자원 · 환경경제연구 제 30 권 제 1 호
Environmental and Resource Economics Review
Volume 30, Number 1, March 2021 : pp. 49~77
DOI: https://doi.org/10.15266/KEREA.2021.30.1.049

Impact of Various Feedstock Attributes on the Social Acceptance on Bioethanol Promotion in South Korea†

Dmitriy D. Li* and Jeong Hwan Bae**

ABSTRACT : This study uses a choice experiment approach to examine whether different types of feedstocks as well as other attributes such as the cost of bioethanol, bioethanol blending ratio, and government support policies affect consumers' biofuel preferences. We apply a standard conditional logit model, a mixed logit model (MLM), and individual coefficient estimation model (ICM) to estimate the parameters of the investigated attributes. The results show that people prefer domestic and non-food feedstock, along with tax exemption as a support policy. All the attributes show unobservable preference heterogeneity in the MLM and ICM. In particular, willingness to pay for attributes are higher in the genetically modified (GM) feedstock-unknown group than in the known one. We show the importance of using domestic and non-food feedstocks and managing GM feedstocks carefully to avoid consumer resistance when producing bioethanol in South Korea.

Keywords : Bioethanol, Biofuel, Feedstock, Choice experiment, Preference heterogeneity

JEL Classification : Q1, Q3

Received: March 4, 2021. Accepted: March 13, 2021.

†The authors would like to thank Dr. Shin Kim in Korea Petroleum Quality and Distribution Authority for financial assistance with fruitful advices, and Editage (www.editage.co.kr) for English language editing.

* Lecturer, Department of Economics, Chonnam National University, First author(e-mail: lddima82@yahoo.com)

** Professor, Department of Economics, Chonnam National University, Corresponding author(e-mail: jhbae@jnu.ac.kr)

바이오에탄올 보급에 대한 사회적 수용성 분석: 바이오에탄올 원료 속성을 중심으로†

이 드미트리* · 배정환**

요 약 : 본 연구는 선택실험법을 이용하여 바이오에탄올 원료유형, 바이오에탄올 혼합율, 바이오에탄올 비용, 정부지원 정책과 같은 속성들이 바이오에탄올 보급정책에 대한 사회적 수용성에 영향을 미치는지를 분석하였다. 바이오에탄올 속성 계수를 추정하기 위해 조건부로짓모형, 혼합로짓모형, 개별계수추정모형을 적용하였다. 추정 결과에 따르면, 소비자들은 국산원료와 비식량원료를 사용한 바이오에탄올을 선호하고 지원정책 가운데는 면세정책을 선호하는 것으로 나타났다. 혼합로짓모형과 개별계수추정모형에 의하면 모든 속성들이 관찰불가능한 이질성을 갖고 있는 것으로 나타났다. 또한 속성별 지불용의액을 추정한 결과, 유전자조작기반 바이오에탄올임을 사전에 인지한 응답자일수록 그렇지 못한 응답자보다 바이오에탄올에 대한 지불용의액이 더 낮게 나타났다. 추정결과를 종합하면, 우리나라에서 바이오에탄올을 보급하기 위해서는 국산원료 및 비식량원료에 기반한 바이오에탄올을 중점적으로 보급해야 하고, 특히 유전자 조작 기반 바이오에탄올에 대한 수용성이 낮게 나타나므로 보급시 이를 충분히 고려해야 할 것이다.

주제어 : 바이오에탄올, 원료, 선택실험법, 선호 이질성

접수일(2021년 3월 4일), 게재확정일(2021년 3월 13일)

† 본 연구는 2018년에 석유기술연구소 의뢰로 수행된 '수송용 바이오알콜의 소비자 선호도 분석 연구' 내용을 수정 및 보완한 것이다.

* 전남대학교 경제학부 시간강사, 제1저자(e-mail: lddima82@yahoo.com)

** 전남대학교 경제학부 교수, 교신저자(e-mail: jhbae@jnu.ac.kr)

I. Introduction

At the Paris conference on climate change in December 2015, the South Korean government announced that South Korea would reduce greenhouse gases (GHGs) by 37% of the Business as Usual (BaU) scenario by the year 2030. South Korea's annual carbon dioxide (CO_2) emission level in 2015 was 690.2 million tons, ranking it 12th among world nations. The CO_2 emission level in South Korea’s transportation sector was 94.189 million tons, which constituted 13.65% of the country's total CO_2 emissions. CO_2 mitigation policies for the country's transportation sector include regulation of CO_2 emissions and fuel economy, subsidy programs for electric or hydrogen-powered cars, and a Renewable Fuel Standard (RFS) policy that requires petroleum producers to blend biodiesel with petro-diesel at increasing annual ratios. For instance, the CO_2 emission and fuel economy targets in 2014 were 97g/km and 24.3km/liter, respectively, while government subsidies on the purchase of plug-in hybrid, electric, and hydrogen fuel cell cars in 2019 are approximately KRW 5,000,000, KRW 9,000,000, and KRW 24,000,000, respectively (South Korean Ministry of Environment, 2019).

The South Korean RFS program established a mandatory 3% blending ratio for biodiesel, a mandatory standard that intended to maintain until 2020. However, until 2019, this mandatory policy applied only to biodiesel and not to other types of biofuels such as bioethanol, biogas, and bio-butanol. In this regard, the Research Institute of Petroleum Technology investigated the technological, economic, and social feasibility of bioethanol and bio-butanol in South Korea between 2017 and 2019. However, it is unclear whether the RFS program will allow for the mandatory use of bioethanol even with no technological barriers to blending bioethanol with gasoline.

One of the major obstacles in the promotion of bioethanol in South Korea is the insufficient availability of domestic feedstock for manufacturing bioethanol, which results in heavy dependence on imported feedstock. At the same time, achieving a higher blending ratio depends on finding a way to reduce dependence on imported feedstock.

Although bioethanol can contribute to abating CO_2 emissions and air pollution[1)], a major objective of biofuel promotion in South Korea is to develop biofuels based on domestic feedstock and thereby increase energy independence. However, the current technology level limits the potential domestic feedstock use in the production of biofuels such as biodiesel and bioethanol.

Will the specific attributes of feedstocks available for bioethanol production affect social acceptance on bioethanol promotion policy? A trade-off between energy independence and energy cost means that biofuels made from domestic feedstock are typically more expensive than bioethanol made from imported feedstock. Domestic feedstock is split into food-based and non-food-based, whereas imported feedstock can be food-based, non-food-based, and genetically modified (GM).

In the United States, GM corn has been widely used as bioethanol feedstock and in animal feed. As of 2017, 14 countries produced GM corn, including the United States, Brazil, and Argentina. In the United States, GM corn accounted for more than 93% of total corn production (International Service for the Acquisition of Agri-biotech Applications, 2017). However, a synthetic review of 40 scientific articles on GM food labeling (Miren et. al., 2014) revealed that consumers showed preferences for non-GM foods and expressed willingness to pay more for those products. This review also found that labeling conventional foods as GM-free can reduce consumers' utility as they have negative perceptions about GM products due to the potential environmental consequences of producing and consuming GM products. Similarly, South Koreans might also have a negative perception of the use of GM-based bioethanol even if it has no effects on human health.

