over second-generation bioethanol compared to conventional fuel. The mean premium was highest in the subsample, which received information about positive environmental effects of the advance fuel (6%) and lowest in the respondent group, which was treated with information on food prices (3.4%). The mean willingness to pay with positive environmental information was also found to be significantly greater than that with no information. Female participants were more likely to purchase the product. Consumers who were knowledgeable about renewable energy sources and who put more value to environmental friendliness of fuel over its price were also willing to pay a premium for the advanced bioethanol.

Introduction

Korea[1] like the United States and some other OECD countries has committed itself to ambitious mid- and long-term targets in increasing the share of biofuels, and specifically bioethanol, in its energy mix. This goes in line with the overall national strategy of a low-carbon green growth, announced in 2010 (Korean Laws in English 2016). As a supporting policy, the government has developed a Renewable Fuel Standard (RFS), according to which, the mandatory blending for biodiesel and bioethanol is to reach 5% by 2020 (Kpetro 2013). However, given the limited availability of crop land in the country, first-generation bioethanol feedstocks would not be able to contribute to meeting those goals without compromising local food production capacity. Thus, Korea should adopt more advanced technologies if the country wishes to produce ethanol from lignocellulosic feedstocks. Kim et al. (2010) conclude that utilization of local resources of cellulosic biomass (e.g. wood and paper wastes) in combination with imported agricultural residues (e.g. from South-East Asia) and novel feedstock (e.g. macroalgae) are expected to contribute to reduction of costs of cellulosic ethanol to $0.2/L by 2030, making the target of substitution of 10% gasoline consumption in Korea by ethanol achievable.

Historically, biodiesel has developed faster than bioethanol in the Korean market. While a low percentage of biodiesel blending became mandatory in 2012 (KEA 2016), mandatory ethanol mixing is scheduled to start only in 2017, in line with the RFS. This can be explained by air quality considerations as heavy duty trucks run mostly on diesel fuel and contribute heavily to

[1] For simplicity in this paper Korea/Korean refers to South Korea/South Korean (officially the Republic of Korea).

city air pollution in Korea. With more than half of Korea's citizens regularly breathing dangerously polluted air, the country's air quality was ranked in 2016 as 173rd out of 180 in its category in the Environment Performance Index (Yale University 2016). This is mainly due to particulate matter and nitrogen oxides pollution. The government had also focused on subsidizing higher grade biodiesel blends for commercial fleet operators. However, continuous government support to research and development in advanced bioethanol gives hope for its commercialization in 5-10 years horizon.

Given high initial costs of investment in research and development of more advanced biofuels, the industry must rely on such government incentives as subsidies and tax exemptions to compete with gasoline suppliers in the country. In addition to government support, consumer acceptance of bioethanol is of utmost importance. In this regard, consumers' willingness-to-pay (WTP) for biofuels should be carefully estimated to assess their potential interest in sharing a portion of burden. Moreover, consumer acceptance also is important in case of mandatory fuel mixing policies (E5 or E10) or the introduction of E85 to the market.[2] As new technologies will be emerging and adopted, the cellulosic biofuels are expected to become more affordable due to their lower feedstock costs. Additionally, their important environmental and social advantages over the first generation biofuels can potentially increase the interest of consumers in accepting advanced biofuels.

In this article, we examine consumer preferences for second-generation bioethanol by analyzing consumer acceptance and WTP for such type of fuel through different information

[2] E5, E10 and E85 refer to 5%, 10% and up to 85% concentration of ethanol in the fuel mix (the remaining percentage being gasoline). While E5 and E10 can be used in any vehicle with a gasoline engine, E85 can be used only in specially modified flexible fuel vehicles (FFV).

treatments based on such advantages of the lignocellulose-based ethanol as better environmental sustainability, lower impact on food prices and enhanced fuel supply security compared to fossil fuels and traditional ethanol. We employ a contingent valuation (CV) methodology, a survey-based economic valuation technique, to quantify consumers' WTP for the ethanol blend. Furthermore, we investigate whether different types of information treatments produce a significant effect on WTP. A double-bounded, dichotomous-choice model is utilized to evaluate the responses.

The study is based on 471 consumer responses to surveys conducted in Korea. The survey collected data on consumers' driving patterns, knowledge about renewable energy, acceptance of relevant government policies and demographic characteristics.

The results of this study demonstrate that consumers tend to value the environmental benefits of the second-generation ethanol more than its advantages in terms of food and fuel supply security. They also suggest that 58% of respondents are willing to purchase the product at the current market price of traditional fuel while an additional 14% are willing to pay a premium for the second-generation ethanol. We estimate that, on average, consumers are willing to pay a 4.3% premium for the product.

Literature review

Consumer survey based CV methodology and choice experiments are applied frequently to measure WTP of consumers in various fields of applied microeconomics. Some of these studies, especially with a focus on consumer acceptance of renewable energy and alternative fuels are of specific relevance for the current study.

Ku and Yoo (2010) conducted a choice experiment in Korea to evaluate WTP for renewable energy investment as would be reflected in household electricity bills. They applied a multinomial probit (MNP) estimation to evaluate how consumers value different attributes of renewable energy sources (given different renewable energy development scenarios) and found that Koreans prioritize protection of wildlife, reduction of air pollution and increased employment opportunities while landscape was not found to be a statistically significant attribute. Another contingent valuation study by Kim et al. (2012) concluded that on average Koreans' WTP for renewable energy portfolio (wind, photovoltaic and hydropower) amounted to 3.7% of their monthly electricity bills. A CV study of the security of the fossil fuel supply showed that Korean public will be less against an increase in the tax on electricity than an increase in the tax on gasoline or diesel fuel (Jinsoo, Kim and Kim 2015). With regard to studies in Korea on the acceptance of the RFS, Huh et al. (2014) concluded, based on a choice experiments study, that the price of biofuel blends should be limited to an increase between Korean Won (KRW) 10 and 20[3] to ensure high acceptance level, secure a budget for infrastructure, and achieve substantial environmental improvement. In another study, where a CV methodology based on a spike model was used, a mean WTP for the RFS in Korea was estimated as 1.5% premium over monthly household transportation expenses (Huh, Lee, and Shin 2015). Compared to our study, that paper utilized a different empirical model, did not use information treatments and had a different approach to setting initial and follows up bids. In addition, the paper focused on RFS as an overall policy, while in our case we deal with a specific type of a renewable fuel. In a recent study on consumer preferences for bioethanol in Korea

[3] According to the World Bank (2016), the official annual average exchange rate of Korean Won to US Dollar was: 1126 KRW, 1095 KRW and 1052 KRW for 1 US Dollar in 2012, 2013 and 2014, respectively.

(Lim, Kim, and Yoo 2017), the mean WTP premium for E5 was estimated at 15.6% of the gasoline retail price in Korea. It should be noted, that this particular study did not focus on second generation-ethanol, used a one-and-one-half-bound dichotomous choice format and utilized a gasoline price surcharge as a payment vehicle instead of directly asking respondent about her WTP for bioethanol. The study also did not have separate information treatments related to impact of bioethanol on food, fuel and environment.

A number of studies on WTP for cellulosic bioethanol were conducted in the United States. Solomon and Johnson (2009) collected data with CV questions and fair-share (FS) surveys to estimate consumers WTP for biomass ethanol from three alternative feedstocks. Their results showed that on average the consumers were willing to pay $252 and $192 premiums per annum for ethanol compared to gasoline in respective CV and FS scenarios. Jensen et al. (2010) in their study based on contingent choice survey showed that mean consumer WTP for E85 from switchgrass was higher than that for E10 from corn. They also found that consumers put a positive weight on food production versus fuel availability. In their recent study on the second-generation ethanol using information treatments, Li and McCluskey (2017) estimated that the mean willingness to pay for second-generation biofuel was an 11% premium over conventional fuel.

Findings of different studies on another widely available biofuel – biodiesel – were also reviewed. While Giraldo et al. (2010) conclude that respondents in one of the regions of Spain are willing to pay a 5% premium for biodiesel compared to its conventional counterpart, a more recent “payment card” study in another Spanish region showed that consumers were not willing to pay for biodiesel, especially when its production may negatively affect food prices (Kallas and Gil 2015). The results of a study conducted in Beijing by Ma et al. (2014) showed that price,

quality, policy and government incentives can affect consumer purchasing intention in diesel consumption.

Data

Consumer surveys were conducted mainly in Seoul and Incheon metropolitan areas, the first and third largest Korean cities, respectively, as well as in some smaller cities, including Bucheon, Gwangju, Seongnam and Suwon. Seoul and Incheon together account for about 25% of the total population of Korea[4]. The surveys were held in late 2012 and early 2013 at busy spots like shopping malls. In total 471 valid responses were analyzed, about 80% of which were collected through face-to-face interviews. Some respondents were given time to complete surveys at home and return them at a later time. Each survey took about 15 minutes to administer.

The survey comprised three parts. First, the respondents were asked general questions intending to elicit information about their knowledge of biofuels and bioethanol, as well as of their opinion about proposed reforms by the Korean government. In the second part, the respondents were divided into four approximately equal groups. Three of them were provided a positive information statement on effects of cellulosic ethanol – the first received information on fuel supply security, the second on environmental benefits and the third - on food prices. The last fourth group of respondent was not provided any additional information. The paragraphs containing information statements and a sample survey are presented in the appendices. The choice of information treatments was driven by relevant studies on positive effects of cellulosic

[4] According to UN (2016), in 2014 the population of Seoul was 10.01 million and of Incheon – 2.84 million.

ethanol compared to first-generation ethanol. As such, Searchinger at el. (2008) concluded that cellulosic ethanol has advantages over its first generation counterpart since it is competing with food crops in much lesser extent and has potentially lower carbon footprint over its lifecycle by even conservative estimates. Sexton and Zilberman (2008) stated that environmental benefits of the second generation biofuels are manifested in lower water input and pesticides demand and lower degree of soil degradation compared to the first generation biofuels.

The information treatment about fuel supply security was of specific interest at the time of the survey preparation as Korea, one of the most important Iranian crude oil importers, had to halt shipments from Iran for two months in 2012 and subsequently reduce oil imports from this county to comply with sanctions imposed by the United States (US EIA 2016).

Next, all participants were asked if they would be willing to pay the same price for a cellulosic ethanol blend as for the typical fuel they buy for their car. If the answer was “no”, the respondents were randomly assigned a discount percentage, and if the answer was “yes” – premium levels. In both cases, the set of assigned values was 5%, 10%, 20% and 30%, compared to the initial bid of KRW 2,000 per liter. The initial bid was selected in line with the average retail price of regular gasoline at the time of the survey. Finally, the survey was concluded with questions on socio-demographic characteristics and driving habits and attitudes, including age, income, education level, employment status and the frequency of fuelling per month.

Data regarding environmental attitudes was obtained through a question involving a trade-off situation between the importance of a greater environmental friendliness of fuel compared to the importance of buying fuel at the lowest price (please see appendix 1 for the specific text).

The demographic characteristics of the respondents for the overall sample are summarized in Table 2.1. The average age is approximately 39 years. About one third of the respondents have at least one child less than 18 years old living with them. There are 58.6% male and 41.4% female participants in the study sample, and there is diversity in terms of education and income levels. As in all surveys, sample representativeness is a concern, and we compare the survey data to national statistics. The portion of male respondents in our sample was 58.6% compared to 49.75% in the general population, according to the 2012 Korean census data (KOSTAT 2014). Similarly, the unemployment rate in the sample was 0.64% compared to national unemployment rate of 3.2%. On the other hand, the median age of respondents (37 years) compares well with the median age in the country (39.1 years). Finally, the absolute majority of household income in the sample fell into the third (KRW 25,000,000 to 49,999,999) and fourth (KRW 50,000,000 to 99,999,999) categories, which corresponds to the national average annual income of KRW 48.92 million per household.

It is not possible to determine the effect of this sample population choice on our empirical results concerning valuation of second-generation bioethanol. There could also be some degree of sample selection bias, in which the people who were more interested in biofuels decided to participate in the survey. In the case of the gender of respondents, it could be the case that men were more interested in responding to the questionnaire as statistically they are the main car drivers in the family. According to KOSIS (2016), there were 16.93 million (59.9%) and 11.33 million (40.1%) male and female drivers in 2012, respectively.

Table 2.2 summarizes the responses to survey questions regarding driving-related habits and characteristics. About two thirds of the respondents own one car, about 29% own two cars, and less than 4.5% have more than two cars in their possession. The respondents reported that

37.6% used fuel other than regular gasoline, which included premium gasoline, liquefied petroleum gas (LPG), and diesel. One third of the participants considered themselves not knowledgeable about renewable energy resources. In addition, 69.6% had positive opinion about the government's low carbon green growth strategy. Further, the respondents reported the mileage that they travel per year: 24.6% drive less than 5,000 km, 33.6% drive between 5,000 to 10,000 km, 31.7% drive between 10,000 to 30,000 km and 10.1% drive more than 30,000 km. The responses rating the tradeoff between higher environmental friendliness of fuel compared to buying fuel at the lowest price indicate that majority are more inclined towards buying fuel at the lowest price, as 73.1% of the answers fall into first 5 response categories.

