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Consumers' Willingness to Pay a Premium for Eco-Labeled LED TVs in Korea: A Contingent Valuation Study

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Abstract: Although the production costs and prices of eco-labeled products are higher than those of conventional ones, the use of greener products can lead to better environmental outcomes. Thus, the consumers' preferences for eco-labeled products should be investigated to understand the potential of markets with green products. This study attempts to examine the consumers' preference or willingness to pay (WTP) a premium for eco-labeled products using a specific case study of a 43-inch LED TV, which is a common home appliance in Korea. For this purpose, a contingent valuation survey of 1000 Korean consumers was conducted in June 2016. We used a one-and-one-half-bounded dichotomous choice question to derive the additional WTP responses and a spike model to analyze zero additional WTP responses. The mean additional WTP a premium for the eco-labeled 43-inch LED TV is estimated to be KRW 29,007 (USD 24.8), which is statistically meaningful at the 1% level. This value amounts to 3.9% of the price of a conventional 43-inch LED TV (KRW 750,000 or USD 640.5) and can be interpreted as the external benefit of an eco-labeled LED TV. We can conclude that Korean consumers are ready to pay a significant premium for eco-labeled LED TVs. Moreover, we examined the consumer's characteristics that affect the probability that the person will be willing to pay a premium for an eco-labeled LED TV and found that it would be effective to set high-income, older, highly-educated, and female consumers with children as marketing targets.

Keywords: eco-labeled LED TV; consumer preference; willingness to pay; premium; contingent valuation

1. Introduction

Various pollutants, such as air pollutants, waste water, and waste, are emitted into the environment in the course of manufacturing electronic products [1,2]. These emitted pollutants exert negative effects on human health, as well as the environment [3]. The Korean government has introduced a scheme for environmentally-friendly products that are created using less water and electricity and emitting fewer pollutants. In other words, the Korean government grants eco-label certification to eco-friendly products that may cause less environmental pollution or save resources compared with other products intended for the same use. The certification is based on the Support for Environmental Technology and Environmental Industry Act. The attached eco-label indicates that the product is manufactured using an eco-friendly process and production method (PPM) [4,5].

Some consumers prefer an eco-labeled product to a conventional one without an eco-label. In this case, an eco-label can help consumers participate voluntarily in increasing the use of eco-friendly PPMs. Consumers' desires to purchase eco-labeled products leads firms to develop and manufacture environmentally-friendly products. However, the production costs of eco-labeled products are higher

than those of conventional ones because the PPMs for eco-labeled products require careful management from the raw materials and subsidiary materials to the packaging [6–9].

For example, the eco-label in Korea demands that the chemical contents of the product must follow the EU's Directive 2006/66/EC. The housing of a product's materials must not contain halogen synthetic resins, such as polyvinyl chloride. Thus, the prices of eco-labeled products are usually higher than those of conventional ones with no eco-label, although there are no differences for consumers' usage between eco-labeled products and conventional ones. In this regard, the consumers' preference for eco-labeled products over conventional products with no eco-label should be investigated. Moreover, market planners and product developers frequently need to assess the market potential of an eco-labeled products that is not yet available for actual test marketing. The contingent valuation (CV) technique for assigning a social value to non-market environmental resources can be ideally suited to estimating the premium for an eco-labeled product over a non-eco-labeled product.

Both the government and chief executive officers of LED TV industry in Korea are currently addressing the likely effectiveness of a provision of an eco-labeled LED TV. If provided, additional costs will be incurred, with the expectation that inhabitants in Korea will reap the ensuing benefits. Employing financial viability as the sole criterion, whether to provide an eco-labeled LED TV or not can be evaluated in a conventional financial feasibility analysis context. In other words, implications of whether to provide the product could, in principle, be deduced from an examination of costs and revenues associated with the product. Moreover, an important first step in fostering a productive debate over how to provide the product is a better understanding of its costs and revenues.

In order to make an informed decision, some information on the expected revenues would be useful. This study addresses a component of the revenues that such an analysis would consider: the additional willingness to pay (WTP) for the eco-labeled product over a non-eco-labeled product. This paper tries to contribute to the current literature. Therefore, the objective of this study is to examine the consumers' WTP a premium for eco-labeled LED TVs. This objective is carried out using a survey approach called the CV method.

CV is a standardized and widely-used survey method for estimating WTP, it involves constructing a hypothetical market or referendum scenario in a survey. The proposed increase (if respondents pay) or decrease (if respondents do not pay) in the quantity or quality of the goods is communicated to respondents in words and with visual aids. Next, respondents are informed of how they will pay for the proposed quantity or quality. Then the provision rule is made clear: if you agree to pay, you get the proposed quantity or quality; if you do not pay, you remain at the current quantity or quality level. Respondents use the hypothetical market to state their WTP or vote for or against a product.