This study uses a choice experiment (CE) approach to examine whether different

1) Stein et al. (2013) showed that increased bioethanol in gasoline blends for vehicles can reduce CO_2 as well as particulate matter and benzene. Wang et al. (2012) suggested that bioethanol made from corn, sugarcane, corn stover, switchgrass, and miscanthus can reduce lifecycle GHG emissions relative to petroleum gasoline by 19 – 48%, 40 – 62%, 90 – 103%, 77 – 97%, and 101 – 115%, respectively. Conversely, Mueller et al. (2018) reported significant reductions in total hydrocarbon, volatile organic compounds, and weighted toxins when 10% and 20% bioethanol-blended gasoline were used in the vehicle fleet of Seoul, South Korea.

attributes of feedstocks as well as other attributes—such as the cost of bioethanol, bioethanol blending ratio, and government support policies—affect people's biofuel preferences or social acceptance. The CE approach derives people's preferences on non-market commodities or services with various attributes. We employ a standard conditional logit model (CLM) to estimate the coefficients of the investigated attributes, but the CLM makes strict assumptions—such as homogeneous respondent preferences, independence from irrelevant alternatives among alternatives in a choice set, and no autocorrelation in error terms across different choice situations. To overcome those restrictions, we apply a random parameter logit model and an individual coefficient estimation model (ICM) to estimate the coefficients of and willingness to pay (WTP) for the different attributes of bioethanol. In terms of policy implications, if people show greater preference for bioethanol made from domestic, non-food, or non-GM feedstock rather than imported, food, or GM feedstock, the South Korean government should place greater emphasis on the former types of bioethanol in its RFS policy.

II. Literature Review

Higher awareness of climate change and energy dependency has increased the popularity of studies on WTP for renewable energy sources. Several studies have examined consumer acceptance and WTP for biofuels, as summarized in Table 1. All these studies used consumer survey-based contingent valuation (CV) or CE approaches to measure WTP.

Given South Korea's RFS program, an increasing number of studies focus on South Korean consumers' WTP for biofuels. For example, Bae (2014) used a CE survey of 500 car owners in South Korea to estimate gasoline consumers' mean WTP for bioethanol from three different production pathways: domestic production of bioethanol from domestic feedstock, domestic bioethanol from imported feedstock, and imported bioethanol. The estimated mean WTP for E10 (a blend of 10% ethanol and 90% gasoline) production of domestic bioethanol with domestic feedstock ranges between KRW 53.2~54.2/liter. Shin and Hwang (2017) also applied the CE method to analyze consumer acceptance of an RFS policy. They showed that for consumers with a monthly income of less than KRW 2 million, the WTP for an RFS was KRW 102.79–152.47/liter (USD 0.329–0.488/gal.), and for consumers with monthly income over KRW 5 million, the WTP was KRW 107.26–289.28/liter (USD 0.344–0.927/gal.). Lim et al. (2017) used the CV approach to investigate the public's WTP premium for the introduction of an E5 (a blend of 5% ethanol and 95% gasoline) bioethanol program in South Korea, and found that the mean additional WTP for E5 was KRW 290/liter, or 15.6% of the gasoline retail price in 2014.

Among international studies on WTP for biofuel, Mamadzhanov et al. (2019) used the CV methodology to estimate consumers' WTP premium for second-generation lignocellulosic bioethanol in South Korea. Their estimated mean WTP for bioethanol was a 4.3% (KRW 86/liter) premium over the gasoline price. They also found that only 8.1% of consumers surveyed were unwilling to purchase bioethanol even with a discount. The remaining respondents were ready to purchase bioethanol, but only 14.2% of them were willing to pay the premium price, with the other 72.6% expecting to pay the gasoline price instead. Moreover, the study results showed that knowledge of renewable energy sources and awareness of the environmental benefits of bioethanol had positive impacts on WTP for bioethanol.

Among similar studies conducted in the United States, Solomon and Johnson (2009) conducted a CV and fair-share survey in the states of Michigan, Minnesota, and Wisconsin to derive respondents' WTP premium for cellulosic bioethanol from different feedstocks. Their results showed that 83.8% of respondents were willing to pay a premium for cellulosic ethanol, with the mean WTP estimated at $556 per annum. They also found higher WTPs among political liberals, females, people with higher incomes, and people concerned about climate change. However, WTPs showed no variance for bioethanols made from different types of feedstocks.

Another U.S. CV study by Petrolia et al. (2010) concluded that people showed greater WTP for E85 than for E10 and that E85 showed less price elasticity than E10, because some consumers with no preference for E10 held strong preferences for E85. Jensen et al. (2010) applied the CE approach to 914 responses from the U.S. population in an analysis of consumer WTP for E85 bioethanol from different feedstocks compared to E10 from corn. Their results indicated higher WTP for E85 from corn, switchgrass, and wood waste than for E10 from corn by 13.57, 18.93, and 16.59 cents per gallon, respectively.

Li and McCluskey (2017) conducted a CV analysis of consumer acceptance and WTP for nature-inspired, second-generation biofuels in Portland, Oregon, Minneapolis, Minnesota, and Boston, Massachusetts. Their results suggested that 66% of respondents were willing to pay a premium for second-generation bioethanol. The mean WTP for second-generation biofuel was highest in Portland, where it was estimated at a 17% premium over the cost of conventional fuel. The premium for respondents in Minneapolis and Boston was 9% and 8%, respectively. The average WTP premium for biofuels in these three regions was 11% over the cost of conventional fuel.

Additional studies attempted to evaluate WTP for alternative fuels in the European Union via the CE (Fimereli & Mourato, 2009) or CV (Loureiro et al., 2013; Lanzini et al., 2016) approaches. Fimereli and Mourato (2009) investigated public acceptance of and preferences for the use of E10, E85, and bio-diesel in the UK, and found that although respondents were willing to pay an average premium of £0.18 to refuel their cars with E10 and E85, they were less likely to choose bio-diesel over petro-diesel. Loureiro et al. (2013) investigated Spanish citizens' WTP for policies that could reduce GHG emissions by using biofuels in the transportation sector, estimating drivers' average WTP premium to be as high as EUR 115.5/year for biofuels. Given the cars' characteristics and the average annual driving distance in Spain in 2010, the WTP premium was equivalent to EUR 0.07/liter for gasoline-powered cars and EUR 0.08/liter for diesel vehicles. Lanzini et al. (2016) investigated car drivers' WTP for biofuels based on a sample of 260 participants in the Northern Italian provinces of Venice, Padua, and

Brescia. The results showed that although 29.2% of respondents were willing to pay only EUR 0.01–0.07/liter and 39.9% were willing to pay up to EUR 0.14/liter, only 13.2% would pay more than EUR 0.14/liter. Meanwhile, 17.7% of respondents declared no willingness to pay any premium price for biofuels.