Methodology

We apply the contingent valuation (CV) methodology to estimate our Korean sample of consumers' WTP for cellulosic ethanol. We utilize a double-bounded dichotomous choice model to analyze the results of the survey (Kanninen 1993; Venkatachalam 2004). The double-bounded model has been shown to be statistically more efficient than a single-bounded model, although there may exist some anchoring bias from the initial bid. It has been argued that the benefit from increased efficiency outweighs the harm from any anchoring bias (Hanemann, Loomis, and Kanninen 1991). CV is a utility-based, stated preference model, widely used to analyze the value consumers place on expressed commodity or public good characteristics.

In our study, consumers answered dichotomous-choice bid questions to measure their WTP for fuel from lignocellulosic feedstocks. Each respondent is asked if he or she is willing to purchase second-generation bioethanol at a specified price, which we refer to as the initial bid.

In our study the initial bid is equal to KRW 2,000 per liter, which was close to the average retail price of regular gasoline at the time of the survey. If the answer is "yes," then the respondent is asked whether he or she is willing to purchase the second-generation bioethanol at a higher price. Alternatively, if the answer to the initial bid question is "no," then the respondent is asked whether he or she is willing to purchase the product at a discounted price. One of four premiums (5%, 10%, 20%, and 30%) or discounts (5%, 10%, 20%, and 30%) is randomly assigned to each respondent. Table 2.3 displays the distribution of bid responses.

The responses to the CV questions produce four possible outcomes in a double-bounded model: (1) the respondent is not willing to purchase second-generation ethanol at the initial bid price and does not want to buy it even at the discounted price (i.e., "no" to both bids); (2) the respondent is not willing to purchase the product at the initial bid but is willing to buy it at the discounted price (i.e. "no" followed by "yes"); (3) the respondent is willing to purchase bioethanol from advanced processing technologies at the initial bid but is not willing to buy it at the premium price (i.e. "yes" followed by "no"); (4) the respondent is willing to purchase second-generation bioethanol at the initial bid and also willing to purchase it at premium price (i.e. "yes" followed by "yes").

Using the double-bounded model with these four outcomes allows us to place the respondent's true WTP for advanced bioethanol into four intervals: $(-\infty, B_D)$, $[B_D, B_I)$, $[B_I, B_P)$ or $[B_P, +\infty)$ where B_D, B_I, and B_P are discounted, initial, and premium bids, respectively. The bidding mechanism results in the following discrete outcomes:

$$D = \begin{cases} 1 & WTP < B_D & (No, No) \\ 2 & B_D \le WTP < B_I & (No, Yes) \\ 3 & B_I \le WTP < B_P & (Yes, No) \\ 4 & B_P \le WTP, & (Yes, Yes) \end{cases} \quad (1)$$

where *WTP* is the respondent's WTP for second-generation bioethanol. The individual WTP outcome is based on the random utility model where the respondent maximizes utility by choosing to purchase a product at the associated bid amount if the utility derived from this good is higher than from refusing the bid and foregoing the product. The probability of each outcome can be expressed as:

$$\Pr(Y = j) = \begin{Bmatrix} G(v(B_D, Z)) \\ G(v(B_I, Z)) - G(v(B_D, Z)) \\ G(v(B_P, Z)) - G(v(B_I, Z)) \\ 1 - G(v(B_P, Z)) \end{Bmatrix} \text{ for } j = \begin{Bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{Bmatrix} \quad (2)$$

where $G(\cdot)$ is a cumulative distribution function characterizing the random components of utility, *v(B,Z)* is the difference in indirect utility function between purchasing a product at bid B and declining the bid, and Z is a vector of characteristics that influence the indirect utility. The function *v(B,Z)* in (3) for the individual *i* can be written as

$$v(B_i, Z_i) = \alpha - \rho' B_i + \lambda' X_i, \quad i = 1, 2, \ldots, n \quad (3)$$

where B_i is the bid amount offered to respondents *i*, and X_i is the observable characteristics of the respondent *i*. α , ρ and λ are unknown parameters to be estimated. Then the log-likelihood function can be expressed as:

$$\ln L = \sum_{i=1}^{n} \begin{Bmatrix} I_{Y_{i=1}} \ln G\left(\alpha - \rho B_{Di} + \lambda' X\right)_i + \\ I_{Y_{i=2}} \ln\left[G\left(\alpha - \rho B_{Ii} + \lambda' X_i\right) - G\left(\alpha - \rho B_{Di} + \lambda' X_i\right)\right] + \\ I_{Y_{i=3}} \ln\left[G\left(\alpha - \rho B_{Pi} + \lambda' X_i\right) - G\left(\alpha - \rho B_{Ii} + \lambda' X_i\right)\right] + \\ I_{Y_{i=4}} \ln\left[1 - G\left(\alpha - \rho B_{Pi} + \lambda' X_i\right)\right] \end{Bmatrix} \quad (4)$$

where $I_{Y_{i=j}}$ is the indicator for each *j* outcome (*j*=1,.., 4) for the individual *i*. We define $G(\cdot)$ function to be the standard logistic distribution with mean zero and variance $\sigma^2 = \pi^2 / 3$. Table 2.4 shows a description and explanation of the explanatory variables used in the model.

Results

Table 2.5 presents the parameter estimates from the double-bounded CV analysis and estimated marginal effects of the variables for the entire investigated sample. Consistent with other similar studies, the bid has a negative effect on WTP at the one percent level of statistical significance. Thus, as the bid amount increases, the probability of a consumer purchasing the second-generation bioethanol decreases. Figure 2.1 shows the distribution of probability of purchasing the product for each bid amount.

We introduced indicator variables for each type of information treatment and observed that none of them has a significant effect on the WTP. However, it is worth noting that the environmental information has a positive sign while food price and fuel security information – negative signs. Consumers who are knowledgeable about renewable energy sources are more likely to purchase the second-generation ethanol. In the similar manner, participants who put more value to environmental friendliness of fuel over its price are more willing to pay for the product. Both knowledge and environmental friendliness variables are significant at the one percent level.

From the demographic variables, only gender is statistically significant, though at the 10% level, so that female participants are estimated to be more likely to purchase the second-generation ethanol than male respondents. Other demographic variables, though insignificant, depict effects that are consistent with similar studies, e.g. both income and education variables' parameter estimates having positive signs.

At this stage we calculate the mean WTP, using Hanemann's approach (1984), as

$$WTP = \frac{1}{\hat{\rho}}(\hat{\alpha} + \hat{Z}'\bar{X}) \quad . \tag{5}$$

We find that for the entire sample, consumers, on average, are willing to pay a 4.3% (KRW 86) premium for the second-generation ethanol compared to traditional fuel. Confidence intervals around the estimated mean WTP are obtained using the delta method (Greene 2008). In percentage terms, the mean WTP for second-generation ethanol falls between a 1% premium to a 7.7% premium over traditional fuel (see Table 2.6).

Next, in order to study the isolated effects of each type of information treatment, we analyze three subsamples, in which we partition our sample of respondents based on the information treatment they received, including no information at all. At this stage, we also introduce a new variable to study the interaction between information and knowledge about renewable energy sources.

First, in the subsample where we pool those participants who received positive environmental information with those who have not received any information (see Table 2.7), we observe that information has a positive effect at the ten percent significance level. Environmental friendliness variable is significant at the one percent level and knowledge about renewable energy sources at the five percent level, both having positive signs. The information-and-knowledge interaction variable has a negative impact on the WTP at the ten percent level of significance. This interaction is expected because as the consumer becomes more knowledgeable, one should expect the impact of additional information to diminish. From demographic variables, age, education and gender all have significantly positive effect on the WTP, while the presence of a child in the family has a negative impact. The estimated mean WTP in this pooled subsample (4.93% premium) is the highest compared to the other two information treatments, suggesting that respondents value the positive impact of the second-generation ethanol on the environment the most.

Second, in the subsample which combines respondents with positive information on food prices and those with no additional information (see Table 2.8), we observe that only knowledge about renewable energy sources, environmental friendliness and gender are statistically significant, all having a positive sign at the at the five percent level. This subsample also has the lowest mean WTP (3.66% premium).

Finally, we analyze the subsample where the respondents who received information on the positive impact of the product on fuel supply security were pooled with participants who received no additional information (see Table 2.9). Here, we observe that knowledge about renewable energy sources, environmental friendliness, and income all have a positive effect on the WTP at the one, five and ten percent levels, respectively.

We are also interested in analyzing the estimated mean WTP in subsamples by information treatment, as also summarized in Table 2.6. Specifically, we test if the difference in estimated mean WTP between subsamples with positive environmental information and no information is significant. Since the confidence intervals overlap, we conduct a one-tailed t-test with the following null and alternative hypotheses:

$$H_0 : WTP_{EnvironmentalInformation} = WTP_{NoInformation}$$
$$H_a : WTP_{EnvironmentalInformation} > WTP_{NoInformation} \quad (6)$$

The null hypothesis can be rejected at the one percent significance level, providing support for the conclusion that the mean WTP with positive environmental information (6.02% premium) is greater than the mean WTP with no information (4% premium).

Finally, we come back to Figure 2.1, where we estimated the probability that a respondent chooses to purchase the second-generation ethanol blend given different levels of bids. We observe that the probability of saying "yes" to the initial bid is 72.6%. The highest level of probability of more than 99% is observed for a 30 percent discount and the lowest one, approaching zero for a 30 percent premium.

Conclusions

Second-generation bioethanol can play a significant role in meeting the Korean government's ambitious target of replacing a considerable amount of liquid fossil fuels with biofuels. Continuous scientific research in advanced biofuels with an ultimate goal of decreasing the costs of such fuels in medium and long term should be coupled with targeted activities to promote biofuels on the market and increase consumer awareness. In this study, we focus on consumers preferences towards second-generation lignocellulosic bioethanol. Specifically, we analyze consumers' willingness to pay (WTP) for such a product under different information treatments, reflecting different advantages of the second-generation ethanol. The results suggest that 72.6% of the surveyed consumers are willing to purchase second-generation bioethanol at the current market price, 14.2% of them are willing to purchase it at a premium price, and only 8.1% are not willing to purchase it even with a discount.

Our results show that respondents who received information about positive environmental benefits from the advanced biofuels place the highest value on the product, suggesting that a policy maker could promote the product by focusing on such its characteristics as lower greenhouse gas emissions, water consumption, and pesticide and fertilizer use. On the other hand, our Korean consumers are found to be less concerned with improved food and fuel security that might be provided through the adoption of the second-generation ethanol. This could be explained by the fact that Korea as a developed country has not recently experienced any major food prices or energy supply crisis. Individuals with high levels of overall knowledge about renewable energy sources are more likely to purchase the product, suggesting that

educating population about renewable energy supply might have a positive impact on the acceptance of the advanced biofuels by consumers. We also found that female respondents are more likely to purchase second-generation ethanol, suggesting the need for awareness raising campaigns specifically targeting males, who constitute two thirds of the drivers in the country.

This study contributes to the literature of consumer study on second-generation bioethanol. First, we find that consumers who received positive information about environmental benefits of the product have higher WTP values than those who did not receive any additional information on the product. Second, our results suggest that consumers who are generally more knowledgeable about renewable energy sources and are more environmentally friendly are more likely to purchase the second-generation bioethanol with a premium. Third, we find that such demographic characteristics as gender and income may also influence consumers' acceptance of the advanced biofuels.