The CV method is based on the premise that the maximum amount of money an individual is willing to pay for a product is an indicator of the value to him/her of that service. In considering their maximum additional WTP for an eco-labeled LED TV over a non-eco-labeled LED TV, individuals should take into account all factors that are important to them in the provision of the product. In this respect, the message of this paper, which uses the CV technique to look into the consumers' WTP a premium for eco-labeled LED TVs, can be quite useful. Moreover, the validity and accuracy of the CV method results is tied, in part, to the accuracy and unbiasedness of the information contained in the survey and the survey implementation [10,11].

Most of the previous studies that examined consumers' additional WTP a premium for eco-friendly products employed stated preference techniques, such as CV and a choice experiment (CE). For example, Milovantseva [3] used a CV method to analyze American households' WTP a premium for green consumption of information and communication technologies and found that the premium was USD 29.6 per household. Mostafa [12] examined Egyptian consumers' WTP for carbon-labeled products using a CV approach and discovered that the additional WTP ranged from EGP 75 (or USD 10.5) to EGP 90 (or USD 12.6) per product.

On the other hand, Sammer and Wüstenhagen [8] examined the influence of eco-labeling on consumer behavior regarding washing machines using CE and detected that consumers' WTP a premium

for an eco-labeled product was more than CHF 1220 (EUR 800). Using CE, Ward et al. [13] investigated how the ENERGY STAR label affects consumers' preferences for refrigerators. The additional WTP for an ENERGY STAR-labeled refrigerator ranged from USD 249.8 to USD 349.3 per product. Lanzini et al. [14] elicited drivers' WTP a premium for biofuels using CE. The premium was estimated to be a surcharge of EUR 0.01 to 0.14 per liter of biofuel.

Gaspar and Antunes [15] analyzed the consumer profiles and choice determinants for appliance purchases. The cost positively correlated with consideration of energy efficiency class in consumer choices. Furthermore, the consumer profiles were identified based on gender, age, and whether or not the purchaser was accompanied when decisions were made. Murray and Mills [16] examined the correlation with consumers' awareness of the Energy Star label and factors associated with the choice of Energy Star labeled appliances. This study found household characteristics have a much stronger association with consumers' awareness of labels than with the choice of Energy Star appliances. Moreover, if eliminating the socio-economic variables' gap in Energy Star appliance adoption, it decreases an electricity cost in house USD 164 million per year and reduces carbon emissions by about 1.1 million metric tons per year. Taufiquea et al. [17] discovered that both general environmental knowledge and knowledge of eco-labels positively influence consumers' attitudes towards environment in driving ecologically conscious consumer behavior. Park [18] investigated a price premium for Korea's Energy Efficiency Grade Label and suggested the need of careful design of labeling programs because energy-efficient products already had higher prices before the introduction of the energy efficiency label.

Of the above-mentioned nine case studies, CV or CE methods are used in accordance with the author's preference and research topic. The CV method is one of the most popular methods used by environmental and resource economists to value environmental and non-market goods [19–21]. In the literature, the authors found various pieces of empirical evidence that people are willing to pay a premium for eco-friendly products. If people accept an additional surcharge for a 43-inch eco-labeled LED TV, they could be interpreted as having a positive preference for a 43-inch eco-labeled LED TV.

Therefore, this study attempts to investigate the public preference, or WTP a premium, for eco-labeled products using a specific case study of a 43-inch LED TV, which is a common home appliance in Korea. For this purpose, a CV survey of 1000 Korean consumers was conducted in 2016. Moreover, we used a one-and-one-half-bounded (OOHB) dichotomous choice (DC) question to derive the additional WTP responses and a spike model to analyze zero additional WTP responses. The remainder of the paper is made up of four sections: the methodology adopted in this study is explained in Section 2; the WTP model used here is described in Section 3; the results are presented and discussed in Section 4; and the paper is concluded in the final section.

2. Methodology

2.1. Goods to be Valued

The object to be valued in this study is an eco-labeled 43-inch LED TV over a conventional 43-inch LED TV. More specifically, we assess the consumers' WTP a premium for an eco-labeled 43-inch LED TV over a conventional 43-inch LED TV. If the following three conditions are satisfied, a certified eco-label can be given to the producers of 43-inch LED TVs. First, an eco-labeled LED TV should be produced through a process emitting less waste water and waste. Second, during the course of its production, fewer pollutants, such as Pb, Cd, Hg, and Cr6+, which negatively affect the land, atmosphere, and human health, should be emitted. Third, the packaging material should be made of recyclable resources. The quality of an eco-labeled LED TV is the same as that of a conventional one. The only difference between the two is the PPM of the products. These points were explicitly conveyed to the respondents during the CV survey.