Although several studies have evaluated the mean WTP premium for bioethanol in South Korea, most of them focus only on consumers' socio-economic attributes, ignoring other important attributes such as the type of feedstocks and/or incentive policies. This study attempts to fill these gaps in the literature. We evaluate consumers'

〈Table 1〉 Comparison of WTPs for biofuels

Countries	Sources	Methodology	Estimated mean willingness to pay
Republic of South Korea	Bae (2014)	CE	KRW 53.2~54.2/liter of bioethanol (domestic material)
Republic of South Korea	Shin and Hwang (2017)	CE	USD 0.329~0.488/gallon (monthly income <USD 1691.6)
			USD 0.344~0.927/gallon (monthly income >USD 4229.1)
Republic of South Korea	Lim et al. (2017)	CV	KRW 290/liter of gasoline (E5) surcharge
Republic of South Korea	Mamadzhanov et al. (2019)	CV	Consumers are willing to pay a 4.3% premium for second-generation ethanol
United States	Solomon and Johnson (2009)	CV	USD 556/person per year for expanded use of cellulosic ethanol
United States	Jensen et al. (2010)	CE	USD 0.14/gallon surcharge for E85 from corn
			USD 0.19/gallon surcharge for E85 from switchgrass
			USD 0.17/gallon surcharge for E85 from wood waste
United States	Petrolia et al. (2010)	CV	USD 0.054~0.124/gallon surcharge for gasoline (E10)
			USD 0.12~0.152/gallon surcharge for gasoline (E85)
United States	Li and McCluskey (2017)	CV	11% premium for second-generation nature-inspired bioethanol
UK	Fimereli and Mourato (2009)	CE	Respondents willing to pay an average premium of £0.18 to refuel their cars with E10 and E85
Spain	Loureiro et al. (2013)	CV	EUR 0.07/liter surcharge for gasoline
Italy	Lanzini et al. (2016)	CV	EUR 0.08/liter surcharge for biodiesel

bioethanol preferences for heterogeneous feedstocks, including domestic vs. imported, food vs. non-food, and GM vs. non-GM. Moreover, this study analyzes how incentive policies such as reduced gasoline taxes, discounted parking fees and tolls, and green mileage benefits affect consumers' preferences for bioethanol.

Ⅲ. Design of the Choice Experiment (CE)

1. Construction of choice sets

Between September 12 and October 2, 2018, we conducted a web-based CE survey of South Korean car owners, with a focus group discussion and preliminary online survey implemented before the final survey. Table 2 summarizes the survey process. The final questionnaire consists of four sections. 1) Basic questions about car ownership, vehicle type, fuel type, fuel cost, driving distance, and reason for driving; relative importance of car characteristics such as horsepower, fuel economy, vehicle capacity, and emissions of

〈Table 2〉 Outline of the survey process

Item	Description
Population	Men and women >19 years old (nationwide)
Sampling frame	South Korea Research MS Panel [Approximately 430,000 people (September 2018)]
Sampling method	Proportional allocation based on residence, gender, and age
Sample size	804 respondents
Sampling error	Maximum at the 95% confidence level is ± 3.5%
Investigation method	Web survey (sending URL via SMSes, e-mails, and mobile CX)
Response (Coordination) Rate	Sent messages to 15,440 people, of whom 1,265 participated in the survey and 804 completed it (63.6% of survey participants)
Weighting method	Cell weighted by region, sex, and age (Based on the population data issued by the Ministry of Government Administration and Home Affairs in August 2018)
Survey date and time	Focus group and preliminary survey: September 12–20, 2018 Main survey: September 27–October 2, 2018

air pollutants and GHGs; knowledge of bioethanol from different feedstocks; and relative importance of benefits from using bioethanol and of various bioethanol support policies. 2) Description of the advantages and disadvantages of blending bioethanol with gasoline for transportation. 3) Choice questions with different choice sets. 4) Socio-demographic questions about subjects, including age, sex, region of residence, education, family income, preference for three aspects of the national agenda (economic growth, social fairness, and environmental conservation), and political preference.

On choice questions, respondents chose their most-preferred option from among three alternatives in one choice set and from repeats of the other three choice sets, as shown in Figure 1. As shown in Table 3, each alternative varies, with different levels for the attributes—including different types of feedstock to produce bioethanol, changes in gasoline prices because of increases in production costs, various blending ratios of bioethanol to gasoline, and different types of bioethanol support policies. Before respondents choose an alternative between option A, B, and opt-out, we provided information on benefits and costs of each feedstock. For instance, bioethanol made from domestic feedstock

The optimal number of choice sets was set at 16 based on a D-efficiency algorithm (Hensher et al., 2015). The 804 participants were divided into four blocks, and each participant responded to four different choice sets. Each choice set included three alternatives, where alternative A or B varied with different levels of bioethanol attributes while alternative C represented an opt-out to allow choosing neither of the two alternative bioethanols. We multiplied the 804 responses by three alternatives and four choice sets to obtain a total of 9,648 observations.

For the experiment, half the respondents were told that the imported corn used as feedstock for making bioethanol was GM based, while the other half was not given this explanation. By dividing the entire sample into two sub-groups, we examined whether awareness of GM feedstock affected parameter estimates of attributes and WTPs for bioethanol.

〈Table 3〉 Bioethanol attributes

Attribute	Sub-attribute	Level
Bioethanol feedstock	Domestic (1)/Imported (0)	1/0
	Food stock (0)/Non-food stock (1)	1/0
Increase in gasoline price (KRW/liter)		25/50/75/100
Bioethanol blending ratio (%)		3/5/7/10
Type of bioethanol support policy	Reduction of gasoline tax	1/0
	Parking fee/toll discount	1/0
	Carbon mileage	Reference level

〈Table 4〉 Comparison of effects for various feedstocks

Types of feedstock	Resource	Non-food based (ex: waste wood, crop residues)	Food based (ex: paddy, barley)	Food based (ex: corn, Tapioca)	Non-food based (ex: Palm residues, waste wood)
	Origin	Domestic	Domestic	Imported	Imported
Effect on growth of domestic rural economy		High	High	None	None
Effect on domestic bioethanol industry		High	High	High	High
Effect on energy independence		High	High	Medium	Medium
Effect on CO_2 mitigation		High	Medium	Low	Medium
Production Cost of bioethanol		High	High	Low	Medium
Effect on food price		None	High	High	None

〈Table 5〉 CO_2 mitigation effects for various bioethanol blending ratios

Blending ratio	Total amount of bioethanol (Unit: Kilo liter)	Mitigation of CO_2 (Unit: ton)
3% blending of bioethanol in gasoline	300,000kl	630,000
5% blending of bioethanol in gasoline	500,000kl	1,050,000
10% blending of bioethanol in gasoline	1,000,000kl	2,100,000

〈Figure 1〉 A sample choice set

Attribute	Bioethanol blended gasoline, type A	Bioethanol blended gasoline, type B	
Increase in gasoline price (KRW/liter)	25	100	Prefer neither A nor B
Domestic/imported feedstock	Domestic	Imported	
Non-food/food stock	Non-food stock	Food stock	
Blending ratio of bioethanol with gasoline (%)	3	7	
Bioethanol support policies	Parking fee/toll discount	Reduction of gasoline tax	
Your choice	☐	☐	☐

IV. Estimation Strategy

We applied the CLM to estimate the parameters of attributes that consist of a representative consumer's utility when she/he consumes a bioethanol-blended gasoline. The CLM can be derived theoretically from a random utility model (RUM) (McFadden, 1974), which is described as follows:

$$U_{nis} = \beta' x_{nis} + u_{nis} \tag{1}$$

where represents the observable attributes of alternatives in a choice set and U_{nis} represents the unobservable factors with a type 1 extreme value.