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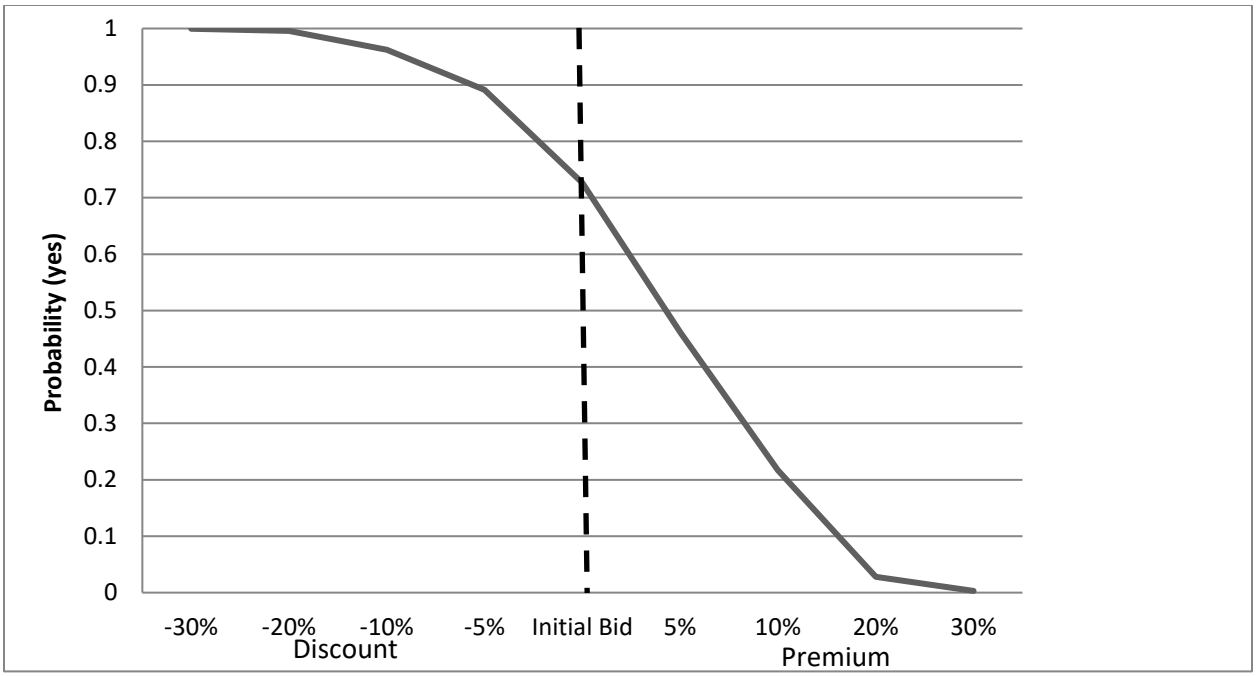

Figure 2.1. Estimated Probability of Choosing Second-generation Bioethanol given Bids

Table 2.1. Summary statistics for demographic variables

Number of respondents	471
Average age (years)	39.23
Variables	**Percentage of respondents**
Male	58.60%
Female	41.40%
Children under 18 present in household	32.70%
Education (highest level)	
Some School	1.28%
High school diploma	23.08%
Some college	18.16%
Bachelors' degree	48.08%
Advanced degree or graduate degree	9.40%
Household income (in 2011 or 2012)	
Less than KRW 15,000,000	4.08%
KRW15,000,000 to 24,999,999	9.44%
KRW 25,000,000 to 49,999,999	47.64%
KRW 50,000,000 to 99,999,999	33.48%
KRW 100,000,000 to 149,999,999	4.29%
KRW 150,000,000 or more	1.07%
Employment status	
Employed	66.03%
Self-employed	12.61%
Unemployed	0.64%
Retired	1.07%
Student	11.32%
Stay at home parent/ caregiver	8.33%
Residence	
Seoul	30.58%
Incheon	27.81%
Other	41.61%

Table 2.2. Response summary to selected questions

Variables	Percentage of respondents
No. of cars	
One	66.67%
Two	28.87%
More than two	4.46%
Knowledge about renewable energy sources	
Very knowledgeable	12.32%
Somewhat knowledgeable	54.35%
Not knowledgeable	33.33%
Type of fuel	
Regular gasoline	62.42%
Premium gasoline, diesel or LPG	37.58%
Opinion about government's low-carbon green growth policy	
Very positive	32.69%
Somewhat positive	36.97%
Neutral	16.24%
Somewhat Negative	4.1%
Very negative	0.64%
Don't know or not familiar	9.4%
Kilometers driven per year	
Less than 5,000	24.63%
From 5,000 to 10,000	33.62%
From 10,000 to 30,000	31.69%
More than 30,000	10.06%
Environmental friendliness	
1	21.72%
2	13.12%
3	15.05%
4	14.41%
5	8.82%
6	12.47%
7	6.88%
8	2.80%
9	2.80%
10	1.93%

Table 2.3. Distribution of bid responses

	Premium (Yes to initial bid)				
	5%	10%	20%	30%	Total
Yes	28	15	12	12	67
No	57	73	73	70	273
Total	85	88	85	82	340
	Discount (No to initial bid)				
	5%	10%	20%	30%	Total
Yes	24	25	22	22	93
No	12	8	9	9	38
Total	36	33	31	31	131

Table 2.4. Description of Explanatory Variables

Variable	Description
Bid	Random bid offered to each respondent
Treatment	
Information	1 = Provision of positive information on environment, food prices or fuel security, 0 = no information
Knowledge about Renewable Energy Sources	
Knowledge	1 = Not knowledgeable about renewable energy sources 2 = Somewhat knowledgeable 3 = Very knowledgeable
Driving Behavior	
Mileage	Reported mileage driven per year, continuous scale of 1 = less than 5,000 kilometers to 4 = more than 30,000 kilometers
Demographics	
Gender	1 = Female, 0 = Male
Education	1 = Bachelor's degree or above, 0 = otherwise
Income	continuous scale of 1 = less than KRW 14,999,999 to 6 = more than KRW 150,000,000
Age	Reported age
Child	1 = Presence of child under 18 in the family, 0 = otherwise
Environmental preferences	
Environmental Friendliness	Tradeoff between lower price and higher environmental friendliness of fuel, continuous scale of 1= lowest price to 10=highest environmental friendliness

Table 2.5. Coefficient Estimates and Marginal Effects of the Explanatory Variables on Mean WTP

Parameters	Coefficient Estimates	Standard Error	Probability	Marginal Effect	Standard Error	T-value
Bid	-22.5988***	1.3267	0.0000			
Constant	20.8039***	1.3943	0.0000			
Information on Environment	0.0536	0.2746	0.8452	0.0024	0.0122	0.1952
Information on Food	-0.2814	0.2633	0.2851	-0.0125	0.0116	-1.0706
Information on Fuel Security	-0.0566	0.2671	0.8323	-0.0025	0.0118	-0.2118
Knowledge	0.5226***	0.1525	0.0006	0.0231***	0.0068	3.4248
Mileage	0.0762	0.0985	0.4390	0.0034	0.0044	0.7742
Age	0.0054	0.0084	0.5225	0.0002	0.0004	0.6393
Education	0.2779	0.1991	0.1627	0.0123	0.0088	1.3959
Income	0.1679	0.1155	0.1462	0.0074	0.0051	1.4577
Environmental Friendliness	0.1622***	0.0437	0.0002	0.0072***	0.0019	3.7415
Child	-0.1107	0.1991	0.5784	-0.0049	0.0088	-0.5561
Gender	0.5639*	0.2032	0.0055	0.0250*	0.0090	2.7834

*Note:**10% significance level, **5% significance level, ***1% significance level

Table 2.6. Estimates of mean WTP (in percentage premium from the initial bid)

Sample	Mean WTP	95% Confidence Interval
Full Sample	4.32% premium	1% to 7.67% premium
Subsamples by information treatment		
No Information	4% premium	2.74% discount to 10.74% premium
Environmental Information	6.02% premium	1.77% discount to 13.81% premium
Food Information	3.36% premium	2.27% discount to 9% premium
Fuel Security Information	4.17% premium	1.7% discount to 10.03% premium

Table 2.7. Coefficient Estimates and Marginal Effects of the Explanatory Variables on Mean WTP with information treatment on environment

Parameters	Coefficient Estimates	Standard Error	Probability	Marginal Effect	Standard Error	T-value
Bid	-20.6389***	1.7294	0.0000			
Constant	17.8677***	1.8276	0.0000			
Information	1.3347*	0.8087	0.0988	0.0647*	0.0389	1.6609
Knowledge	0.6293**	0.3201	0.0493	0.0305**	0.0155	1.9678
Inf*Knowledge	-0.7756*	0.4446	0.0811	-0.0376*	0.0214	-1.7571
Mileage	0.1083	0.1342	0.4196	0.0052	0.0065	0.8091
Age	0.0269**	0.0123	0.0284	0.0013**	0.0006	2.1952
Education	0.5394*	0.3004	0.0726	0.0261*	0.0145	1.8032
Income	0.0035	0.1667	0.9832	0.0002	0.0081	0.0211
Environmental Friendliness	0.2562***	0.0645	0.0001	0.0124***	0.0030	4.0752
Child	-0.5983**	0.2923	0.0407	-0.0290**	0.0141	-2.0608
Gender	0.8576***	0.2866	0.0028	0.0416***	0.0137	3.0263

Note:*10% significance level, **5% significance level, ***1% significance level.

Table 2.8. Coefficient Estimates and Marginal Effects of the Explanatory Variables on Mean WTP with information treatment on food prices

Parameters	Coefficient Estimates	Standard Error	Probability	Marginal Effect	Standard Error	T-value
Bid	-24.0983***	2.0228	0.0000			
Constant	21.2777***	2.0861	0.0000			
Information	0.0357	0.8122	0.9649	0.0015	0.0337	0.0440
Knowledge	0.7405**	0.3398	0.0293	0.0307**	0.0141	2.1858
Inf*Knowledge	-0.1891	0.4456	0.6714	-0.0078	0.0185	-0.4242
Mileage	0.1817	0.1492	0.2232	0.0075	0.0062	1.2208
Age	0.0128	0.0129	0.3215	0.0005	0.0005	0.9901
Education	0.1993	0.2866	0.4869	0.0083	0.0119	0.6956
Income	0.2672	0.1690	0.1139	0.0111	0.0070	1.5876
Environmental Friendliness	0.1243**	0.0632	0.0493	0.0052**	0.0026	1.9793
Child	-0.1413	0.2788	0.6121	-0.0059	0.0116	-0.5076
Gender	0.6644**	0.3017	0.0277	0.0276**	0.0125	2.2043

Note:*10% significance level, **5% significance level, ***1% significance level.

Table 2.9. Coefficient Estimates and Marginal Effects of the Explanatory Variables on Mean WTP with information treatment on fuel supply security

Parameters	Coefficient Estimates	Standard Error	Probability	Marginal Effect	Standard Error	T-value
Bid	-24.3088***	2.0959	0.0000			
Constant	22.0035***	2.1597	0.0000			
Information	0.2496	0.7596	0.7425	0.0103	0.0312	0.3287
Knowledge	0.8919***	0.3355	0.0079	0.0367***	0.0137	2.6747
Inf*Knowledge	-0.1970	0.4242	0.6424	-0.0081	0.0174	-0.4647
Mileage	0.0380	0.1432	0.7905	0.0016	0.0059	0.2656
Age	0.0053	0.0122	0.6621	0.0002	0.0005	0.4371
Education	-0.0873	0.3036	0.7736	-0.0036	0.0125	-0.2877
Income	0.3031*	0.1607	0.0594	0.0125*	0.0066	1.8979
Environmental Friendliness	0.1446**	0.0625	0.0208	0.0059**	0.0025	2.3403
Child	-0.2352	0.2905	0.4183	-0.0097	0.0119	-0.8111
Gender	0.3047	0.3048	0.3173	0.0125	0.0125	0.9990

Note:*10% significance level, **5% significance level, ***1% significance level.

Chapter 2 Appendix 1 *English Translation of information statements*

On the environment

In recent studies, the scientists have shown that the second generation bioethanol (cellulosic ethanol) produces considerably lower environmental impact and greenhouse gases emissions compared to the first generation ethanol (produced from corn, rice and other grains). In case of the first generation ethanol, grain production requires higher water, pesticide and fertilizer use, leads to soil degradation, and requires conversion of forest lands to croplands, which leads to higher carbon footprint and loss in biodiversity. Second generation bioethanol, on the other hand, can be produced either from wastes or on marginal lands which are not used as cropland. Additionally, the second generation bioethanol can potentially have higher yields per hectare, which can lead to its lower competition for cropland with food production.

On food prices

In recent studies, the scientists have shown that the second generation bioethanol (cellulosic ethanol) produces considerably lower impact on food prices compared to the first generation bioethanol (produced from corn, rice and other grains). First reason is that cellulosic ethanol feedstocks (forest, wood and paper wastes, switch grass and agricultural residues) are not food products themselves. Second, is that the cellulosic ethanol does not compete for crop land in the extent the first generation ethanol does. This is because the cellulosic ethanol is produced either from wastes products or from feedstocks that can be grown on marginal lands, which are not normally used for food production.

On fuel supply security

Presently Korea relies heavily on oil/LPG imports from foreign countries and is the 7th largest oil importer in the world. At the same time, taking into account the political turmoil in many oil producing countries, the stability of fuel supply may become an issue for Korea. On the other hand, the second generation bioethanol (cellulosic ethanol) which can be produced from locally available feedstocks (forest, wood and paper wastes, switch grass and agricultural residues) can potentially at least partially reduce such dependency of Korea on oil imports.

Question to elicit environmental attitudes

When purchasing fuel for your vehicle, how important is **higher environmental friendliness** of fuel, compared to buying fuel at the **lowest price**? Please rate your feeling of importance on a scale of 1 to 10, where 1 means buying fuel at the lowest price is the most important and 10 means higher environmental friendliness is the most important.

