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Willingness to pay for fuel-cell electric vehicles in South Korea

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A B S T R A C T

The South Korean government is considering hydrogen as a promising future energy source for transportation and is investing a huge amount of public funds in building hydrogen-fuel infrastructures. This article tries to look into the willingness to pay for a fuel-cell electric vehicle (FCEV). Four attributes chosen in this study are improvement in fuel efficiency, improvement in hydrogen station accessibility, decrease in air pollutants and carbon dioxide emissions, and vehicle type. The potential consumers' trade-offs amidst each of the attributes and price were evaluated in the choice experiment (CE) survey of 1000 people during May 2017 using a random utility maximization model. The CE data were examined through a Bayesian approach to the mixed logit model. The marginal values for a 1 km/L increase in fuel efficiency, a 1%p improvement in hydrogen station accessibility, a 1%p decrease in air pollutants and carbon dioxide emissions, and the shift from sedan to sport utility vehicle are computed to be KRW 1.33 million (USD 1182), 0.28 (249), 2.98 (2649), and 10.47 (9307), respectively. These results can be useful for policy-making and decision-making regarding the FCEVs. For example, they can provide information on how much value potential consumers place on a new FCEV.

1. Introduction

Because environmental regulations have been tightened around the world, advanced countries have been striving to increase the development and supply of eco-friendly alternative-fuel vehicles (AFVs). It is widely accepted that the AFVs emit minimal air pollutants and greenhouse gases (GHG) and produce high fuel efficiency using alternative fuels. Some developed countries even announced ambitious plans to get rid of internal combustion engines from the market in the long run. For example, Norway and the Netherlands refer to after 2025, India refers to after 2030, Britain and France refer to after 2040 [1]. It is likely to induce an artificial reduction of the internal combustion engine market.

As the paradigm of the global vehicle market has changed rapidly, the eco-friendly AFV market has grown at 22% annually [2]. Governments around the world are pursuing various policies to respond to the expansion of the eco-friendly AFV market and to accelerate market transition. As a result, many studies have been conducted to obtain quantitative information on consumers' preference for various eco-friendly AFVs. The previous studies were conducted for the United States, Japan, Netherlands, and Canada and France (e.g., Refs. [3–6]. Furthermore, there have recently been many studies on consumer preference for AFVs in South Korea (e.g., Refs. [7–10].

In South Korea, vehicle ownership has grown every year and reached 2.5 million by the end of 2017, meaning one vehicle per 2.3 people [11]. Most of the vehicles in the country use gasoline and diesel as fuel, accounting for 46.03% and 42.52%, respectively, at the end of 2017. Air pollutants emitted from the vehicles that use gasoline or diesel have caused serious damage to humans and the ecosystem. In addition, as almost all of the crude oil used in the country is imported from foreign countries, those who use gasoline or diesel vehicles are experiencing changes in the price of petroleum products due to fluctuations in international oil prices. Thus, the country is also demanding eco-friendly AFVs.

One response to the demand is to expand the supply of electric vehicles (EVs) which emit minimal air pollutants and GHG [12]. Consequently, the EV is emerging as a very important alternative to improve air quality in urban areas. However, the EVs are also criticized for not reducing air pollutants and GHG emissions since about half of the electricity is produced from coal in the country [13]. For this reason, some people call EVs “coal vehicles.” Coal is expected to be the most influential generation source in the future

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for a long time. Moreover, since EV are heavier than gasoline or diesel vehicles, abrasion of tires and brake pads of EV may cause more particulate matters than that of gasoline or diesel vehicles [14,15].