The utility of choosing alternative i in a choice situation s by each consumer n is derived from a vector of the attributes (x_{nis}), of which parameter vector (β) implies a relative preference weight on the utility. In a RUM, the conditional logit probability of an individual n choosing an alternative i from j=1, ..., J alternatives in a choice situation s is written as follows:

$$P_{nis} = \frac{\exp(x'_{nis}\beta)}{\sum_{j=1}^{J} \exp(x'_{njs}\beta)} \tag{2}$$

The CLM is limited in terms of unrealistic assumptions, such as independence from irrelevant alternatives, homogeneity in respondents' preferences, and lack of autocorrelation in error terms across different choice situations. Although the CLM with interaction terms (CLM_INT) can reflect the observable heterogeneity of respondents, it cannot take into account unobservable heterogeneity. Thus, various alternative models—such as the latent class model (LCM), mixed logit model (MLM), and hybrid model integrating both LCM and MLM (HYBRID)—have been suggested to account for unobservable heterogeneity in individuals' preferences, autocorrelation of error terms, and relaxation of the independence from irrelevant alternatives (Bujosa et al., 2010; Yoo and Ready, 2014).

In particular, the LCM, MLM, and HYBRID model can capture respondents' unobserved heterogeneity as well as correlated error terms in cases in which individuals' choices can be correlated over repeated choice tasks through learning or fatigue effects (Yoo and Ready, 2014). The LCM can detect discrete heterogeneity by considering discrete groups with group-specific tastes, but it cannot capture heterogeneity within a group. Conversely, the MLM can capture continuous variations in respondents' preferences. The RUM and choice probability for the MLM are represented as follows:

$$U_{nis} = {\beta_n}' x_{nis} + u_{nis} \tag{3}$$

$$P_{nis}^{MLM} = \int \prod_{s=1}^{S} \prod_{j=1}^{J} \frac{\exp(\beta_n^{'} x_{nis}^{'})}{\sum_{(j=1)}^{J} \exp(\beta_n^{'} x_{njs}^{'})} g(\beta/\theta) d\beta \tag{4}$$

where $g(\beta/\theta)$ is a probability density function of β.

The MLM can consider random coefficients of attributes (β_n) that differ among individuals in the population with a probability density $g(\beta)$. Therefore, because it is impossible to predict how random parameters are distributed among the population, it is important to define the probability distribution of the random parameters in the MLM. In general, random parameters should have normal distributions (Train, 2009; Yoo and Ready, 2014). In this study, we assumed a normal distribution for the random parameters.

As an extension of the MLM, the ICM implies a conditional mean of the coefficient distribution for a sub-group of individuals who all confront the same alternatives and make the same choices (Train, 2009). Revelt and Train (2001) proved that an approximation of the expected value of coefficients conditional on a given response pattern y_{nks}, with attributes x_n, can be derived from the following simulation:

$$\widehat{\beta_n} = \frac{1}{Q}\left\{\frac{\sum_{q=1}^{Q}\beta_n^{[q]}\prod_{s=1}^{S}\prod_{j=1}^{J}\left[\frac{\exp\left(\beta_n^{[q]}x_{nis}\right)}{\sum_{j=1}^{J}\exp\left(\beta_n^{[q]}x_{nis}\right)}\right]^{y_{njs}}}{\sum_{q=1}^{Q}\prod_{s=1}^{S}\prod_{j=1}^{J}\left[\frac{\exp\left(\beta_n^{[q]}x_{nis}\right)}{\sum_{j=1}^{J}\exp\left(\beta_n^{[q]}x_{nis}\right)}\right]^{y_{njs}}}\right\} \tag{5}$$

where $\beta_n^{[q]}$ is the qth draw for individual n from the estimated distribution of β.

This study uses the CLM, MLM, and ICM to estimate the parameters of attributes including types of bioethanol with different feedstocks, various blending ratios, changes in gasoline prices, and varying government support policies. In particular, we derive WTPs for the attributes from the estimation outcomes.

V. Estimation Results

1. Conditional logit model (CLM)

We divided parameter estimation of bioethanol attributes into three groups based on the total sample, GM-unknown group, and GM-known group. The monetary attribute (gasoline price increases) is considered a continuous variable, whereas the bioethanol blending ratio attribute is considered a categorical variable. All other attributes—such as use of domestic or non-food feedstock for bioethanol production and bioethanol supportive policies (petroleum tax exemption, parking-fee or toll discounts, or green mileage)—are taken as dummy variables.

Table 6 compares parameter estimates for the total sample with those for the GM-known and GM-unknown groups. Overall, the estimated coefficient of the monetary variable conformed to expectations and remained fairly stable across all groups. Parameter estimates for the use of domestic and non-food feedstocks, 3% and 5% bioethanol blending ratios, and petroleum tax exemption policy show that the GM-unknown group has highest preferences for bioethanol followed by the total sample, and the GM-known group. It is presumed that the GM-known group has the lowest

〈Table 6〉 Comparison of CLM estimation results for different groups

Attribute	Total group	GM-known group	GM-unknown group
Price	-0.0153*** (0.0009)	-0.0158*** (0.0013)	-0.0149*** (0.0013)
Domestic feedstock	0.4160*** (0.0424)	0.3677*** (0.0599)	0.4625*** (0.0602)
Non-food feedstock	0.1309*** (0.0415)	0.1043* (0.0589)	0.1561*** (0.0588)
E3[a]	1.7527*** (0.0974)	1.6636*** (0.1372)	1.8477*** (0.1388)
E5[a]	1.6265*** (0.0971)	1.5740*** (0.1360)	1.6805*** (0.1392)
E7[a]	1.8879*** (0.0943)	1.9255*** (0.1326)	1.8565*** (0.1346)
E10[a]	1.7078*** (0.1002)	1.7285*** (0.1412)	1.6917*** (0.1429)
Tax exemption	0.7750*** (0.0616)	0.7484*** (0.0871)	0.8053*** (0.0875)
Toll discount	0.3271*** (0.0570)	0.3855*** (0.0814)	0.2707*** (0.0802)
Observations	9,648	4,812	4,836
LR chi2(7)	1464.69	698.37	777.33
Log likelihood	-2800.7941	-1,412.9882	-1,382.2989
Pseudo R2	0.2073	0.1982	0.2195

[a]E3, E5, E7, and E10 represent a 3%, 5%, 7%, and 10% blending ratio, respectively, of bioethanol with gasoline.