2.2. Method for Measuring a Premium of an Eco-Labeled 43-Inch LED TV: The CV Approach

A premium for an eco-labeled 43-inch LED TV should be understood as a case of a non-market good including environmental goods. The people's WTP for a non-market good constitutes the underpinning rule for the benefits of the associated policy [22], and can be gauged using certain preference techniques, a representative one of which is the CV technique. Arrow et al. [10] concluded that the CV method is able to generate credible information that can be applied in relation to decisions regarding administration and jurisdiction. The CV approach is likely to be in accordance with the general notion of microeconomics.

2.3. CV Survey Instrument and Sampling

We conducted a pre-test on the survey questionnaire with a focus group (30 people) to examine whether the questionnaire could be properly understood and to obtain the distribution of the WTP values. The pre-test results helped us to rectify the errors in the questionnaire and to refine the bids to be presented to the respondents. The final questionnaire consisted of (a) explanations of the general background and purpose of the survey; (b) a question on the issue of the additional WTP for an eco-labeled 43-inch LED TV; and (c) questions regarding household characteristics.

A professional survey company implemented a random sampling and field CV survey. In the CV survey, the respondents were asked to make a responsible decision about payment. To satisfy this condition, the survey firm selected and interviewed heads of households or home-keepers; the respondents' ages ranged from 20 to 65. We chose to use face-to-face interviews so that the respondents were provided with sufficient information on the objects to be valued. Based on the interviewers' comments, the interviewees gave their WTP responses without any particular difficulty. The trained interviewers carried out 1000 personal interviews at the interviewees' homes during June 2016.

2.4. Method of WTP Elicitation and Bid Amounts

In accordance with Arrow et al.'s [10] guidance on the CV approach, we adopted a DC question format. Open-ended questions are not encouraged, as they will generate an overestimated WTP [11]. Generally, interviewees are asked questions that have 'yes' or 'no' answers that indicate the interviewees' WTP a concrete amount for a non-market good; in this study, the questions specifically addressed an eco-labeled 43-inch LED TV.

The number of questions identifies the DC question form—a single-bounded (SB) or a double-bounded (DB) DC format. A SB DC question asks the respondent one question, but a DB DC question offers him or her two bids. As the additional question obviously gives a greater range for the WTP, DB questions are likely to be more efficient than SB ones [23]. However, many studies in the literature claim that some bias is captured when moving from an SB to a DB question [24–26]. In summary, the SB and DB formats may, respectively, suffer from statistical inefficiency and response bias. To overcome these complications, a OOHB DC question method is suggested by Cooper et al. [27]. The merits of using of an OOHB DC question, as employed in our study, are presented in Cooper et al. [27].

2.5. Payment Vehicle

The interviewees could easily reveal their true WTP the medium through which the amount would be paid. The medium is called the payment vehicle, and may be a tax, a fund, a donation, or an expenditure. The respondents should feel at home with the payment vehicle, and the goods to be valued should have a clear connection with it. For this reason, the payment vehicle used for this study was a 43-inch LED TV price surcharge. This is appropriate for our analysis and is also familiar to the respondent. Furthermore, some previous studies use price-added to goods [28–30]. Other former studies [3,12] also used a premium on the product price as a payment vehicle. Therefore, the premium is employed in this study as the payment vehicle. The WTP question was posed in the following

manner: "Is your household willing to pay an additional given amount for an eco-labeled 43-inch LED TV over a conventional one?"

3. Modeling of WTP: OOHB DC Spike Model

The basic modeling of WTP using DC CV data is usually based on the work of Hanemann et al. [23], Cameron and James [31], and Cameron [32]. In particular, OOHB DC CV data can be analyzed following Cooper et al. [27]. There are N respondents. Several sets of two bids are determined before the CV survey is carried out and a set is randomly presented to the respondent. Any set offered to respondent i is made up of two bids, a lower bid (B_i^L) and an upper bid (B_i^U). About half of the interviewees are offered B_i^L as the first bid. If the answer is "yes", a follow-up question is asked concerning B_i^U. If the answer to this is "no", no further question is needed. $B_i^U$is presented to the other half of the respondents as the first bid. If the response is "yes", no further question is required. If the response is "no", a subsequent question regarding B_i^L is asked.