Another alternative is to increase the supply of fuel-cell electric vehicles (FCEVs). The fuel-cell combines hydrogen with oxygen to make water and obtain electricity and heat. Therefore, its emissions of air pollutants are zero. Moreover, FCEVs are equipped with air filters and can reduce particulate matters emissions. Nevertheless, GHG emissions may be feared if the electricity used to produce hydrogen is produced from coal, as is the case with EVs. However, the South Korean government aims to produce hydrogen using electricity produced from renewable sources, and in particular to use surplus power generated by curtailment of renewable energy to produce hydrogen. Therefore, FCEVs are a much greater environmental improvement than EVs. The FCEV's merits of a short time to charge hydrogen fuel and high fuel efficiency are advantageous for long-distance driving [16].

However, the high cost of deploying a hydrogen-station infrastructure and the high price of an FCEV prevent the supply of FCEVs from expanding. In spite of that, the South Korean government made a long-term goal of supplying 630,000 FCEVs and installing 520 hydrogen stations by 2030 [17–19]. To expand the supply of FCEVs, the South Korean government has endeavored to supplement these shortcomings through various policy measures, which include subsidization of the purchasing of FCEVs, reduction in taxation, and support for hydrogen station installation costs.

Through these policies, the use of FCEVs at the end of 2017 increased by 5.6 times compared to 2015. Although the subsidy policies are quite useful in expanding the supply of FCEVs, it is difficult to sustain such policies for a long time because of the considerable financial burden. Thus, in order to continue expanding the supply of FCEVs, alternative policies should be considered and the public preferences for the FCEV have to be clarified. It is with regard to such situations that this article tries to investigate the public preference for the attributes of FCEVs to provide policy makers and stakeholders with important quantitative information.

There are four sections in the rest of this article. The literature review is provided in the next section. The methods and econometric models employed in the article are explained in the third section. The results are reported and discussed in the fourth section. Conclusions and some implications of the study are presented in the last section.

2. Literature review

The preceding study cases are summarized in Table 1. There have been studies on consumers' preferences and WTPs for AFVs in other countries which mainly have applied the stated preference method. There are two main approaches, contingent valuation (CV) and choice experiment (CE).

Martin et al. [5] investigated how consumers value the benefit of fuel cell vehicles by using a CV method. Hoen and Koetse [3] analyzed consumer preferences and willingness to accept for AFVs by design a CE. Poder and He [6] conducted a CV to look into the WTP for a cleaner vehicle that reduces exhaust gases 62.2%. Choi et al. [8] analyzed consumer preferences in battery electric vehicles by using a CE.

3. Methodologies

3.1. Methodology

As addressed above, the primary objective of this article is to look into the public preference for the attributes of the FCEV using the specific case of South Korea. One complication in conducting the survey is the fact that the market of FCEVs has not yet become popular in South Korea. For example, Hyundai Nexo, the first FCEVs model, was released to the market in February 2018. In this case, revealed preference methods utilizing the data obtained from the market cannot be applied. Therefore, a nonmarket good valuation method that can be applied to investigating the public preference for a good or service that cannot be evaluated in the market should be adopted here.

Two techniques that have been widely employed for nonmarket good valuation in the literature are the CE and CV. The CE method asks the respondents to evaluate value trade-offs among some attributes and indirectly derives their willingness to pay (WTP). The CV method asks the respondents directly about the magnitude of their WTP. They are called stated preference methods.

Although the two methods have their own advantages and disadvantages, we investigate people's preferences for a FCEV by using the CE method for three reasons (e.g., Refs. [7,18–23]. First, the FCEV is a representative good with multiple attributes. Usually, the CV method is applied to a single-attribute good while the CE method is applied to a multi-attribute good. Therefore, the CE method is more suitable for valuing a multi-attribute good than the CV method.

Second, this study is interested in estimating a function to value a variety of changes in a good or service of concern rather than valuing a specific improvement or deterioration of a good or service of concern. The CV method gives us a specific value while the CE method provides us with a valuation function. Thus, the latter is more appropriate for the objective of this study than the former. For example, the results from the CE approach can give information on how much value potential consumers place on a new FCEV with multiple attributes.