Chapter 2 Appendix 2 ***English translation of a sample survey***

SECTION 1		
No	Question	Answers
1	What type of fuel do you mostly use in your vehicle?	☐ Regular gasoline ☐ Premium gasoline ☐ Diesel ☐ Liquefied Petroleum Gas (LPG)
2	How knowledgeable do you consider yourself on **renewable energy sources** and their effects on environment?	☐ Very knowledgeable ☐ Somewhat knowledgeable ☐ Not knowledgeable
3	What is your opinion about the **Low-Carbon Green Growth** policy of the Korean Government?	☐ Very positive ☐ Somewhat positive ☐ Neutral ☐ Somewhat negative ☐ Very negative ☐ Don't know or not familiar
4	Are you aware of the plan of the Korean Government to considerably increase the share of the **biofuels** in the Korea's fuel mix by 2030?	☐ Aware ☐ Heard something related to this ☐ Not aware at all
5	How many cars do you have in your household?	☐ One ☐ Two ☐ More than two
6	How often do you stop to refuel your vehicle?	☐ Once a month or less frequently ☐ Two-three times a month ☐ Once a week or more frequently
7	Approximately how many kilometers do you drive per year?	☐ Less than 5,000 ☐ From 5,000 to 10,000 ☐ From 10,000 to 30,000 ☐ More than 30,000
8	When purchasing fuel for your vehicle, how important is **higher environmental**	1 2 3 4 5 6 7 8 9 10

	friendliness of fuel, compared to buying fuel at the **lowest price**? Please rate your feeling of importance on a scale of 1 to 10, where 1 means higher environmental friendliness is the most important and 10 means buying fuel at the lowest price is the most important.	
9	How do you feel about **wider availability of biofuels in Korea in the nearest future**, e.g. bioethanol, biodisel, biogas?	☐ Very positive ☐ Somewhat positive ☐ Neutral ☐ Somewhat negative ☐ Very negative ☐ Don't know
10	What is the most important factor when you buy fuel for your vehicle?	☐ Recommendations of the vehicle manufacturer ☐ Environmental friendliness ☐ Company that runs a fuel station ☐ Price ☐ Others, please fill in_____
In questions 11-16, you will be asked about your willingness to pay for cellulosic ethanol blend.		
Please read carefully the following statement: **In recent studies, the scientists have shown that the second generation bioethanol (cellulosic ethanol) produces considerably lower environmental impact and greenhouse gases emissions compared to the first generation ethanol (produced from corn, rice and other grains). In case of the first generation ethanol, grain production requires higher water, pesticide and fertilizer use, leads to soil degradation, and requires conversion of forest lands to croplands, which leads to higher carbon footprint and loss in biodiversity. Second generation bioethanol, on the other hand, can be produced either from wastes or on marginal lands which are not used as cropland. Additionally, the second generation bioethanol can potentially have higher yields per hectare, which can lead to its lower competition for cropland with food production.**		
11	Suppose the price of fuel you usually purchase is KRW 2,000 /liter. If you were going to purchase the cellulosic ethanol blend for your vehicle today, and if the cellulosic ethanol blend was offered at the	☐ Yes ☐ No →SKIP to Q.13

	same price as the typical fuel you buy for your car, would you purchase it?	
12	Now, if the price of the cellulosic ethanol blend was KRW 2100/liter, would you be willing to purchase it?	☐ Yes → SKIP to Q.14 ☐ No → SKIP to Q.14
13	Now, if the price of the cellulosic ethanol blend was KRW 1900/liter, would you be willing to purchase it?	☐ Yes ☐ No
14	What is the most important factor to you in your choice of where to fuel your car?	☐ Price ☐ Quality ☐ Vicinity to home/work ☐ Retailer ☐ Other _____
15	At which gas station retailer chain do you most often refuel your vehicle?	☐ GS oil ☐ S-oil ☐ Hyundai Oil Bank ☐ SK ☐ Other
16	Would you consider it an advantage for the gas station if it started offering cellulosic ethanol blend for its customers?	☐ Yes ☐ No ☐ Not sure
SECTION 2		
17	What is your gender?	☐ Male ☐ Female
18	Which city do you live in Korea?	
19	Are you the person who mostly drives the car(s) in your household?	☐ Yes ☐ No
20	How many members do you have in your household?	
21	Do any children under 18 live in your household?	☐ Yes ☐ No
22	What kind of living environment are you in?	☐ Urban (city center) ☐ Urban (suburban) ☐ Rural

23	What is the highest level of education that you have completed?	☐ Some school ☐ High School diploma ☐ Some College ☐ Bachelors' degree ☐ Advanced degree or graduate degree
24	In which income bracket would your household fall into in the year of 2011?	☐ Less than 14,999,999 KRW ☐ 15,000,000 - 24,999,999 KRW ☐ 25,000,000 - 49,999,999 KRW ☐ 50,000,000 – 99,999,999 KRW ☐ 100,000,000 – 149,999,999 KRW ☐ Greater than 150,000,000 KRW
25	Which one of the following categories best describes your employment status:	☐ Formally employed ☐ Self employed ☐ Unemployed ☐ Retired ☐ Student ☐ Housewife
26	Please indicate your age	

CHAPTER THREE

COMPARISON OF CONSUMER PREFERENCES FOR SECOND-GENERATION BIOETHANOL IN KOREA AND THE UNITED STATES

Abstract: This study compares consumer preferences for second-generation bioethanol in Korea and the United States. We conducted consumer surveys across major cities in both countries. A double-bounded dichotomous-choice contingent valuation methodology was utilized to estimate willingness to pay and to analyze factors that affect consumer choice. The results suggest that, in both countries, the average respondent is willing to pay a premium for second-generation bioethanol compared to conventional fuel. Nevertheless, the premium is significantly higher in the United States (11.0%) compared to Korea (4.4%). Furthermore, we find that attitudinal and demographic variables have unidirectional marginal effects on willingness to pay in the two countries, while the magnitudes differ. The effect of environmental information regarding second-generation bioethanol is found to be significantly positive in both countries.

Introduction

Liquid biofuels continue to conquer new markets globally. In 2004, the worldwide production of ethanol and biodiesel stood at 28.5 and 2.4 billion liters, respectively. The amount rose to 94 billion liters for ethanol and 29.7 billion liters for biodiesel in 2014 (REN21 2016). The absolute majority of ethanol is produced from corn by the United States and sugarcane by Brazil. The use of grain and fruit feedstocks for the production of the first-generation ethanol has recently raised sustainability concerns (Mohr and Raman 2013). On the other hand, the second-generation ethanol is produced from switch grass, wood and paper wastes, or agricultural residues. It competes with food crops in a much lesser extent and has potentially lower carbon footprint over its lifecycle (Searchinger et al. 2008). In addition, compared to the first generation biofuels, environmental benefits of the second-generation biofuels also include lower water and pesticides input as well as lower degree of soil degradation (Sexton and Zilberman 2008).

In this article, we examine consumer preferences for second-generation bioethanol by analyzing consumer acceptance and willingness-to-pay (WTP) for such type of fuel in a combined sample that includes consumers from Korea and the United States. Moreover, this research studies similarities and differences across consumers in Korea and the United States with respect to their acceptance of second-generation bioethanol.

Both Korea and the United States are ranked as high-income countries. According to the World Bank (2016), in 2014 the gross national income per capita based on purchasing power parity was USD 34,620 in Korea and USD 55,860 in the United States. The countries are also similar in terms of education level. In 2012, the percentage of tertiary-educated adults was

41.73% in Korea and 43.05% for the United States (OECD 2014). Both countries feature highly developed petrochemical and automotive industries. However, the level of market penetration of biofuels is substantially different. In the Korean market, biodiesel has been a more common biofuel than ethanol. While a low percentage biodiesel blending became mandatory in 2012, mandatory ethanol mixing is scheduled to start only in 2020, in line with the Renewable Fuel Standard (RFS) (KEA 2016).

The United States and Korea are also major greenhouse gas (GHG) emitters. Though in absolute terms the emissions of the former are 9 times that of the latter, per capita emissions in 2014 in the United States (16.5 metric tons) were not a lot higher than emissions per person in Korea (11.6 metric tons) (World Bank). Korea became party to the Paris Agreement on climate in December 2016. According to its Intended Nationally Determined Contribution (INDC), Korea plans to reduce its GHG emissions by 37% from the business-as-usual level by 2030 across all economic sectors. In the transport sector, the Korean Government plans to continue introducing low-carbon standards for fuel efficiency and emissions from vehicles (UNFCCC 2017).

In both countries, the introduction of a second-generation ethanol to markets is now seen as an important element for meeting the national biofuel targets set by the Energy Independence and Security Act of 2007 (36 billion gallons in 2022) in the United States and the RFS introduction in Korea. In 2014, fuel ethanol production in the United States stood at 14.3 billion gallons, making it the biggest fuel ethanol producer in the world (RFA 2015). The biodiesel production in the US for the same year amounted to 1.271 billion gallons (EIA 2017). Fuel

ethanol and biodiesel production in Korea is relatively small and relies mostly on imported feedstocks.

There are a number of studies on consumer WTP for bioethanol in both Korea and the United States. Huh et al. (2014) in their choice experiment study on acceptance of the RFS in Korea concluded that the price of biofuel blends should be limited to an increase between Korean Won (KRW) 10 to 20 (a premium of less than 1% over conventional fuel) to ensure high acceptance level. As for the papers dealing specifically with second-generation bioethanol in the United States, Solomon and Johnson (2009) showed that consumers were willing to pay premiums for advanced ethanol compared to gasoline. Jensen et al. (2010) based on contingent choice survey found that mean consumer WTP for E85 from switch grass was higher than that for E10 from corn.

Some recent articles on consumer preferences for bioethanol include, for example, Lim et al. (2017) for Korea and Li and McCluskey (2017) for the United States. In the article by Li and McCluskey (2017), whose survey data is used as a part of this study, the mean willingness to pay for second-generation biofuel was an 11% premium over conventional fuel. Lim et al. (2017) found that the mean WTP premium for E5 is 15.6% of the gasoline retail price in Korea. This result for Korea was considerably higher compared to other similar studies (Huh, Lee, and Shin 2015). Since the second-generation bioethanol has gained much attention over the past years, it is important to conduct a systematic study to compare how consumers respond to such a product in these two countries.

Comparative studies are conducted to provide insights to consumer acceptance of new products across cultures. For example, Huh et al. (2015) concluded that although the level of

willingness to pay for renewable electricity in Korea has increased in recent years, it remains low when compared to other countries, such as Japan. McCluskey et al. (2006) utilized a contingent valuation (CV) methodology to compare responses towards genetically modified food in Asia, North America, and Europe and made marketing recommendations based on their findings. They found strong similarities in how the consumer samples from Canada and United States responded, and concluded that China and Japan differed from each other more than Norway and Japan in acceptance of genetically modified food. In the current study, we use a similar approach in comparing countries by estimating the significance of difference between marginal effects of explanatory variables on the willingness to pay for the second-generation ethanol blend in Korea and the United States. We employ a CV methodology, a survey-based economic valuation technique, to quantify consumers' WTP for the product. A double-bounded, dichotomous-choice model is utilized to evaluate the responses in separate country samples, as well as in the combined sample, and investigate differences between the Korean and the U.S. consumers.

The study is based on 940 consumer responses to surveys conducted in Korea and the United States. The surveys collected data on consumers' driving patterns, knowledge about renewable energy, environmental friendliness and demographic characteristics.

The results of this study demonstrate that in the combined sample consumers who received positive information about the second-generation ethanol are likely to pay a higher price for the product than those who received no additional information. We find that demographic characteristics such as education, gender and the presence of children in the household are also significant. For example, respondents who had at least one child in the family were less likely to purchase the second-generation ethanol than those who had no children. We estimate that, on

average, consumers in the combined sample are willing to pay an 8.4% premium for the second-generation biofuel product.

The WTP premium is significantly higher in the United States (11.0%) compared to Korea (4.4%). Furthermore, attitudinal and demographic variables have unidirectional marginal effects on willingness to pay in both countries, while the magnitude and statistical significance differ. The effect of environmental information regarding the second-generation bioethanol is significantly positive in both countries.

Data

The study is based on consumer surveys conducted in the United States and Korea. The Korean data was collected in late 2012 and early 2013[5] at shopping districts mainly in Seoul and Incheon metropolitan areas, as well as in the smaller cities of Bucheon, Gwangju, Seongnam and Suwon. In total, 471 valid responses were analyzed. The U.S. survey was conducted in 2014 and 2015 in three cities: Portland, Oregon; Minneapolis, Minnesota; and Boston, Massachusetts. The interviewers randomly recruited respondents from busy spots at each location. In total 599 valid face-to-face interviews were analyzed with approximately 200 per city. In both countries, the surveys solicited information regarding respondent's willingness to pay for second-generation biofuels, driving habits, environmental attitudes, demographic information, and other factors that

[5] We assume that the difference in time periods when surveys were conducted in Korea and the U.S. does not affect our findings, as no major policy change regarding bioethanol occurred in Korea between 2013 and 2015.

might influence their fuel purchase decisions. The U.S. survey also collected information about risk preferences.

Both surveys featured information treatments in order to assess how the provision of positive information on second-generation bioethanol affects the willingness to pay for this product. In the U.S. survey, the sample was split into two equal groups. 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, including their positive effects on food prices and environmental sustainability. The other half received no information. In Korea, the respondents were divided into four approximately equal groups. Three of them were provided a positive information statement on effects of cellulosic ethanol – the first received information on fuel supply security, the second on environmental benefits and the third - on food prices. The last fourth group of respondents was not provided any additional information.

To facilitate comparability between the two samples, we exclude from our analysis the Korean respondents who received the fuel security information, as none of the U.S. consumers received such information. This decreases the Korean sample size to 341. We also merge Korean respondents who received information on food prices and environmental benefits into one group, as the information statement in the U.S. survey combined these two aspects in one treatment. The paragraphs containing the information that was presented to the consumer samples are included in the Appendix.