*Statistical significance within 10%. **Statistical significance within 5%. ***Statistical significance within 1%.

preferences on bioethanol attributes because of negative attitudes toward GM feedstock.

For all groups, the estimation result shows that the relative preference for domestic feedstock is higher than for non-food feedstock. Among the various blending ratios, respondents in all groups prefer the 7% ratio, emphasizing its viability as an option if the South Korean government wishes to choose a specific blending ratio at or under 10%. Additionally, the analysis indicates that respondents in all groups prefer petroleum tax exemptions rather than toll/parking fee discounts.

2. Mixed logit model (MLM)

The MLM assumes that coefficients of attributes are random to reflect individuals' unobservable preference heterogeneity. We assume normal distribution for the coefficients for all attributes except the monetary attribute (Dprice)[2]. Note that the price attribute's coefficient has a sign opposite to that of the CLM estimation because the value of the price attribute is multiplied by -1 and divided by 100. According to Hole (2007), estimation can be more efficient in restricting the sign of coefficients to be either positive or negative and to provide lognormal distribution. Table 7 shows that all the mean and standard deviation parameters are statistically significant, which indicates that the attribute parameters are random. In other words, people show unobservable preference heterogeneity for such attributes.

Overall, relative preferences for all mean parameters in the MLM are higher than those in the CLM. The MLM results show the largest unobservable heterogeneity for the petroleum tax exemption policy, followed by domestic feedstock, toll discount, non-food feedstock, E5, E10, E3, and E7.

2) When the price attribute parameter is included as a random parameter in the MLM, mean as well as standard deviation values are estimated within a 1% significance level, but a WTP-SPACE model could not estimate the WTP of each attribute based on the MLM model. Thus, we adjusted the parameter of price attribute. Yoo and Ready (2014) considered the parameter of a monetary attribute to be fixed.

〈Table 7〉 Parameter estimates from the Mixed Logit Model

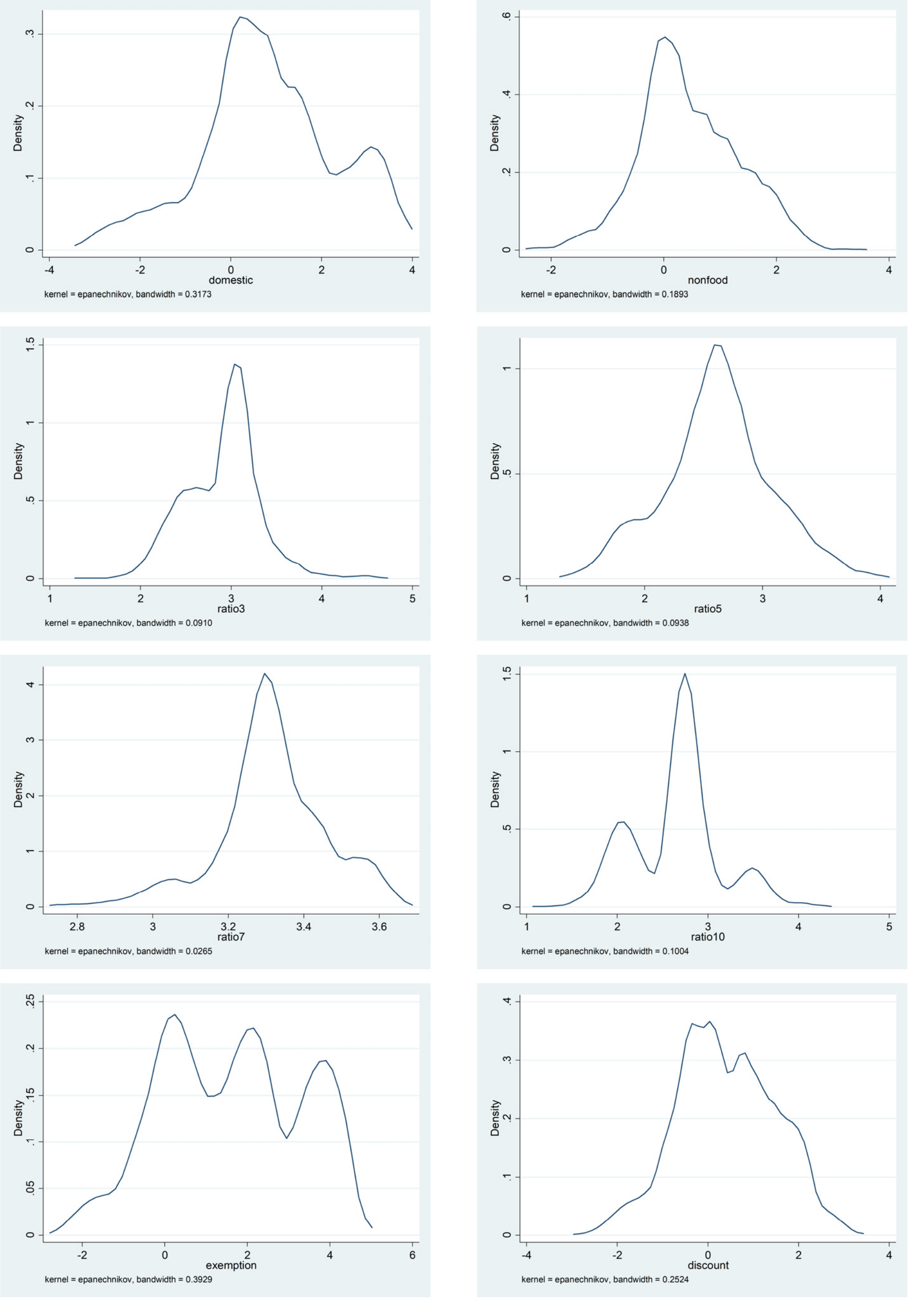
	Attribute	Total group	GM-known group	GM-unknown group
Mean	Dprice[a]	3.2492*** (0.2320)	3.2651*** (0.3342)	3.5449*** (0.3644)
	Domestic feedstock	0.7527*** (0.1153)	0.6880*** (0.1572)	0.9143*** (0.1717)
	Non-food feedstock	0.4910*** (0.1111)	0.3854*** (0.1410)	0.5912*** (0.1656)
	E3[b]	2.9007*** (0.2116)	2.7029*** (0.3015)	3.3057*** (0.3210)
	E5[b]	2.6056*** (0.1926)	2.4005*** (0.2584)	3.0137*** (0.3040)
	E7[b]	3.3134*** (0.2159)	3.2920*** (0.3055)	3.4899*** (0.3304)
	E10[b]	2.6354*** (0.2067)	2.6207*** (0.2786)	2.9762*** (0.3145)
	Tax exemption	1.5588*** (0.1540)	1.3451*** (0.2340)	1.7307*** (0.2396)
	Toll discount	0.3597*** (0.1163)	0.6276*** (0.1591)	0.3695* (0.1897)
SD	Domestic feedstock	2.1943*** (0.1761)	2.1060*** (0.2743)	2.4051*** (0.2721)
	Non-food feedstock	1.6044*** (0.1643)	1.1417*** (0.2132)	1.9437*** (0.2617)
	E3[b]	1.1427*** (0.2068)	1.2003*** (0.3729)	1.0503*** (0.2667)
	E5[b]	1.2489*** (0.2843)	1.4081*** (0.3210)	1.0644** (0.4227)
	E7[b]	0.6338** (0.2878)	1.3262*** (0.3015)	0.8337* (0.4688)
	E10[b]	1.2426*** (0.2465)	1.0472*** (0.2773)	1.1892*** (0.3880)
	Tax exemption	2.4757*** (0.2295)	2.9001*** (0.4415)	2.4713*** (0.3026)
	Toll discount	1.7572*** (0.1693)	1.2057*** (0.2696)	2.1804*** (0.2923)
Observations		9,648	4,812	4,836
Log likelihood		-2582.5029	-1313.2459	-1258.2474
LR $\chi^2(8)$		436.58	199.48	248.1