Third, since the CE does not directly pursue WTP, it can reduce the number of protest responses, which are frequently observed in works applied CV. How to deal with protest responses has always been an important issue in the applied CV literature. This is because

Table 1
Summary of the findings from some previous studies dealing with eco-friendly cars.

Countries	Sources	Methodologies[a]	Main results
United States	Martin et al. [5]	CV	Compared to gasoline cars, more than half of the respondents had additional willingness to pay (WTP) of USD 4000 or more for zero-emission vehicles.
Canada and France	Poder and He [6]	CV	Mean WTP for a 62.2% reduction in exhaust gases is about 5440 Canadian dollars. This value is less than the market price difference between conventional and cleaner vehicles.
Netherlands	Hoen and Koetse [3]	CE	Preference for alternative fuel vehicles (AFVs) such as hybrid, electric, plug-in hybrid, and fuel cell increases with improvements on characteristics of AFVs. The average amount of willingness to accept for AFVs was EUR 10,000 to 20,000
South Korea	Choi et el. [8]	CE	The Marginal WTP for the infrastructure for battery electric vehicles increases by 1% and reducing 1 Korean won in fuel cost for 1 km drive was USD 69, and USD 96 respectively.

Note:
[a] CV and CE indicate contingent valuation and choice experiment, respectively.

deleting all the protest responses from the dataset to be analyzed may cause an overestimation of the mean WTP and treating all the protest responses as zero WTP may produce an underestimation of the mean WTP. In particular, most empirical CV studies on South Korea suffer from protest responses for some reason. For example, people do not have much confidence in the government's policies to improve something or have strong resistance to the WTP question itself.

3.2. CE approach

The CE approach is theoretically grounded in the random utility maximization model. The model implies that if an individual chooses one alternative among several alternatives the utility resulting from selecting that alternative is always greater than the utility resulting from choosing another. Therefore, the application of the approach requires a survey of potential consumers. CE is a useful method for estimating the relative values for different attributes of an environmental and nonmarket good or new product. The public preference for FCEVs can be effectively assessed through the CE approach.

In general, respondents are required to choose the most preferred alternative out of several alternatives, which include a baseline state alternative, presented to them in the CE survey. Each alternative comprises several attributes of concern, including the price attribute. CE is a useful method to estimate the relative importance of several attributes for a good or service [20]. Marginal WTP (MWTP) for increasing or decreasing the level of each attribute can be obtained through analyzing the data on respondents' choices and then interpreting or utilizing the results.

3.3. Attributes

In designing a CE, the first important thing to do is to determine the appropriate attributes of FCEVs and defining their levels. Extensive literature review and consultation with experts enabled us to identify a preliminary list of attributes of FCEVs. Most previous studies reveal that purchasing price (e.g., Refs. [3,24–27], fuel availability (e.g., Refs. [25,28], and emission reduction (e.g., Refs. [24,28] have important implications for consumers' preferences for AFVs including FCEVs. The final set of attributes was chosen through discussion with experts such as policy makers, stakeholders, and environmental activists.

The final determined attributes of FCEVs are fuel efficiency, improvement in hydrogen station accessibility, air pollutants and carbon dioxide emissions, vehicle type, and purchasing price. A focus group interview with 30 people was implemented to check whether the attributes were fully meaningful, understandable, and persuasive to the respondents. Their responses were affirmative. Thus, there are five important attributes that consumers would consider when purchasing a new FCEV.

The descriptions and levels of attributes are reported in Table 2. The baseline state of fuel efficiency attribute is 0 km/L, which indicates that there is no improvement in fuel efficiency compared to gasoline sedans. The baseline state of accessibility attribute is 0%, which presents that there is no improvement on accessibility to hydrogen stations for fueling. It intends the number of hydrogen stations has not increased. The upper bound of this attribute is 60% represents the situation that the number of hydrogen stations achieves 60% of the current number of gas stations. In the case of air pollutants and carbon dioxide emissions attribute, the baseline state is 0%p, which means that there is no decrease in air pollutants and carbon dioxide emissions. They are assumed to be orthogonal in terms of valuation function rather than production function. Furthermore, all other attributes of FCEVs are assumed to be the same in the course of the value judgments required in the CE survey.