In both surveys, all participants were asked if they would be willing to pay the same price for a cellulosic ethanol blend as for the typical fuel they buy for their car. If the answer was “no”,

the respondent was then asked if he or she would buy the fuel at a randomly assigned discount price. If the answer was “yes”, the responded was then asked if he or she would buy the fuel at a randomly assigned higher price. In both cases, the set of assigned values was 5%, 10%, 20% and 30%, compared to the initial bid. The initial bid in Korea was set to KRW 2,000 (USD 1.78) per liter of second-generation ethanol. The initial bid was selected in line with the average retail price of regular gasoline at the time of the survey. In the U.S. sample, the initial bid was the price that the respondent stated that he or she paid for fuel at his or her most recent fuel purchase. The mechanism for assigning random information treatments and premium/discount values was random mixing of questionnaires before the survey.

Data regarding environmental attitudes was obtained through a question involving a trade-off situation between the importance of a greater environmental friendliness of fuel compared to the importance of buying fuel at the lowest price (please see the appendix for the specific text).

The demographic characteristics of separate samples are well as the combined sample is summarized in Table 3.1. The average respondent in the combined sample was about 41 years old. About one third of the respondents had at least one child younger than eighteen years living with them. The Korean and U.S. samples were similar in terms of the age of respondents and the presence of a child in household. Male respondents constituted majority in the Korean sample, 58.2%, while in the U.S. sample there more female (53%) than male (47%) participants. In the combined sample, there were 51.2% male and 48.8% female respondents. The proportion of respondents having at least a first university degree was 57.7% in the Korean and 51.3% in the U.S. samples, respectively. The unemployment rate was lower in the Korean sample (0.85%)

than in the U.S. sample (4.33%). In both cases, the unemployment rates were lower than national averages.

Table 3.2 compares the responses to some attitudinal questions in Korea and the U.S. The share of households having two or more vehicles is remarkably higher in the U.S. sample compared to the Korean data. The share of respondents who view themselves as not knowledgeable about renewable energy resources is considerably higher in the Korean sample. The responses rating the tradeoff between higher environmental friendliness of fuel compared to buying fuel at the lowest price indicate that the majority of respondents in Korea are more inclined towards buying fuel at the lowest price, as 74.06% of the answers fall into first 5 response categories. For the U.S. data the number of respondents falling into the first and last 5 response categories is approximately the same, which demonstrates that in the U.S. sample consumers on average attach more value to environmental friendliness of fuel compared to its price than consumers in Korea.

Methodology

Model

We apply the contingent valuation (CV) methodology to estimate consumers' WTP for cellulosic ethanol in the combined sample. We utilize a double-bounded dichotomous choice model to analyze the results of the survey (Kanninen 1993; Venkatachalam 2004). The double-bounded model has been shown to be statistically more efficient than a single-bounded model, although there may exist some anchoring bias from the initial bid. It has been argued that the

benefit from increased efficiency outweighs the harm from any anchoring bias (Hanemann, Loomis, and Kanninen 1991). CV is a utility-based, stated preference model, widely used to analyze the value consumers place on expressed commodity or public good characteristics.

In our study, consumers answered dichotomous-choice bid questions to measure their WTP for second-generation bioethanol. The responses to the CV questions produce four possible outcomes in a double-bounded model: (1) the respondent is not willing to purchase second-generation ethanol at the initial bid price and does not want to buy it even at the discounted price (i.e., "no" to both bids); (2) the respondent is not willing to purchase the product at the initial bid but is willing to buy it at the discounted price (i.e. "no" followed by "yes"); (3) the respondent is willing to purchase bioethanol from advanced processing technologies at the initial bid but is not willing to buy it at the premium price (i.e. "yes" followed by "no"); (4) the respondent is willing to purchase second-generation bioethanol at the initial bid and also willing to purchase it at premium price (i.e. "yes" followed by "yes").

Using the double-bounded model with these four outcomes allows us to place the respondent's true WTP for advanced bioethanol into four intervals: $(-\infty, B_D)$, $[B_D, B_I)$, $[B_I, B_P)$ or $[B_P, +\infty)$ where B_D, B_I, and B_P are discounted, initial, and premium bids, respectively. The bidding mechanism results in the following discrete outcomes:

$$D = \begin{cases} 1 & WTP < B_D & (No, No) \\ 2 & B_D \le WTP < B_I & (No, Yes) \\ 3 & B_I \le WTP < B_P & (Yes, No) \\ 4 & B_P \le WTP & (Yes, Yes), \end{cases} \quad (1)$$

where *WTP* is the respondent's WTP for second-generation bioethanol. The individual WTP outcome is based on the random utility model where the respondent maximizes utility by choosing to purchase a product at the associated bid amount if the utility derived from this good is higher than from refusing the bid and foregoing the product. The probability of each outcome can be expressed as:

$$\Pr\left(Y=j\right)=\left\{\begin{array}{c} G\left(v\left(B_D,Z\right)\right) \\ G\left(v\left(B_I,Z\right)\right)-G\left(v\left(B_D,Z\right)\right) \\ G\left(v\left(B_P,Z\right)\right)-G\left(v\left(B_I,Z\right)\right) \\ 1-G\left(v\left(B_P,Z\right)\right) \end{array}\right\} \text{for } j=\left\{\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array}\right\}, \tag{2}$$

where $G(\cdot)$ is a cumulative distribution function characterizing the random components of utility, *v(B,Z)* is the difference in indirect utility function between purchasing a product at bid B and declining the bid, and Z is a vector of characteristics that influence the indirect utility. The function *v(B,Z)* in (3) for the individual *i* can be written as

$$v\left(B_i,Z_i\right)=\alpha-\rho' B_i+\lambda' X_i, \quad i = 1, 2, \ldots, n \tag{3}$$

where B_i is the bid amount offered to respondents *i*, and X_i is the observable characteristics of the respondent *i*. α , ρ and λ are unknown parameters to be estimated. Then the log-likelihood function can be expressed as:

$$\ln L = \sum_{i=1}^{n} \begin{Bmatrix} I_{Y_{i=1}} \ln G\left(\alpha - \rho B_{Di} + \lambda' X\right)_i + \\ I_{Y_{i=2}} \ln\left[G\left(\alpha - \rho B_{Ii} + \lambda' X_i\right) - G\left(\alpha - \rho B_{Di} + \lambda' X_i\right)\right] + \\ I_{Y_{i=3}} \ln\left[G\left(\alpha - \rho B_{Pi} + \lambda' X_i\right) - G\left(\alpha - \rho B_{Ii} + \lambda' X_i\right)\right] + \\ I_{Y_{i=4}} \ln\left[1 - G\left(\alpha - \rho B_{Pi} + \lambda' X_i\right)\right] \end{Bmatrix}, \quad (4)$$

where $I_{Y_{i=j}}$ is the indicator for each *j* outcome (*j*=1,.., 4) for the individual *i*. We define $G(\cdot)$ function to be the standard logistic distribution with mean zero and variance $\sigma^2 = \pi^2 / 3$.

Table 3.3 shows a description and explanation of the explanatory variables used in the model.

Country comparison

In this section, we assess the differences in responses between the Korean consumers and U.S. consumers in our sample. The United States is a top producer of ethanol fuel in the world, while Korea is one of the major importers of the U.S. ethanol, accounting for five percent of all U.S. fuel ethanol exports (RFA 2015). Therefore, studies of similarities and differences between the consumer preferences for this type of fuel in the two countries can be relevant for the U.S. ethanol industry and policy makers in Korea. The institutional and scientific cooperation between Korea and the United States on the use of ethanol as fuel has been already ongoing, as demonstrated for instance by regular workshops conducted by the U.S. Department of Agriculture in Korea (U.S. Embassy in Korea 2017).

We compare the marginal effects of different factors on WTP, calculated separately for both countries (see Table 3.6) to assess consumer attitudes towards second-generation ethanol, since the estimated coefficients are not directly interpretable in a double-bounded logit regression model. Our hypothesis tests proceed in the following way. For example, for the comparison between the United States and Korea for the j^{th} marginal effect, we tested the following:

$$H_0 : \theta_{K,j} - \theta_{US,j} = 0 \text{ versus } H_1 : \theta_{K,j} - \theta_{US,j} \neq 0 \quad . \tag{5}$$

Our sample sizes are large enough to justify asymptotic normality for the distribution of the test statistic,

$$Z = \frac{\theta_{K,j} - \theta_{US,j}}{\sqrt{\frac{n_K}{T}\text{var}(\theta_{K,j}) + \frac{n_{US}}{T}\text{var}(\theta_{US,j})}} \xrightarrow{asy} N(0,1) \text{ under } H_0 \tag{6}$$

where n_K and n_{US} represent the number of observations for the Korean and the U.S. data sets, respectively, and $\text{var}(\theta_{K,j})$ and $\text{var}(\theta_{US,j})$ represent the estimated variance of marginal effect j for the Korean and U.S. data sets, respectively. Finally, $T = n_K + n_{US}$ is the total of the sum of observations in both countries.

Results

Table 3.4 presents the parameter estimates from the double-bounded CV analysis and estimated marginal effects of the variables for the combined sample. As expected, the bid has a negative effect on WTP at the one percent level of statistical significance. Thus, as the price increases, the probability of a consumer purchasing the second-generation bioethanol decreases.

We introduced an indicator variable for the information treatments and observed that it has a positive effect at the ten percent significance level. The respondents who report that they are knowledgeable about renewable energy sources are more likely to purchase the second-generation ethanol. In the similar manner, participants who place more value on the environmental friendliness of fuel over its price are more willing to pay for the product. Both of these variables have positive signs and are significant at the five percent level. From the demographic variables, a higher level of education has a significantly positive effect on the WTP. Being female is associated with a greater likelihood to purchase the second-generation ethanol compared with being male. The presence of a child in the household has a negative impact on the WTP. All of these variables are significant at the ten percent level. Finally, the variable indicating that a respondent is from the United States has a strongly positive effect on the WTP, providing evidence that the U.S. consumers are likely to pay a higher price for the second-generation ethanol compared to the consumers in Korea.

We would like to reiterate here the difference between information treatments in the Korean and U.S. surveys. As explained above, the text given to the respondents in the United States combined information about positive effects of second-generation ethanol on environment

and food prices in one treatment while in Korea information on environment and food prices was given to two different groups. We acknowledge the limitation in comparing data from the two countries caused by the difference in treatments. To study the isolated effects of each type of information treatment in the Korean survey, we analyzed two subsamples, in which we pooled separately respondents who received information on environment and food prices with those who haven't received any information. We find that in the subsample where we pooled those who received positive environmental information with those who have not received any information at all, information had a significantly positive effect. In the similarly constructed subsample but with the food prices information treatment, information had a positive sign but was not statistically significant. We also observed that the estimated mean WTP for the second-generation ethanol in the first subsample was higher than that in the second, as shown in Table 3.5. These findings demonstrate that the Korean respondents valued the environmental benefits of advanced bioethanol higher than its positive impact on food prices.

The results from the country comparison between the United States and Korea, based on differences between the marginal effects of the explanatory variables on mean WTP for the second generation ethanol in each country, are reported in Tables 3.6 and 3.7. The U.S. and Korean data have in common that the marginal effects of education, age and self-reported knowledge about renewable energy sources are positive. Compared to the U.S. sample, the respondents from Korea were less responsive to the information treatment on positive effects of second-generation ethanol on food prices and the environment. In contrast, the relative valuation on environmental friendliness of fuel over its price had a significantly more positive effect on the WTP for the product in Korea than in the United States, where the marginal effect is positive but

not statistically significant. Similarly, being female had a significantly more positive effect on the WTP in the Korean sample compared to the U.S. sample. The presence of children under eighteen years in the household had a larger negative effect on the WTP in the U.S. sample.

Next, we calculate the mean WTP, following Hanemann (1984), as

$$WTP = \frac{1}{\hat{\rho}}(\hat{\alpha} + \hat{Z}'\bar{X}) \quad . \tag{7}$$

We find that for the combined sample, consumers, on average, are willing to pay an 8.4% premium for the second-generation ethanol compared to traditional fuel. Confidence intervals around the estimated mean WTP are obtained using the delta method (Greene 2008). In percentage terms, the mean WTP for second-generation ethanol falls between a 4.6% premium to a 12.2% premium over traditional fuel (see 3.8).

We also estimate mean WTP in the separate samples for Korea and the U.S., as displayed in Table 3.8. We find that on average, the U.S. consumers are willing to pay a significantly higher premium for the product than consumers in Korea.

Conclusions

In this study, we focus on the comparison of consumer preferences towards second-generation cellulosic bioethanol in Korea and the United States by analyzing consumers' willingness to pay for such a product. Our results suggest that in the combined sample, including both countries, consumers are willing to pay an 8.4% premium for the product. We also find that

the provision of information on positive effects of second-generation bioethanol increases willingness to pay for the product. Moreover, individuals with higher levels of self-reported overall knowledge about renewable energy sources and higher environmental friendliness were found to be more likely to purchase the product, suggesting that educating population about renewable energy supply on the global scale might have a positive impact on the acceptance of the advanced biofuels by consumers worldwide. We also found that female respondents are more likely to purchase second-generation ethanol, suggesting the need for awareness raising campaigns specifically targeting males. Finally, we find that the U.S. sample is more likely to purchase the product and pay a higher premium for it. This could be explained by the fact that ethanol was introduced as a fuel to the U.S. market much earlier than the Koreans became familiar with it.