[a]We derive the value of Dprice by multiplying the value of the price attribute by -1. Thus, if the estimated parameter for Dprice has a positive sign, it should be interpreted as a negative sign.
[b]E3, E5, E7, and E10 represent a 3%, 5%, 7%, and 10% blending ratio, respectively, of bioethanol with gasoline.

3. Individual coefficient estimation model (ICM)

Although the mixed logit models can capture whether individual attribute contains unobservable hetereogeneity, they cannot provide in which degree individuals have heterogeneity. The ICM (individual-level coefficient estimation model) can provide more details on unobservable heterogeneity by using Kernel density function for each attribute. We show the kernel density distributions of domestic feedstock; non-food

〈Figure 2〉 Kernel density plots for individual coefficient estimates



feedstock; 3%, 5%, 7%, and 10% bioethanol ratios; tax exemption; and toll discount in Figure 2. Kernel density distributions for domestic and non-food feedstock show that some respondents have negative preferences for bioethanol produced from these sources. In contrast, kernel density distributions for various bioethanol ratios show positive preferences for all respondents. Meanwhile, some respondents have negative preferences for tax exemption and toll discount policies.

4. WTP estimation results

Based on the CLM and MLM estimation results, this section derives the WTP of respondents for each attribute of bioethanol. Table 8 compares the WTPs for attributes of bioethanol across the total sample, GM-known group, and GM-unknown group. In the GM-unknown group, the WTPs for all attributes except toll discount are highest relative to the other two groups, showing the importance of the source of bioethanol feedstock—GM or non-GM. Among the attributes, the WTP for E7 is highest, followed by those for E10, E5, tax exemption, domestic feedstock, toll discount, and non-food feedstock. Therefore, in terms of highest WTP, the best combination of feedstock, blending ratio, and government support policies would be a bioethanol made from domestic non-food feedstock with a 7% blending ratio and a tax exemption policy (calculated as KRW 209.65/liter for the total sample, KRW 198.58/liter for the GM-known group, and KRW

〈Table 8〉 Comparison of WTPs between different groups based on CLM results

(unit: KRW/liter)

WTP	Domestic feedstock	Non-food feedstock	E3	E5	E7	E10	Tax exemption	Toll discount
Total group								
Mean	27.17	8.55	114.48	106.24	123.31	111.55	50.62	21.37
GM-known group								
Mean	23.21	6.58	105.02	99.36	121.55	109.11	47.24	24.33
GM-unknown group								
Mean	31.10	10.50	124.24	113.01	124.84	113.75	54.15	18.20

220.59/liter for the GM-unknown group).

We also calculate average WTPs based on the MLM estimation for comparison with the corresponding CLM estimates as shown in Table 9. Although the mean WTPs for all attributes based on the MLM estimation are similar to the corresponding CLM estimates, the MLM-based WTP estimates are slightly lower. This comparison implies that accounting for unobservable heterogeneity in the estimation of attributes leads to underestimated overall WTPs. In parallel with CLM-based WTPs, the combination of feedstock, bioethanol blending ratio, and government support policy that provides the highest WTP for bioethanol is domestic and non-food feedstock, 7% blending ratio, and gasoline tax exemption. Thus, the highest WTPs for the total sample, GM-known group, and GM-unknown group are calculated as KRW 188.22/liter, KRW 174.89/liter, and KRW 189.74/liter, respectively.

〈Table 9〉 Mean WTPs from the MLM estimates

Attribute	Total group	GM-known group	GM-unknown group
Domestic feedstock	23.17	21.07	25.79
Non-food feedstock	15.11	11.80	16.68
Blending ratio3	89.27	82.78	93.25
Blending ratio5	80.19	73.52	85.02
Blending ratio7	101.97	100.82	98.45
Blending ratio10	81.11	80.26	83.96
Tax exemption	47.97	41.20	48.82
Toll discount	11.07	19.22	10.42

Because the parameter of the monetary attribute (increases in gasoline price) is fixed, we divided a parameter of a non-monetary attribute by the parameter of the monetary one to calculate WTPs for non-monetary attributes.

〈Table 10〉 Model comparison based on the AIC and BIC

Model	Observation	LL (null)	LL (model)	d.f.	AIC	BIC
clm	9,648	-3533.14	-2850.18	8	5716.355	5773.751
mlm	9,648	-2800.79	-2582.5	17	5199.006	5320.972

LL = log likelihood; d.f. = degree of freedom.

We applied the Akaike information criteria (AIC) and Bayesian information criteria (BIC) to determine whether the CLM or MLM does a better job of measuring WTP for the attributes of bioethanol. As shown in Table 10, the MLM is found to be better, as both the AIC and BIC for the MLM have lower values than those for the CLM. Finally, we use WTP estimates from the MLM to measure attribute values for bioethanol.

The estimation results for bioethanol WTPs show that feedstock types (domestic, imported, food-based, non-food based, or GM-based) affect South Korean gasoline consumers' bioethanol WTPs significantly. In this context, the current RFS program does not offer different credits for types of biofuels based on individual feedstocks.

In the United States, the Renewable Identification Number (RIN) program promotes renewable fuels such as bioethanol, biogas, and biodiesel for transportation. Under the RIN program, the United States Environmental Protection Agency categorizes renewable fuels into four types based on the associated reduction rate of GHGs, as shown in Table 11. The South Korean government should also consider categorization of renewable fuels based on environmental performance or degree of technological innovation, as multiple types of renewable fuels might be included in the RFS program.

〈Table 11〉 Definition of RIN D-codes

RIN D-code	Fuel type	GHG Reduction Requirement	Fuel
D3/D7	Cellulosic biofuels	60%	Cellulosic ethanol, cellulosic naphtha, cellulosic diesel, renewable CNG/LNG, etc.
D4	Biomass-based diesel	50%	Biodiesel, renewable diesel, etc.
D5	Advanced biofuels	50%	Sugarcane ethanol, renewable heating oil, biogas, etc.
D6	Renewable fuel	20% or less	Corn ethanol, etc.