The number of possible alternatives generated from Table 2 amounts to 270. However, it is not necessary or appropriate to present all these alternatives to the respondent, because of the respondents' bounded rationality and time/cost constraints. Therefore, only 16 alternatives were chosen by applying a main effect orthogonal design using SPSS 12.0 package. They were randomly mixed and then divided into eight sets of two options. Each choice set is made up of two alternatives and the baseline state alternative. Each respondent would randomly belong to one of the two groups. Four choice sets were offered to each respondent. A respondent was asked to select one preferred alternative out of three alternatives within each choice set.

3.4. Survey instrument and method

There are three parts in the survey instrument. Several questions about the FCEV make up the first part to check respondents' perceptions before the CE survey on FCEVs begins in earnest. To help respondents understand, a description of the features and

Table 2
Descriptions and levels of four chosen attributes and price attribute used in this study.

Attributes	Descriptions	Levels
Fuel efficiency	Improvement in the fuel efficiency of a car (unit: km/L)	Level 1: 0[a] Level 2: 6 Level 3: 16
Accessibility	Percentage of an improvement on accessibility to hydrogen stations for fueling	Level 1: 0%[a] Level 2: 30% Level 3: 60%
Air pollutants and carbon dioxide emissions	Percentage of a decrease in air pollutants and carbon dioxide emissions compared to a gasoline sedan	Level 1: 0%p[a] Level 2: 50%p Level 3: 90%p
Vehicle type	Type of vehicle	Level 1: Sedan[a] Level 2: SUV[b]
Price	Purchasing price of a hydrogen fuel-cell electric vehicle car (unit: million Korean won = USD 889)	Level 1: 20[a] Level 2: 25 Level 3: 30 Level 4: 35 Level 5: 40

Notes:
[a] Indicates the baseline state of each attribute. USD 1.0 was approximately equal to KRW 1125 at the time of the survey.
[b] SUV indicates sport utility vehicle.

effects of the FCEV is provided with color photographs in this section. Such work not only relieves respondents of the burden of a full-fledged survey but also provides significant statistical data in itself. Explanations about the attributes and questions concerning the value trade-off works conventionally required in the CE survey are presented in the second part. The questions about the respondents' socio-economic information are contained in the third part.

A professional polling firm administered a nationwide CE survey of 1000 randomly chosen interviewees through in-person interviews during May 2017. Each household gave us four observations. Thus, we would get a dataset whose size is 4000 (1000×4). The survey was administered to householders or housewives aged over 20 and under 65 years old, those who are likely to purchase a car regardless of whether they currently own the car or not. Definitions and sample statistics of respondents are presented in Table 3. Prior to conducting the main survey, 30 people were surveyed in advance to help raise respondents' understanding of the questionnaire.

3.5. Utility function

The utility function is assumed to have a linear functional form. The levels of fuel efficiency, accessibility, air pollutants and carbon dioxide emissions, vehicle type, and purchasing price are X_s for $s = 1, 2, 3, 4, p$, respectively. In addition, an alternative-specific constant (ASC) is introduced to capture the effect of any other factors not contained in the model following Train's [29] suggestion. ASC is one if the respondent chooses the third alternative (baseline state), zero otherwise. The utility of a respondent n obtains when s/he chooses the most preferred alternative i is specified as:

$$\begin{aligned} V_{ni} &= W_{ni}(X_{ni}) + \varepsilon_{ni} = \beta' X_{ni} + \varepsilon_{ni} \\ &= ASC_n + \beta_1 X_{1,ni} + \beta_2 X_{2,ni} + \beta_3 X_{3,ni} + \beta_4 X_{4,ni} + \beta_p X_{p,ni} + \varepsilon_{ni} \end{aligned} \tag{1}$$