Further, when comparing consumers in the two countries, we find that they did not significantly differ in terms of marginal effects of such variables as education, age and self-reported knowledge about renewable energy sources on the willingness to pay. However, we find that the U.S. consumers were more responsive to information treatment compared to the respondents in Korea. On the other hand, environmental friendliness of fuel over its price had a significantly more positive effect on the WTP for the product in Korea than in the United States. Our results suggest that on the global scale, more effort should be made to educate population about renewable energy sources. In addition, policy makers should focus on positive effects of second-generation bioethanol on food prices and the environment when introducing this product to the market and when designing information campaigns. Finally, international cooperation

could also play an important role in the wider availability and introduction of advanced biofuels to global markets.

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Table 3.1. Summary statistics for demographic variables

	Korea	U.S.	Combined
Number of respondents	341	599	940
Average age (years)	38.85	42.19	40.97
Variables	**Percentage of respondents**		
Male	58.24%	47%	51.16%
Female	41.76%	53%	48.84%
Children under 18 present in household	32.95%	31%	31.72%
Education (highest level)			
Some School	1.43%	2.68%	2.22%
High school diploma	22.29%	11.54%	15.51%
Some college	18.57%	34.45%	28.59%
Bachelors' degree	48.57%	29.93%	36.81%
Advanced degree or graduate degree	9.14%	21.40%	16.88%
Employment status			
Employed	67.05%	60.50%	62.92%
Self-employed	11.36%	16.17%	14.39%
Unemployed	0.85%	4.33%	3.05%
Retired	0.85%	8.00%	5.36%
Student	11.65%	8.67%	9.77%
Stay at home parent/ caregiver	8.24%	2.33%	4.52%

Table 3.2. Response summary to selected questions in Korea and the U.S.

Variables	Percentage of respondents	
	Korea	**U.S.**
No. of cars		
One	68.75%	34.33%
Two	27.65%	35.00%
More than two	3.69%	30.00%
Knowledge about renewable energy sources		
Very knowledgeable	11.08%	17.33%
Somewhat knowledgeable	55.68%	64.17%
Not knowledgeable	33.24%	18.50%
Miles (kilometers for Korea) driven per year		
Less than 5,000	26.07%	14.67%
From 5,000 to 10,000	34.38%	27.67%
From 10,000 to 15,000(10,000 to 30,000)	29.51%	29.33%
From 15,000 to 20,000 (more than 30,000)	10.03%	17.00%
More than 20,000		11.17%
Environmental friendliness		
1	21.90%	13.00%
2	13.26%	5.17%
3	15.27%	9.33%
4	14.70%	11.00%
5	8.93%	13.33%
6	12.39%	13.00%
7	7.20%	12.17%
8	2.02%	11.67%
9	1.73%	5.00%
10	2.59%	6.17%

Table 3.3. Descriptions of the explanatory variables

Variable	Description
Bid	Random bid offered to each respondent
Treatment	
Information	1 = Provision of positive information on second-general bioethanol, 0 = no information
Self-reported Knowledge about Renewable Energy Sources	
Knowledge	1 = Not knowledgeable about renewable energy sources 2 = Somewhat knowledgeable 3 = Very knowledgeable
Knowledge*Information	Interaction variable between knowledge and information
Demographics	
Gender	1 = Female, 0 = Male
Education	1 = Bachelor's degree or above, 0 = otherwise
Age	Reported age
Child	1 = Presence of child under 18 in the family, 0 = otherwise
USA	1 = Respondent from the United States, 0 = otherwise
Environmental preferences	
Environmental Friendliness	Tradeoff between lower price and higher environmental friendliness of fuel, continuous scale of 1= lowest price to 10=highest environmental friendliness

Table 3.4. Coefficient Estimates and Marginal Effects of the Explanatory Variables in the Combined Sample

Parameters	**Coefficient Estimates**	**Standard Error**	**Probability**	**Marginal Effect**	**Standard Error**	**T-value**
Bid	-13.2895***	0.5022	0.0000			
Constant	12.6310***	0.6075	0.0000			
Information	0.7463*	0.4107	0.0692	0.0562*	0.0309	1.8195
Knowledge	0.3201**	0.1602	0.0456	0.0241**	0.0120	2.0017
Knowledge* Information	-0.2583	0.2066	0.2112	-0.0194	0.0155	-1.2511
Age	0.0033	0.0046	0.4738	0.0002	0.0003	0.7165
Education	0.2910**	0.1290	0.0241	0.0219**	0.0097	2.2598
Environmental Friendliness	0.0641**	0.0257	0.0124	0.0048**	0.0019	2.5030
Child	-0.2819**	0.1328	0.0338	-0.0212**	0.0100	-2.1247
Gender (Female)	0.2786**	0.1273	0.0286	0.0210**	0.0096	2.1931
USA	0.5912***	0.1393	0.0000	0.0445***	0.0104	4.2638

*Note:**10% significance level, **5% significance level, ***1% significance level.

Table 3.5 . Estimates of mean WTP (in percentage premium from the initial bid) in pooled subsamples of Korean data

Subsamples by information treatment	Mean WTP
Environmental Information	4.93% premium
Food Prices Information	3.66% premium

Table 3.6. Coefficient Estimates and Marginal Effects of the Explanatory Variables on Mean WTP in separate samples in Korea and the U.S.

	Korea		United States	
Parameters	**Coefficient Estimates**	**Marginal effect**	**Coefficient Estimates**	**Marginal effect**
Bid	-21.4530***		-10.9219***	
Constant	19.6315***		11.2759***	
Information	0.6940	0.0323	1.1446**	0.1048**
Knowledge	0.7388**	0.0344**	0.2125	0.0195
Knowledge* Information	-0.4560	-0.0213	-0.3983	-0.0365
Age	0.0113	0.0005	0.0001	0.0000
Education	0.3790*	0.0177*	0.2414	0.0221
Environmental Friendliness	0.1787***	0.0083***	0.0373	0.0034
Child	-0.2189	-0.0102	-0.3564**	-0.0326**
Gender (Female)	0.6747**	0.0315**	0.0715	0.0065

*Note:**10% significance level, **5% significance level, ***1% significance level.

Table 3.7. Comparison of Marginal Effects on WTP between Korea and the U.S.

Variable	**z-statistic**	**p-value**
Information	-1.63	0.10
Knowledge	0.91	0.36
Knowledge*Information	0.69	0.49
Age	1.11	0.27
Education	-0.33	0.74
Environmental Friendliness	1.87	0.06
Child	1.63	0.10
Gender (Female)	1.87	0.06

Table 3.8. Estimates of mean WTP (in percentage premium from the initial bid).

Sample	Mean WTP	95% Confidence Interval
Combined Sample	8.39% premium	4.58% to 12.2% premium
U.S. sample	11% premium	5.21% to 16.79% premium
Korean sample	4.39% premium	0.38% to 8.4% premium

Chapter 3 Appendix: *Information statements used in both surveys*.

The English translation of information statements in the Korean survey:

On the environment

In recent studies, the scientists have shown that the second generation bioethanol (cellulosic ethanol) produces considerably lower environmental impact and greenhouse gases emissions compared to the first generation ethanol (produced from corn, rice and other grains). In case of the first generation ethanol, grain production requires higher water, pesticide and fertilizer use, leads to soil degradation, and requires conversion of forest lands to croplands, which leads to higher carbon footprint and loss in biodiversity. Second generation bioethanol, on the other hand, can be produced either from wastes or on marginal lands which are not used as cropland. Additionally, the second generation bioethanol can potentially have higher yields per hectare, which can lead to its lower competition for cropland with food production.

On food prices

In recent studies, the scientists have shown that the second generation bioethanol (cellulosic ethanol) produces considerably lower impact on food prices compared to the first generation bioethanol (produced from corn, rice and other grains). First reason is that cellulosic ethanol feedstocks (forest, wood and paper wastes, switch grass and agricultural residues) are not food products themselves. Second, is that the cellulosic ethanol does not compete for crop land in the extent the first generation ethanol does. This is because the cellulosic ethanol is produced

either from wastes products or from feedstocks that can be grown on marginal lands, which are not normally used for food production.

Information statement in the US survey:

First-generation bioethanol is produced from corn, rice and other grains, and so producing first-generation ethanol can increase food prices. Second-generation bioethanol (cellulosic ethanol) has a lower impact on food prices because it is made from weeds, straw, and other agricultural residues, which can be grown on marginal lands. Scientists at WSU are developing a nature-inspired second- generation bioethanol that uses termites to convert wood waste into usable fuel. Nature-inspired lignocellulose processing systems are more energy efficient, environmentally sustainable and economically feasible than the existing thermochemically-based technologies.

Question to elicit environmental attitudes:

When purchasing fuel for your vehicle, how important is **higher environmental friendliness** of fuel, compared to buying fuel at the **lowest price**? Please rate your feeling of importance on a scale of 1 to 10, where 1 means buying fuel at the lowest price is the most important and 10 means higher environmental friendliness is the most important.

CHAPTER FOUR

CONSUMER PREFERENCES FOR LOCAL OYSTERS

Abstract: This study examines consumer preferences for locally produced oysters in two distinct groups of respondents by using incentive compatible economic field experiments. A series of dichotomous-choice tasks and a demographic survey were administered to 341 local residents of Delaware and 417 tourists to investigate factors that influence respondents' decisions to purchase oysters and their willingness to pay for them. We find that price the consumers' frequency of oyster consumption had a positive effect on willingness to pay for oysters. The consumers were less likely to purchase oysters if they were offered oysters of non-local origin. In both investigated samples, the participants had higher willingness to pay for local oysters than for oysters harvested more than 100 miles away from the experiment location. This difference was more pronounced in the sample containing tourists. Moreover, tourists were willing to pay a premium of $0.56 per oyster for the locally-harvested product.

Introduction

Recent years have witnessed the increase in consumers' preferences for locally produced foods. This is particularly manifested in the increase of Community Supported Agriculture organizations (CSAs) and farmers' markets across the United States (Thilmany, Bond, and Bond 2008). There are numerous motivations for consumers to prefer locally-produced goods, including helping local producers (Zepeda and Leviten-Reid 2004), creating local jobs (Cooke and Watson 2011), and product quality/freshness considerations (Ahearn and Sterns 2013). In the seafood sector, consumer preferences for local products can be additionally explained by food safety concerns (Wessells and Anderson 1995), interest to maintain sustainability of fisheries, and willingness to eliminate negative externalities related to transportation of seafood products across long distances (McClenachan et al. 2014).

A number of studies show that consumers are willing to pay a premium for locally produced goods (Adams and Salois 2010). For example, McClenachan et al. (2016) investigated willingness to pay (WTP) for seafood across the three types of sustainability: ecological sustainability, local origin and social sustainability through an in-person survey of consumers in Maine, USA. They found that while respondents were willing to pay a premium for all three types of sustainability options, the WTP was lowest for social sustainability.

In addition to being a nutritious seafood, oysters provide a wide spectrum of ecosystem services ranging from water filtration and provision of habitat to carbon sequestration and increase of landscape diversity (Coen et al. 2007). These services provide benefits at the local, regional and global levels.

With reference to the role of oysters in achieving ecological sustainability, the field experiment of consumers in Delaware by Li et al. (2017) measured the potential for oysters to improve water quality by comparing respondents' preferences for oysters from water with different levels of nutrient pollution. They found that having oysters harvested from moderate or high nutrient water yielded an 11 percent increase in the likelihood of purchasing the product. They also found that relative to oysters from waters with an unknown level of nutrients, an average consumer was willing to pay premiums of $0.54 and $ 0.52 for oysters harvested from waters with moderate and high nutrient level, respectively. The data from these field experiments were collected as part of a larger project on various aspects of consumer demand for oysters.

In this paper, we utilize a part of data collected from the same project and follow a similar experimental design. However, we focus on investigating consumer preferences for locally produced oysters and introduce consumer differentiation. Specifically, we estimate willingness to pay for local and non-local oysters from two groups of respondents – local residents of the U.S. coastal state of Delaware and tourists arriving to Delaware by ferry to seek answers for the following research questions: (1) Do consumers prefer local to non-local oysters? (2) Are consumers willing to pay a premium for local oysters over non-local ones? (3) What demographic characteristics influence the likelihood of making a purchase of oysters among local and tourists? The questions are specifically relevant to Delaware, the only state on the U.S. East coast without shellfish aquaculture but planning to develop oyster industry in the near future. In March 2017, the Delaware's Department of Natural Resources and Environmental Control announced an initial offering of shellfish aquaculture sites available for leasing in

Delaware's Inland Bays (State News Service 2017). The analysis of preferences for locally grown oysters in different groups of consumers is critical to predicting demand for oysters, drawing up of marketing strategies targeting different types of consumers and informing local businesses about opportunities to offer local oysters to tourists and local clients.