(Source: https://www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information)

VI. Conclusion and Highlights

We used the CE approach to derive potential consumers' preferences on the blending of bioethanol with gasoline in South Korea's transportation sector. Analysis based on the CE survey shows that the South Korean government should consider the importance of the use of domestic vs. imported, non-food vs. food, or GM vs. non-GM feedstocks for producing bioethanol when potential consumers choose a bioethanol blended gasoline. People show stronger preferences for the use of domestic rather than imported feedstock in bioethanol production. Additionally, they prefer non-food feedstocks to food feedstocks such as corn, wheat, or sugarcane for making bioethanol. Regarding the blending ratio of bioethanol with gasoline, our results show that respondents demonstrate the highest relative preferences for the 7% blending ratio when the ratio ranges between 3~10%, thus establishing the desirability of blending bioethanol with gasoline at the 7% level. Furthermore, people show strong preferences for bioethanol support policies, with a preference for gasoline tax exemptions over toll discounts.

An important distinguishing feature of this study comes from our division of the sample into GM-known and GM-unknown groups, and our finding that WTPs for the attributes of bioethanol in the GM-known group are lower than those in the GM-unknown group. According to the estimation results based on the MLM, WTP for bioethanol of the GM-known group is about KRW 175/liter when it is made from domestic and non-food feedstock with a 7% blending ratio and a gasoline tax exemption policy, but the GM-unknown group's WTP is about KRW 190/liter for the same bioethanol. Although GM-based feedstock is used for making only non-edible bioethanol, South Koreans might fear the possibility that GM feedstock, as a source, would reach the food sector. Just as WTPs for bioethanol in other studies (Bae, 2014; Shin and Hwang, 2017; Lim et al., 2017; Mamadzhanov et al., 2019) range from KRW 52/liter to KRW 290/liter, WTPs for bioethanol in this study also fall within the same range.

At present, the South Korean government has not determined whether its RFS program should allow for blending bioethanol with gasoline, and if so, how much bioethanol should be blended. This study can provide the government with useful information about potential consumers' positive preferences for bioethanol made with domestic non-food feedstock, while revealing negative opinions on the use of GM-based feedstock. Although Korean consumers showed negative preferences on bioethanol made from GM based feedstock, most bioethanol made in the U.S. is based on the GM feedstock due to higher productivity than non-GM feedstock. So, Korean government will need to consider benefits and costs of promotion of bioethanol made from GM feedstock. Additionally, this study shows that the government should provide different credits depending on the types of feedstocks used in manufacturing bioethanol. We show that South Koreans prefer the use of domestic or non-food feedstocks over imported or food-based feedstocks. In this regard, the South Korean government might learn from the experience of the U.S. RIN program, wherein different types of renewable fuels carry different credits depending on their associated reduction rate of GHGs.

[References]

Bae, J. H., "Supply Portfolio of Bioethanol in the Republic of South Korea," *The South Korean Economic Review*, Vol. 30, No. 1, 2014, pp. 133~161.

Bae, J. H., and M. Rishi, "Increasing consumer participation rates for green pricing programs: A choice experiment for South South Korea," *Energy Economics*, Vol. 74, 2018, pp. 490~502.

Bujosa, A., A. Riera, and R. L. Hicks, "Combining Discrete and Continuous Representations of Preference Heterogeneity: A Latent Class Approach," *Environmental and Resource Economics*, Vol. 47, No. 4, 2010, pp. 477~493.

Fimereli, E., and S. Mourato, *Consumer preferences for bioethanol blends*, 2009 EAERE Summer School, 5th-11th July 2009, Venice, pp. 1~17, 2009.

Hensher, D. A., J. M. Rose, and W. H. Green, *Applied Choice Analysis. Second ed*, Cambridge University Press, Cambridge, pp. 1~1698, 2015.

Hole, A. R., "Fitting mixed logit models by using maximum simulated likelihood," *Stata J*, Vol. 7, 2007, pp. 388~401.

International Service for the Acquisition of Agri-biotech Applications(ISAAA), "Global status of commercialized biotech/GM Crops:2017," *ISAAA Briefs*, Vol. 53, 2017, pp. 1~100.

Jensen, K. L., C. D. Clark, B. C. English, R. J. Menard, D. K. Skahan, and A. C. Marra, "Willingness to pay for E85 from corn, switchgrass, and wood residues," *Energy Economics*, Vol. 32, No. 6, 2010, pp. 1253~1262.

Lanzini, P., F. Testa, and F. Iraldo, "Factors affecting drivers' willingness to pay for biofuels: the case of Italy," *Journal of Cleaner Production*, Vol. 112, 2016, pp. 2684~2692.

Li, T., and J. J. Mccluskey, "Consumer preferences for second-generation bioethanol," *Energy Economics*, Vol. 61, 2017, pp. 1~7.

Lim, S. Y., H. J. Kim, and S. H. Yoo, "Public's willingness to pay a premium for bioethanol in South Korea: A contingent valuation study," *Energy Policy*, Vol. 101, 2017, pp. 20~27.

Loureiro, M. L., X. Labandeira, and M. Hanemann, "Transport and low-carbon fuel: A study of public preferences in Spain," *Energy Economics*, Vol. 40, 2013, pp. 1~26.

Mamadzhanov, A., J. J. McCluskeym, and T. Li, "Willingness to pay for a second- generation bioethanol: A case study of South Korea," *Energy Policy*, Vol. 127, 2019, pp. 464~474.

McFadden, D., *Conditional logit analysis of qualitative choice behavior*, Berkeley: CA. University of California, pp. 1~38, 1973.

Ministry of Trade, Industry and Energy, *Implementation Plan for Renewable Energy 3020 Agenda*, 2017.

Miren, I. S., S. Javier, and W. Carmina, "Consumer reaction to information on the labels of genetically modified food," *Rev Saúde Pública 2014*, Vol. 48, No. 1, 2014, pp. 154~169.

Mueller, S., J. Lie, B. Keesom, and S. Unnasch, *The impact of higher ethanol blend levels on vehicle emissions in 5 global cities*, Workshop at the University of Illinois at Chicago, pp. 1~104, 2018.

Petrolia, D. R., S. Bhattacharjee, D. Hudson, and C. W. Herndon, "Do Americans want ethanol? A comparative contingent-valuation study of willingness to pay for E-10 and E-85," *Energy*

Economics, Vol. 32, No. 1, 2010, pp. 121~128.

Revelt, D., and K. Train, *Customer-specific Taste Parameters and Mixed Logit: Households' Choice of Electricity Supplier*, Econometrics 0012001, University Library of Munich, Germany, 2001.

Shin, J., and W. -S. Hwang, “Consumer preference and willingness to pay for a renewable fuel standard (RFS) policy: Focusing on ex-ante market analysis and segmentation,” *Energy Policy*, Vol. 106, 2017, pp. 32~40.