MWTP for a particular attribute implies a representative consumer's WTP for an increase in the level of the attribute. Thus, the MWTP means economic value or economic benefit of consuming a unit of the attribute. Based on the estimation results of equation (1) and Roy's identity, respondents' MWTP for attribute s can be easily derived as:

$$MWTP_{X_s} = -(\partial W/\partial X_s)\big/(\partial W/\partial X_p) = -\beta_s \Big/ \beta_p \quad \text{for} \quad s = 1, 2, 3, 4 \tag{2}$$

3.6. Model of obtaining utility function

Since the nature of a respondent's choice in his/her CE task is fundamentally discrete, discrete choice models that assume the utility maximization behavior of rational respondents are very suitable for the objective of this article. With the help of a discrete choice model, the data collected can be analyzed. In equation (1), W_{ni} and ε_{ni} are deterministic and stochastic parts of the utility, respectively. X_{ni} is a vector containing the levels of attributes for alternative i given to respondent n. ε_{ni} is defined as a random error term that is independent and identically distributed with Type I extreme values.

Let $h(\cdot)$ be a probability density function. McFadden [30] suggested the random utility maximization model to deal with the probability of respondent n selecting alternative i, P_{ni}, as follows:

$$\begin{aligned} P_{ni} &= \Pr(V_{ni} > V_{nm}, \forall \;\; i \neq m) \\ &= \Pr(W_{ni} + \varepsilon_{ni} > W_{nm} + \varepsilon_{nm}, \forall \;\; i \neq m) \\ &= \Pr(\varepsilon_{nm} - \varepsilon_{ni} < W_{ni} - W_{nm}, \forall \;\; i \neq m) \\ &= \int_{\varepsilon} I(\varepsilon_{nm} - \varepsilon_{ni} < W_{ni} - W_{nm}, \forall \;\; i \neq m) h(\varepsilon_n) d\varepsilon_n \end{aligned} \tag{3}$$

where $I(\cdot)$ is an indicator function. Its value is zero when the argument is false and one otherwise.

The mixed logit (ML) model does not require a restrictive assumption of the independence from irrelevant alternatives (IIA), which is adopted in multinomial logit model that has been most frequently applied in econometric modeling of the CE data. The ML model makes the coefficient have a probability distribution for the population reflect the heterogeneity of individual preferences.

Usually, the ML model assumes that the β_n follows the normal or log-normal distribution. Let $g(\cdot)$ be a probability density function. In the ML model, the probability of interviewee n selecting alternative i can be derived as:

$$P_{ni} = \int \frac{\exp\left(\beta' X_{ni}\right)}{\sum_m \exp(\beta X_{nm})} g(\beta) d\beta \tag{4}$$

Using the Bayesian approach given in Train [31] to deal with the ML models has recently received interest [32]. Due to the complexity of the likelihood function of the ML model, the Bayesian approach has several advantages over the classical approach. First, the Bayesian approach can solve computational complexity problems. Second, it can overcome problems associated with initial point and global optimal solutions. Therefore Bayesian approach is employed in this article.

4. Results and discussion

4.1. Results

As noted earlier, it is necessary to assume the form of distribution for β_n in the ML model to reflect the heterogeneity of the respondents' preferences. This study assumes that they followed two widely used distributions: normal or log-normal. At the first stage of the analysis, normal distribution is assumed for all the parameters. However, having assumed a normal distribution, the parameter estimate for Accessibility was negative, unlike previous expectations. In addition, the parameter estimate for Vehicle type was not statistically significant. Therefore, the distributions of the parameters for the two attributes were changed from normal to log-normal.

The results of estimating two ML models are reported in Table 4. The table contains the mean and variance of the coefficient estimates from the two models. One is the model described above and

Table 3
Definitions and sample statistics of respondents.

Variables	Definition	Mean	Standard deviation
Age	The respondent's age	46.32	9.51
Education	The respondent's education level in years	14.23	2.28
Income	The respondent's monthly income (unit: million Korean)	4.40	2.01

Table 4
Estimation results of the mixed logit models.