We find that both local residents and tourist respondents have a higher WTP for locally grown oysters than for oysters originating more than 100 miles away from the consumer. The difference in WTP for those two types of oysters is more pronounced in the sample containing tourists and they had a higher WTP for local oysters than local residents. Analyzing the impact of demographic characteristics on the decision to purchase oysters, we find that in both samples, being a frequent oyster consumer significantly increased the likelihood of making the purchase. In the local residents' sample, the age of a respondent had a significantly negative effect. In the tourists' sample the likelihood of buying oysters increased with the level of education of a participant. In both samples the offer of non-local oysters significantly decreased the likelihood of saying "yes".

The paper contributes to the existing literature on estimating consumer preferences for locally produced seafood by introducing consumer differentiation. This could be specifically relevant to areas with developed tourism industry, which is true for many coastal areas in the United States. The findings can inform debates and policy decisions on the development of oyster aquaculture.

Literature Review

The definitions of "local food" differ widely across studies (Hand and Martinez 2010), including grown within a certain distance from the consumer (Darby et al. 2008) or produced within the same political boundary such as a state (Giraud, Bond, and Bond 2005) or a county (Schneider and Francis 2005). The *New Oxford American Dictionary* defines its 2007 word of the year, "locavore," as a "person who tries to eat only food grown or produced within a 100-mile radius". In this study, we adhere to that definition of "local", acknowledging however, that there is no general consensus that 100 miles distance from the consumer equates to local.

A number of studies investigated consumer valuation of different oyster attributes, including the origin of oysters. Kecinski et al. (2017) conducted choice experiments across four locations along the U.S. Atlantic coast to investigate consumer preferences for brand, locality and growing method of oysters. They found that while respondents overall preferred wild-caught oysters, frequent consumers were more likely to choose farmed oysters. They also found that the respondents did not exhibit preferences for local oysters.

Petrolia et al. (2014) conducted a national survey of consumer preferences for oysters from the Gulf of Mexico. They found considerable differences between responses of the Gulf taste panel participants in branded as opposed to blinded rounds. As such, when participants were aware of oyster brands they were more likely to prefer local brands to generic oysters. In the absence of such information, respondents had no preference for locally harvested oysters or even had a significant distaste for a local variety. In online consumer surveys, respondents

valued quality and seafood safety attributes of their locally produced oysters higher than those of oysters from other regions.

Through a discrete choice experiment administered to restaurant chefs in Hawaii, Chen et al. (2017) estimated marginal willingness to pay for locally grown oysters. They used random parameters logit model to analyze their results and found that restaurateurs were willing to pay an additional $5.25 for one dozen oysters that were grown locally. They conclude that in the presence of evidence of an existing price premium introducing labeling of local oysters could be a valuable marketing strategy.

Experimental Design[6]

Field experiments were conducted in two locations in Delaware. Local residents were surveyed at the State Division of Motor Vehicles, while tourists were interviewed in Lewes, Delaware - at a waiting area for arrival and departures of ferries from and to Cape May, New Jersey. The administrators recruited respondents randomly at each location.

We used a price-based revealed-preference model to estimate consumer WTP for oysters. In a single-bounded dichotomous-choice setting, experiment participants were offered an opportunity to purchase and consume oysters. Those who elected to purchase oysters completed the following tasks sequentially: chose the number of oysters to consume (three, six, nine or twelve), selected the preparation method (raw on a half shell, deep fried, or taken home in a bag on ice), were asked about WTP for oysters at different prices. After selecting the number of

[6] The experimental design was prepared as part of a larger project on various aspects of consumer demand for oysters (see e.g. Li et al. (2017)). We followed the same procedure, including the sequence of questions.

oysters to buy and the method of preparation, participants answered eight dichotomous-choice questions regarding purchasing oysters at randomly generated prices. The posted prices were generated from random draws from a normal distribution that was based on market prices for oysters, resulting in a common range between $0.50 to $2.50 per oyster. The price distribution was based on consultations with local oyster experts and represents the common market prices for oysters at the time of the experiment.

A number of oyster characteristics were identified prior to the experiments in consultation with local oyster experts, including restaurant owners, retailers, fishermen and conservation professionals to accurately reflect real-world questions to be included in the research. For the purpose of the present study, we focus on dichotomous choice questions related to three oyster attributes: (1) local, (2) non-local and (3) unknown harvest location. “Local” was defined to participants as oysters harvested within 100 miles from the experiment location. Conversely, “non-local” was defined as oysters not harvested within 100 miles. In the last option, the respondents were not given any information about the harvest location. A typical question would ask a participant if she would be willing to purchase local oysters for $1.50 each, based on the number of oysters to purchase and the preparation method, already selected by the participant. To account for potential order effects, the order of presentation for each oyster product that carries different location characteristic was randomized before participants made their purchasing decisions.

Participants responded “yes” or “no” to each oyster option and listed price. To maintain incentive-compatibility, participants were informed prior to the experiments that one of the decision rounds would be randomly selected to be binding at the end of experiment. In this

setting, the respondent's dominant strategy is to answer "yes" and purchase oysters only if the listed price is lower than the participant's true WTP. We also seek to avoid in this way possible overestimation of willingness to pay for oysters as hypothetical WTP are found to be consistently and significantly higher than the WTP that reflects real economic commitments (Neill et al. 1994) .The experiment lasted approximately ten minutes, and each participant received a $10 participant fee.

At the end of the experiment, all participants completed a survey that collected information on their demographic characteristics, shopping preferences, and perceptions regarding a number of oyster attributes. Eight oyster attributes– appearance, species, size, saltiness, smell, shell color, meat color and harvest location – were selected for the survey, based on discussions with local seafood experts.

Identical set-up, signs, and recruitment protocols were followed consistently at each location throughout the study. With the assistance of banners and flyers, administrators randomly approached individuals at each location and verbally recruited adult participants. After participants indicated that they were oyster consumers and expressed an interest in taking part in the study, a consent form was provided to them. Once they read and signed the consent form, they were handed a tablet computer containing the experiment questions and the survey. After completing the experiment and the survey, participants who had chosen to purchase the oysters in the decision selected for implementation paid the posted price from the $10 participation fee and were given the oysters. Participants who did not buy oysters in the implemented round received the full participation fee and no oysters.

In each experiment, one or two employees of a professional oyster-shucking service brought equipment to the site and prepared and presented the oysters, ensuring both high-quality presentations and adherence to food safety requirements. The participants made their decisions in a space that was physically separated from the shucking table. Thus, the participants could not see, smell, or taste the exact oysters they were considering for purchase.

Model

We utilize a single-bounded dichotomous choice model to analyze the results of the field experiment (Venkatachalam 2004). The three dichotomous-choice bid questions each can result in two possible outcomes in single-bounded models: a respondent is or is not willing to purchase the product at the proposed price. Thus, the respondent's true willingness-to-pay can be placed in one of the two intervals, $(-\infty, p)$ or $[p, +\infty)$, where p is the listed price randomly drawn from market price for oysters. The bidding mechanism produces the following discrete outcomes

$$D = \begin{cases} 0 & WTP < p \quad (No) \\ 1 & p \le WTP \quad (Yes) \end{cases} \tag{1}$$

where *WTP* is the respondent's WTP for oysters. The individual WTP outcome is based on the random utility model where the respondent maximizes utility by choosing to purchase a product

at the associated bid amount if the utility derived from this good is higher than from refusing the bid and foregoing the product. The probability of each outcome can be expressed as

$$\Pr(Y = D) = \begin{Bmatrix} G(v(p,Z)) \\ 1 - G(v(p,Z)) \end{Bmatrix} \text{for} \quad D = \begin{Bmatrix} 0 \\ 1 \end{Bmatrix} \tag{2}$$

where $G(\cdot)$ is a cumulative distribution function characterizing the random components of utility, $v(p,Z)$ is the difference in indirect utility function between purchasing a product at price p and declining the price, and Z is a vector of characteristics that influence the indirect utility. The function $v(p,Z)$ in equation (2) for the individual i can be written as

$$\begin{gathered} v(p_{ij}, Z_{ij}) = \alpha - \rho' p_{ij} + \lambda' X_i, \\ i = 1,2,...,n \qquad j = 1,2,3 \end{gathered} \tag{3}$$

where p_{ij} is the price of oyster j offered to respondent i, and X_i is a vector of observable characteristics of the respondent i, including the frequency of consumption of oysters per year, gender, age, education, income, shopping behavior, and oyster perception factors calculated by factor analysis. α, ρ, and λ are unknown parameters to be estimated. Then, the log-likelihood function can be expressed as

$$\ln L = \sum_{i=1}^{n} \left\{ \begin{array}{l} I_{D=0} \ln G\left(\alpha - \rho' p_{ij} + \lambda' X_i\right) + \\ I_{D=1} \ln\left[1 - G\left(\alpha - \rho' p_{ij} + \lambda' X_j\right)\right] \end{array} \right\} \quad (4)$$

where $I_{D=\{0,1\}}$ is the indicator for each D outcome for the individual i . We define $G(\cdot)$ function to be the standard logistic distribution with mean zero, a within-subject error term $\mu_i \sim N(0, \sigma_\mu^2)$ and an individual error term $\varepsilon_{ij} \sim N(0, \sigma^2)$, where $\sigma^2 = \pi^2 / 3$.

Data

In total 758 individuals participated in the dichotomous choice experiment and survey; 341 of those were local residents and 417 were tourists. The demographic characteristics of both investigated samples are summarized in Table 4.1.

The average respondent in the sample containing local residents was about 40 years old, while the average age of the tourist respondent was about 49. The ratio of females was higher in the tourists' sample (56.51%) than among the surveyed local residents (45.06%). The proportion of respondents having at least a first university degree was 63.11% in the tourists' sample and 31.45% in the sample containing local residents. The samples also differed in the ratio of respondents having annual household income above $75,000. For local residents that number stood at 22.15% while among tourists roughly every second respondent reported income above that threshold (51.12%). We can conclude that an average surveyed tourist was older, had higher income and higher level of education compared to her local counterpart. This could be explained

by the fact that beach visitors are usually more upscale in terms of economic status. The two samples do not differ much in the number of frequent consumers of oysters (6 times and more per annum) and in the number of respondents who reported to be primary shoppers in the household.

It is not possible to determine the effect of the sample population choice on our empirical results concerning valuation of oyster attributes and willingness to pay for local and non-local oysters. The administrators tried to sample only individuals who ate or were willing to try oysters, by asking them at the beginning of the recruitment protocol whether the person consumed oysters. There could be some degree of sample selection bias since all who elected to participate were interested in the product. The locations of surveys could also restrict the extent to which the results can be generalized to wider populations.

Participants evaluated the importance of each oyster attribute on a 1 to 9 scale, where 1 represented not at all important and 9 indicated extremely important. Figure 4.1 depicts the average score of participant valuations in both samples for eight oyster attributes: species, shell size, meat size, saltiness, smell, shell color, meat color, and harvest location. Respondents in both samples, on average, valued oyster smell and meat color the most (average score in the range of 6 to 7) and oyster size and species the least (score 4 to 5). Other oyster attributes received the average score of about 5.5 in both samples.

Results

We estimated correlation coefficients for consumer valuations for pairs of oyster attributes, as presented in Table 4.2 and Table 4.3 for the samples of local residents and tourists, respectively. All of the coefficients are positive and significantly correlated at one percent level of statistical significance, which indicated that consumers who value one oyster attribute as very important are likely to place relatively high importance scores on other attributes.

We used a factor analysis to identify potential influences on consumption behavior such as general perceptions of seafood safety and quality. Table 4.4 shows factor loadings (Hair et al. 1998) for two identified factors for the sample containing local residents. The findings for the tourists' sample are similar and thus are not provided. The first factor captures a latent sense of perceived importance equally associated with all oyster attributes that we refer to as *undiscerning*. The second describes the latent sense of professional critics regarding oysters as it puts significantly more weight on the harvest location and species. We refer to this factor as *discerning*. We incorporate these factors in the econometric model and expect that the variable for undiscerning will have an insignificant coefficient on the oyster purchase decision while the variable for discerning will have a positive coefficient.

Using a random effects logit model, we investigate factors that influence respondents' decision to purchase oysters. Table 4.5 summarizes the findings for the local residents' sample. As anticipated, price had a significant and largely negative effect. When the price increases by one dollar, respondents are 18 percent less likely to say "yes" to purchasing oysters. Frequent oyster consumers were more likely to buy oysters. This variable was significant at the 10%

significance level. Age had a significantly negative but relatively small effect. Discerning consumers of oysters, who value mostly oyster species and harvest location attributes, are more likely to buy oysters. Participants were less likely to buy oysters when they knew that the oysters were not local, at the 5% significance level. Having oysters of non-local origin decreased the probability of a participant saying "yes" to the oyster option by 6 percent. While variable representing the local origin of oyster was not statistically significant, it had a positive sign. Demographic variables signifying gender and education of respondents were not statistically significant in the sample containing local residents.

Similarly, Table 4.6 summarizes the findings for the tourists' sample. The price, as expected, has again a significant and largely negative effect. When the price increases by one dollar, respondents in the tourists' sample are ten percent less likely to say "yes" to purchasing oysters. As in the case of local residents' sample, frequent consumers were more likely to buy oysters. Education had a significantly positive effect at the 1% level of statistical significance. With each additional education category, the probability of "Yes-decisions" increased by three percent. No other demographic variable had a statistically significant effect. The variable representing the local origin of oysters was statistically significant this time and had a positive sign. Having oysters of local origin increased the probability of a tourist participant saying "yes" to the oyster option by three percent, at the 10% statistical significance level. In contrast, harvested from non-local waters oysters yielded an 11 percent decrease in the probability of making a purchase. This shows strong distaste of surveyed tourists for non-local oysters.