Solomon, B. D., and N. H. Johnson, “Valuing climate protection through willingness to pay for biomass ethanol,” *Ecological Economics*, Vol. 68, No. 7, 2009, pp. 2137~2144.

Stein, R. A., J. E. Anderson, and T. J. Wallington, “An Overview of the Effects of Ethanol-Gasoline Blends on SI Engine Performance, Fuel Efficiency, and Emissions,” *SAE International Journal of Engines*, Vol. 6, No. 1, 2013, pp. 470~487.

Train, K. E., *Discrete choice methods with simulation*, Cambridge, Cambridge University Press, pp. 1~388. 2009.

Wang, M., J. Han, J. Dunn, H. Cai, and A. Elgowainy, “Well-to-Wheels Energy Use and Greenhouse Gas Emissions of Ethanol From Corn, Sugarcane, and Cellulosic Biomass for US Use,” *Environmental Research Letters*, Vol. 7, No. 4, 2012, pp. 1~13.

Yoo, J., and R. C. Ready, “Preference heterogeneity for renewable energy technology,” *Energy Economics*, Vol. 42, 2014, pp. 101~114.

Appendix

〈Table A1〉 Summary of technical statistics

Variable	Observations	Mean	Standard deviation	Min	Max
Respondents' choice	9,648	0.3333	0.4714	0	1
Gender	9,648	0.5609	0.4963	0	1
Age	9,648	3.8408	1.1535	2	6
Educational level	9,648	4.0012	0.5870	1	6
Vehicle type	9,648	4.9876	2.2256	1	10
Type of fuel used	9,648	1.4689	0.6448	1	4
Operating distance	9,648	2.4316	1.0820	1	4
Purpose of car use	9,648	1.8134	1.3476	1	6
Importance of fuel economy	9,648	1.4055	0.6045	1	5
Importance of horsepower	9,648	1.9080	0.6976	1	5
Importance of emissions	9,648	1.8806	0.8047	1	5
Importance of displacement	9,648	2.4179	0.8298	1	5
Average monthly fuel consumption	9,648	2.2774	0.8930	1	4
Awareness of bioethanol	9,648	1.3794	0.4853	1	2
Importance of reducing GHG emissions	9,648	1.5249	0.6825	1	5
Importance of agriculture activation	9,648	1.7823	0.7588	1	5
Importance of revitalizing the domestic ethanol industry	9,648	1.8756	0.7914	1	5
Importance of imported energy replacement	9,648	1.5746	0.7601	1	5
Monthly average income	9,648	6.7189	1.5213	1	8
Importance of economic growth, environmental preservation, and income disparity	9,648	2.1903	0.8638	1	3
Political affiliation	9,648	1.9515	0.7895	1	3

〈Table A2〉 Description of socio-demographic variables

Variable	Description	Level
Choice	Respondent's choice	1—Selected, 0—Unselected
GMO	Provision of information on GM corn for bioethanol	1—GM feedstock-known group, 0—GM feedstock-unknown group
Price	Increases in gasoline price	Increases in gasoline price (KRW/liter)—25/50/75/100
Domestic	Domestic feedstock	Domestic feedstock—1, Imported feedstock—0
Food	Food-based feedstock	Food-based feedstock—0
Nonfood	Non-food-based feedstock	Non-food-based feedstock—1
Exemption	Reduction of gasoline tax	Reduction of gasoline tax for bioethanol-blended gasoline
Discount	Parking/toll discount	Parking fees and highway parking/toll discounts (use a sticker on bioethanol vehicles for public and private parking/toll discounts)
Mileage	Carbon mileage	Provide carbon mileage to consumers who buy bioethanol (carbon mileage can be used as cash for green purchases)
Ratio	Bioethanol blending ratio	3%, 5%, 7%, 10%
Sex	Gender	1—Male, 0—Female
Age	Age	1—<18, 2—19-29, 3—30-39, 4—40-49, 5—50-59, 6—>60
education	Education level	1—<Elementary school, 2—Middle school, 3—High school, 4—College/university, 5—Graduate school
Cartype	Vehicle type	1-5—Sedan, 6-8—SUV, 9—Hybrid, 10—Electric car, 9+10—green car
Fueltype	Type of fuel used	1—Gasoline; 2—Diesel I; 3—LPG; 4—Electricity
Distance	Distance between home and power plants	1—10km, 2—11km ~ 20km, 3—21km ~ 30km, 4—>3km
Purpose	Purpose of car use	1—commuting, 2—business, 3—commuting to school, 4—leisure, 5—shopping
efficiency	Importance of fuel economy	1—Very important, 5—Not important
Hp	Importance of horsepower	1—Very important, 5—Not important
Emission	Importance of emissions of pollutants or GHGs	1—Very important, 5—Not important
Capacity	Importance of displacement	1—Very important, 5—Not important

〈Table A2〉 Description of socio-demographic variables (continued)

Variable	Description	Level
Cost	Average monthly fuel consumption (KRW)	1—<100,000, 2—110,000~200,000, 3—210,000~300,000, 4—>310,000
awareness	Awareness of bioethanol	1—Recognized, 2—Not recognized
co2	Importance of reducing GHG emissions	1—Very important, 5—Not important
Farm	Importance of agriculture activation using domestic feedstock	1—Very important, 5—Not important
Industry	Importance of revitalization of domestic ethanol industry	1—Very important, 5—Not important
Switch	Importance of domestic energy replacing imported energy	1—Very important, 5—Not important
Income	Monthly average income (KRW)	1—<990,000, 2—1,000,000~1,490,000, 3—1,500,000~1,990,000, 4—2,000,000~2,490,000, 5—2,500,000~2,990,000, 6—3,000,000~3,990,000, 7—4,000,000~4,990,000, 8—> 5,000,000
paradigm	Importance of economic growth, environmental preservation, and income disparity	1—Economic growth, 2—Environmental preservation, 3—Income disparity
Politics	Political affiliation	1—Conservative, 2—Neutral, 3—Progressive

〈Table A3〉 Distribution of socio-demographic variables

Type	Group	Number of persons	Percentage (%)
Total respondents		(804)	100.0
Gender	Male	(451)	56.1
	Female	(353)	43.9
Age (years)	19–29	(112)	13.9
	30–39	(202)	25.1
	40–49	(263)	32.7
	50–59	(156)	19.4
	60 or older	(71)	8.8
Residence	Seoul	(208)	25.9
	Incheon/Gyeonggi	(251)	31.2
	Daejeon/Sejong/Chungcheong	(87)	10.8
	Gwangju/Jeolla	(66)	8.2
	Daegu/Gyeongbuk	(65)	8.1
	Busan/Ulsan/Gyeongnam	(100)	12.4
	Gangwon/Jeju	(27)	3.4
Education	<High school	(119)	14.8
	All others	(685)	85.2
Monthly income (KRW)	<2 million	(37)	4.6
	2–3 million	(111)	13.8
	3–5 million	(309)	38.4
	>5 million	(347)	43.2
Political tendency (5 points)	Conservative	(209)	25.9
	Neutral	(234)	29.1
	Progressive	(361)	44.9