Variables[a]	Estimates from the model without covariates[d]			Estimates from the model with covariates[d]		
	Assumed distribution	Mean of the coefficient estimate	Variance of the coefficient estimate	Assumed distribution	Mean of the coefficient estimate	Variance of the coefficient estimate
ASC[b]	Normal	−0.6315***	15.7116***	Normal	−0.0109	0.0641***
Fuel efficiency (unit: km/L)	Normal	0.0549***	0.0514***	Normal	0.0223*	0.1244***
Accessibility (unit: %)	Log-normal	0.0115***	0.0003**	Log-normal	0.6046***	12.3866***
Air pollutants and carbon dioxide emissions (unit: %p)	Normal	0.1233***	0.1043***	Normal	0.0319	0.3354***
Vehicle type	Log-normal	0.4329***	9.2494***	Log-normal	0.6338***	49.8344***
Price (unit: million KRW)	Normal	−0.4135***	3.6754***	Normal	−0.2806*	2.1078***
ASC*Age[c]				Normal	0.0713**	0.1673***
ASC*Education[c]				Normal	−0.1777***	0.2289***
ASC*Income[c]				Normal	0.0407	0.2146***
Number of observations 4000						

Notes:
[a] The variables are defined in Table 2.
[b] ASC refers to an alternative-specific constant that represents dummy for the respondent's choosing current status alternative.
[c] Age, Education, and Income indicate the respondent's age, the respondent's education level in years, and the respondent's monthly income (unit: million Korean won).
[d] *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

the other is a model with three more variables of the respondents' characteristics to allow for their impacts on the selection probability. For this purpose, the interviewee's age (Age), the interviewee's education level expressed in years (Education), and the interviewee's monthly income (Income) are considered in the model with covariates. They penetrate the utility function as an interaction term between each variable and ASC where ASC indicates ASC relating to the choice of the baseline state alternative.

As expected, the mean value of coefficient estimate (MVCE) for Price is negative. This shows that the purchasing price is negatively related to the utility. However, the MVCEs for other attributes are positive. This implies that the level of each attribute has a positive relationship with the utility. Improvement in the fuel efficiency of a car, improvement in accessibility to hydrogen stations for fuelling, decrease in air pollutants and carbon dioxide emissions compared to a gasoline sedan, and change of an FCEV's vehicle type from sedan to sport utility vehicle (SUV) increase the utility. Thus, correct signs of the estimates are found as expected.

In the model with covariates, MVCE for ASC*Income is not significant at the 5% level. However, the MVCE for ASC*Age and ASC*Education are statistically significant at 5% and 1% level, respectively. The MVCE for ASC*Age term is positive. This means that respondents' utility for the baseline state alternative decreases with the increase in age of respondents. Whereas, the MVCE for ASC*Education term is negative, which indicates that respondents' utility for the baseline state alternative increase with the decrease in education level of respondents.

4.2. Discussion

The coefficient estimates shown in Table 4 are appropriate for determining the overall tendency of respondents' preferences for individual attributes but are not appropriate for comparing the respondents' relative preferences for individual attributes because their units are different. Therefore, it is necessary to calculate and compare the MWTP of respondents for each attribute. The MWTP is derived based on the above mean of the coefficient estimates, and the results are contained in Table 5.

Since the inclusion of covariates may affect MWTP estimates, in this study, the MWTP estimates were calculated from a model without covariates. The MWTP estimates for a 1 km/L increase in fuel efficiency, a 1%p improvement in hydrogen station accessibility, and a 1%p decrease in air pollutants and carbon dioxide emissions, and the shift from sedan to SUV are estimated to be KRW 1.33 million (USD 1182), 0.28 (249), 2.98 (2649), and 10.47 (9307), respectively. These values are interpreted as the public preference for FCEVs in South Korea.