Next, we calculate the mean WTP in both samples, using Hanemann's approach (1984), as

$$WTP = \frac{1}{\hat{\rho}}(\hat{\alpha} + \hat{Z}'\bar{X}) \quad (5)$$

Before calculating the mean WTP we truncate protest respondents from our samples. We define protest respondents as those participants who answered "No" to all oyster purchase options (Dziegielewska and Mendelsohn 2007). While administrators strived to recruit for experiments only those who consumed oysters or were interested to taste them, the samples still contained 26% and 25% of first time oyster consumers for local residents and tourists, respectively. This could explain the relatively high number of protest respondents observed in both samples. We acknowledge that eliminating protest respondents from the sample reduces the downward bias in WTP estimation but may introduce self-selection bias (Halstead et al. 1992).

We find that consumers in the sample containing local residents were willing to pay an average of $1.67 for an oyster while the mean WTP among tourists was $1.69. We use our truncated samples to estimate marginal WTP for levels of interest for specific oyster attributes. An average local resident is willing to pay $0.43 less per oyster for non-local oysters at the 1% level of significance. From demographic characteristics, primary shoppers in the household were willing to pay $0.28 less per oyster at the 10 percent level of statistical significance. In the sample containing tourists, respondents were willing to pay a premium of $0.56 per oyster for oysters of local origin, which is significant at the 5 percent level. This amount is consistent with the premium restaurant owners were willing to pay for local oysters in Hawaii, identified by Chen et al. (2017), i.e. $5.25 per dozen oysters. As in the case of local consumers, participants

were willing to pay less for oysters originating more than 100 miles from the survey location but the negative marginal WTP for that attribute is higher and amounts to $1.34 per oyster, at the 1 percent level of statistical significance.

Next, we estimate mean WTP in each sample, separately for local and non-local oysters. The results, summarized in Table 4.7, suggest that in both samples participants on average were willing to pay more for local oysters than for the oysters coming from more than 100 miles distance from the survey location. The difference between WTP for local and non-local oysters was higher in the sample containing tourists than in the sample containing local residents.

Our results show that the tourists appear to care more about the origin of oysters than local population. This could be explained by the general propensity of tourists to prefer local food at a destination, e.g. to enrich their cultural experiences (Sengel et al. 2015), or by the association of a "local" attribute with freshness and quality, which could be valued more by travelers.

Conclusions

Buying local food can support local businesses and reduce negative externalities related to transportation. In the case of seafood, consumers may additionally prefer local products because of food safety and quality considerations and the value of ecosystem services provided by certain types of species, including oysters. Understanding of consumers' preferences for local oysters is important for producing relevant policy recommendations for the development of

aquaculture sector and tourism. This is specifically relevant in Delaware, the only East Coast state without oyster aquaculture.

This study focuses on estimating willingness to pay for local and non-local oysters in two distinct samples – one consisting of local residents in Delaware and the other of tourists arriving to Delaware by ferry. We also identify how different demographic characteristics affect the decision to purchase oysters.

We find that the average local resident is willing to pay $1.67 per oyster and that the probability of making a purchase increases with the frequency of oyster consumption and with the relative preference of a consumer for oysters' species and harvest location over smell and size. The probability of purchase decreases with the age of consumer and with the offer of non-local oysters. For the average tourist consumer, the willingness to pay amounted to $1.69 per oyster and a participant was more likely to purchase oysters if she was a frequent oyster consumer, had relatively higher level of education and was offered local oysters as an option and less likely to do so if offered non-local oysters. We also find that in both investigated samples, participants were willing to pay more for local oysters and for those of non-local origin. This difference was more evident for tourist consumers.

The findings provide additional arguments for the development of oyster aquaculture in Delaware as both local residents and tourists in our study value the origin of oysters. Adequate branding of local oysters, once they became available, would be important to underline their origin. Our results also suggest that with the growth in oyster farming, local businesses could supply local oysters to arriving tourists at a premium price. Additional information campaigns

might be necessary in Delaware to raise awareness about economic and environmental benefits of shellfish aquaculture.

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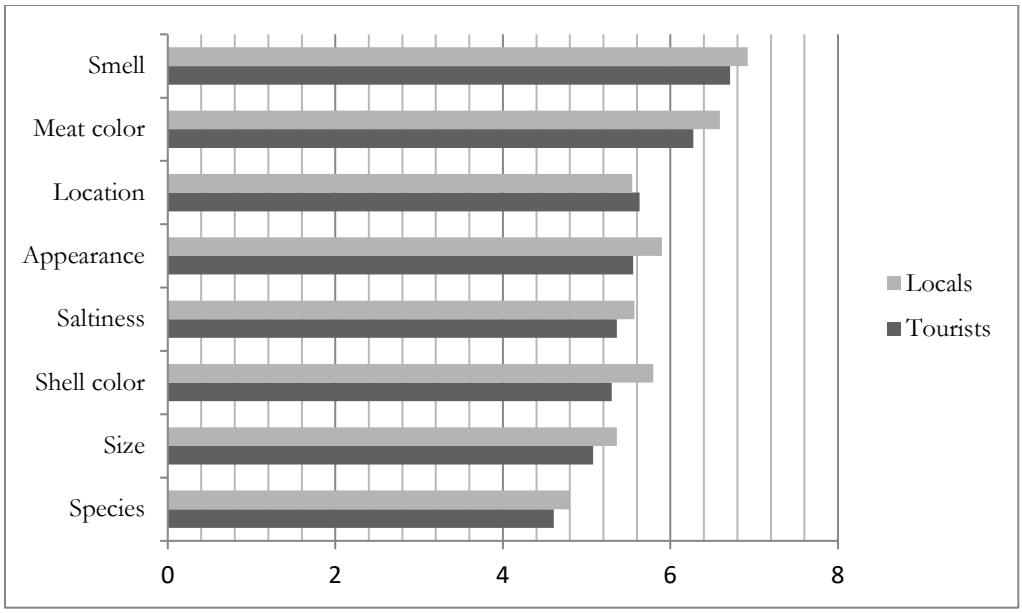

Figure 4.1. Importance of oyster attributes

Table 4.1 Summary Statistics for Demographic Variables

	Local residents	Tourists
Number of respondents	341	417
Average age (years)	40.20	48.65
Variables	**Percentage of respondents**	
Female	45.06%	56.51%
Primary shopper	67.59%	65.11%
Education (highest level)		
Some school	6.23%	1.21%
High school diploma	33.83%	16.50%
Some college	28.49%	19.17%
Bachelor's/Associate degree	22.55%	34.95%
Graduate/Professional degree	8.90%	28.16%
Household income (in 2014 or 2015)		
Less than $10,000	13.47%	3.23%
$10,000 to $24,999	16.47%	10.42%
$25,000 to $34,999	19.46%	7.44%
$35,000 to $74,999	28.44%	27.79%
$75,000 to $99,999	8.98%	14.89%
$100,000 to $149,999	8.98%	18.86%
$150,000 to $249,999	3.59%	11.41%
$250,000 or more	0.60%	5.96%
Annual Oyster Consumption (times)		
0	23.67%	34.95%
1-2	36.09%	30.83%
3-5	22.78%	13.59%
6-9	9.17%	8.74%
9 or more	8.28%	11.89%

Table 4.2. Correlation coefficients between Consumer Valuations for Oyster Attributes for the sample of local residents

	Smell	**Meat color**	**Saltiness**	**Location**	**Appearance**	**Size**	**Shell Color**	**Species**
Smell	1.00							
Meat color	0.67	1.00						
Saltiness	0.43	0.50	1.00					
Location	0.35	0.47	0.31	1.00				
Appearance	0.53	0.54	0.42	0.35	1.00			
Size	0.37	0.45	0.39	0.41	0.41	1.00		
Shell color	0.43	0.64	0.38	0.39	0.66	0.40	1.00	
Species	0.24	0.30	0.30	0.52	0.35	0.50	0.35	1.00

Note: Pair-wise correlation coefficients between all variables are significant at the 1 percent level.

Table 4.3. Correlation coefficients between Consumer Valuations for Oyster Attributes for the tourists' sample

	Smell	**Meat color**	**Saltiness**	**Location**	**Appearance**	**Size**	**Shell Color**	**Species**
Smell	1.00							
Meat color	0.68	1.00						
Saltiness	0.53	0.51	1.00					
Location	0.43	0.44	0.50	1.00				
Appearance	0.48	0.60	0.47	0.34	1.00			
Size	0.40	0.50	0.49	0.38	0.56	1.00		
Shell color	0.40	0.60	0.45	0.43	0.63	0.48	1.00	
Species	0.30	0.31	0.45	0.48	0.31	0.53	0.36	1.00

Note: Pair-wise correlation coefficients between all variables are significant at the 1 percent level.

Table 4.4. Summary of Factor Analysis Results for the local residents' sample

Variable	**Factor Loading**	
	Factor 1 (Undiscerning)	**Factor 2 (Discerning)**
Location	0.5954	0.2880
Species	0.5431	0.4424
Size	0.6158	0.2466
Appearance	0.7219	-0.1461
Saltiness	0.5808	-0.0356
Smell	0.6768	-0.2478
Shell color	0.7341	-0.1309
Meat color	0.8056	-0.2154

Table 4.5. Coefficient Estimates of the Explanatory Variables on Yes-Decisions to Purchase Oysters for the local residents' sample.

Parameters	Coefficient Estimates	Standard Error	Probability	Marginal Effects
Price	-1.92***	0.30	0.00	-0.18***
Frequent	0.38*	0.20	0.06	0.04*
Female	-0.28	0.39	0.48	-0.03
Age	-0.03**	0.01	0.03	-0.003**
Education	0.09	0.13	0.48	0.01
Income	0.08	0.09	0.35	0.01
Primary shopper	-0.30	0.40	0.46	-0.03
Discerning	0.60**	0.28	0.03	0.06**
Undiscerning	-0.14	0.24	0.56	-0.01
Local	0.17	0.26	0.50	0.02
Non-local	-0.64**	0.27	0.02	-0.06**

*Note:**10% significance level, **5% significance level, ***1% significance level, N=972

Table 4.6. Coefficient Estimates of the Explanatory Variables on Yes-Decisions to Purchase Oysters for the tourists' sample.

Parameters	**Coefficient Estimates**	**Standard Error**	**Probability**	**Marginal Effects**
Price	-1.50***	0.28	0.00	-0.10***
Frequent	0.69***	0.20	0.00	0.05***
Female	-0.42	0.44	0.34	-0.03
Age	-0.01	0.01	0.24	-0.001
Education	0.36***	0.15	0.01	0.03***
Income	0.02	0.08	0.77	0.002
Primary shopper	0.15	0.46	0.74	0.01
Discerning	0.32	0.30	0.27	0.02
Undiscerning	-0.11	0.24	0.63	-0.01
Local	0.47*	0.25	0.06	0.03*
Non-local	-1.60***	0.32	0.00	-0.11***

*Note:**10% significance level, **5% significance level, ***1% significance level, N=1,221

Table 4.7. Estimates of mean WTP for local and non-local oysters ($/oyster)

	Sample	
Oyster type	**Local residents**	**Tourists**
Local	$1.82($1.63-2.00)	$2.14 ($1.75-2.54)
Non-local	$1.63($1.46-1.81)	$1.51 ($1.24-1.78)

Note: 95% confidence intervals provided in brackets.

CHAPTER FIVE

DISSERTATION CONCLUSIONS

The objective of this dissertation is to gain a deeper understanding of existing and new markets for renewable energy and local food. Willingness to pay for a second-generation bioethanol in Korea is estimated in respondent groups treated with different types of positive information about the product. The mean premium was highest in the subsample, which received information about positive environmental effects of the advance fuel and lowest in the respondent group, which was treated with information on food prices. The mean willingness to pay with positive environmental information was also found to be significantly greater than that with no information. Female participants were more likely to purchase the product.

In the comparative study of consumer preferences for advanced bioethanol in the United States and Korea, the premiums for the second-generation bioethanol are significantly higher in the United States than in Korea. Marginal effects of different variables on the willingness to pay are compared between the countries. The results suggest that attitudinal and demographic variables have unidirectional marginal effects on willingness to pay in the two countries, while the magnitudes differ. The effect of environmental information regarding second-generation bioethanol is found to be significantly positive in both countries.

In the study of local markets for oysters using two distinct groups of respondents, tourists appear to care more about the origin of the product than local residents. Consumers were less likely to purchase oysters if they were offered oysters of non-local origin. In both investigated samples, participants had higher willingness to pay for local oysters than for oysters harvested

more than 100 miles away from the experiment location. This difference was more pronounced in the sample containing tourists.

Overall, the results demonstrate growing consumer awareness of environmental benefits of advanced biofuels and locally produced seafood. However, more specific marketing strategies are required for different groups of consumers.