Using the results presented in Table 4, we can estimate a value that potential consumers place on a new FCEV. In other words, multiplying the figures reported in Table 4 by the levels of attributes gives us the value of an FCEV alternative. As an illustration, the results of calculating the value at which potential consumers assess several hypothetical FCEV alternatives are shown in Table 6. For example, the value of the second alternative with 5 km/L increase in fuel efficiency, a 50%p improvement in hydrogen station accessibility, and a 50%p decrease in air pollutants and carbon dioxide emissions, and the SUV is computed as KRW 180.1 million (USD 0.16 million).

5. Conclusions

The current number of internal combustion engine cars are expected to decrease and future cars are expected to become FCEVs. Since the South Korean government is also making and implementing various policy measures to expand the FCEVs, their supply is supposed to expand in the near future. During their expansion, the public preference for FCEVs needs to be accurately identified. This article attempted to examine the public preference for FCEVs and estimate the monetary value of individual attributes of FCEVs using a CE approach. For this purpose, the four attributes of fuel efficiency, accessibility, air pollutants and carbon dioxide emissions, and vehicle type were investigated considering

Table 5
Marginal willingness to pay (MWTP) estimates based on the results of the model without covariates.

Attributes	MWTP estimates per household per year
Improvement of fuel efficiency (unit: km/L)	KRW 1.33 million (USD 1182)
Improvement of accessibility (unit: %)	KRW 0.28 million (USD 249)
Decrease in air pollutants and carbon dioxide emissions (unit: %p)	KRW 2.98 million (USD 2649)
Vehicle type change from sedan to sport utility vehicle	KRW 10.47 million (USD 9307)

Note: At the time of the survey, USD 1.0 was approximately equal to 1125 Korean won.

Table 6
Hypothetical fuel-cell electric vehicle alternatives.

Attributes	Alternative A	Alternative B	Alternative C
Improvement of fuel efficiency (unit: km/L)	10 km/L	5 km/L	15 km/L
Improvement of accessibility (unit: %p)	30%p	50%p	60%p
Decrease in air pollutants and carbon dioxide emissions (unit: %p)	30%p	50%p	80%p
Vehicle type	Sedan	SUV[b]	SUV[b]
The value of a fuel-cell electric vehicle alternative[a]	KRW 111.1 million (USD 0.099 million)	KRW 180.1 million (USD 0.160 million)	KRW 285.6 million (USD 0.254 million)

Notes:
[a] USD 1.0 was approximately equal to KRW 1125 at the time of the survey.
[b] SUV indicates sport utility vehicle.

heterogeneity of respondents' preferences for individual attributes. The results indicate that the South Korean public expresses deep interest in the FCEV and place significant values on the attributes of FCEVs.

The authors think that the study has two important policy contributions. First, it provided some suggestions about which attributes to focus on when developing FCEVs. For example, interestingly, the public evaluated a 1%p decrease in air pollutants and carbon dioxide emissions higher than 1%p improvement of accessibility. Moreover, the consumers prefer an SUV FCEV to a sedan FCEV. Second, the study can provide implications for the calculation of a government subsidy. As mentioned earlier, the price of the FCEV is quite a lot higher than that of an existing car. The subsidy payment policy would be a key factor in expanding the supply of FCEVs. An adequate amount of subsidies can remove the gap between the public WTP for an FCEV and the price of the FCEV.

Moreover, this article seems to contribute to the literature in two research perspectives. First, the article utilized a CE technique to look into the public preference for the attributes of FCEVs and found that the application was successful because the estimation results were statistically meaningful, and the respondents actively participated in the CE survey. Comparison of the results from our work with those from future works that are applied to other countries will give new implications. Second, the authors utilized the ML model not to make a restrictive IIA assumption but to allow for the preference for heterogeneity and obtained the MWTP estimates for attributes. This article reveals that the ML model is more theoretically promising than the conventional multinomial logit model, and it is as easily applied as the conventional multinomial logit model.

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