There are six possible outcomes to this process: "yes–yes" ($WTP > B_i^U$), "yes–no" ($B_i^L < WTP < B_i^U$), and "no" ($WTP < B_i^L$), from the first case, and "no–yes" ($B_i^L < WTP < B_i^U$), "no–no" ($WTP < B_i^L$), and "yes" ($WTP > B_i^U$) from the second case. Therefore, we can set up six binary-valued indicator variables, I_i^{YY}, I_i^{YN}, I_i^N, I_i^Y, I_i^{NY}, and I_i^{NN}, such that:

$$\begin{array}{l} I_i^{YY} = \mathbf{1}(i\text{th interviewee}'\text{s answer is "yes-yes"}) \\ I_i^{YN} = \mathbf{1}(i\text{th interviewee}'\text{s answer is "yes-no"}) \\ I_i^{N} = \mathbf{1}(i\text{th interviewee}'\text{s answer is "no"}) \\ I_i^{Y} = \mathbf{1}(i\text{th interviewee}'\text{s answer is "yes"}) \\ I_i^{NY} = \mathbf{1}(i\text{th interviewee}'\text{s answer is "no-yes"}) \\ I_i^{NN} = \mathbf{1}(i\text{th interviewee}'\text{s answer is "no-no"}) \end{array} \quad (1)$$

where $1(\cdot)$ is an indicator function that is one if the interviewee's answer is consistent with its superscript, and zero otherwise.

When a considerable proportion of interviewees give zero WTP answers, because of their indifference towards the object to be valued, researchers need to pay particular attention to these zero WTP observations. We utilized a spike model to analyze our OOHB DC CV data with a number of zero observations. The spike model was originally proposed for SB DC CV data by Kriström [33], was adjusted for DB DC CV data by Yoo and Kwak [34], and is sometimes applied to OOHB DC CV data (e.g., [21,35]). Let the random variable for the WTP be W and the cumulative distribution function of the WTP be $H_W(\cdot)$. In our OOHB DC spike model, $H_W(\cdot)$ has the functional form:

$$H_W(B;\alpha,\beta) = \begin{cases} [1+\exp(\alpha-\beta B)]^{-1} & \text{if } B > 0 \\ [1+\exp(\alpha)]^{-1} & \text{if } B = 0 \\ 0 & \text{if } B < 0 \end{cases} \quad (2)$$

where α and β are the parameters to be estimated. The spike, defined as the probability of the respondent's having zero WTP, is computed as $[1+\exp(\alpha)]^{-1}$.

Those interviewees who answered "no" when presented with ${B_i}^L$ as the first bid, or "no-no" when presented with ${B_i}^U$ as the first bid, were asked an extra question, "Do you have zero willingness to pay?". This is because they were separated into two groups: those who have a true zero WTP, and those who have a positive WTP that is less than ${B_i}^L$.

Consequently, we can define two more binary-valued indicator variables:

$$\begin{array}{l} I_i^{TY} = 1(i\text{th interviewee's additional answer is "yes"}) \\ I_i^{TN} = 1(i\text{th interviewee's additional answer is "no"}) \end{array} \quad (3)$$

Using Equations (1)–(3), we can derive the log-likelihood function of the OOHB DC spike model as:

$$\begin{aligned} \ln L = \sum_{i=1}^{N} \{ & (I_i^{YY} + I_i^{Y}) \ln[1 - H_W(B_i^U; \alpha, \beta)] \\ & + (I_i^{YN} + I_i^{NY}) \ln[H_W(B_i^U; \alpha, \beta) - H_W(B_i^L; \alpha, \beta)] \\ & + I_i^{TY} (I_i^{N} + I_i^{NN}) \ln[H_W(B_i^L; \alpha, \beta) - H_W(0; \alpha, \beta)] \\ & + I_i^{TN} (I_i^{N} + I_i^{NN}) \ln H_W(0; \alpha, \beta) \} \end{aligned} \quad (4)$$

Moreover, we can obtain the estimates for α and β by applying the maximum likelihood estimation method to Equation (4). Using these, and the well-known mean formula, the mean WTP can be calculated as:

$$E(W) = \int_0^{\infty} [1 - H_W(B; \alpha, \beta)] dB - \int_{-\infty}^{0} H_W(B; \alpha, \beta) dB = (1/\beta) \ln[1 + \exp(\alpha)] \quad (5)$$

4. Estimation Results

4.1. Data

We collected 1000 observations from the CV survey of randomly-chosen households over the entire nation. We used seven sets of additional WTP values, detected through a pre-test, as mentioned before: (4000, 12,000); (8000, 16,000); (12,000, 24,000); (16,000, 32,000); (24,000, 40,000); (32,000, 48,000); and (40,000, 60,000). The figures given are in Korean won, and the first and the second elements of each set are, respectively, the lower and the higher bids. At the time of the questionnaire, the exchange rate was USD 1.0 to approximately KRW 1171.

Table 1 shows the distribution of responses by each bid level. As expected, the proportion of those stating "yes" to an offered bid decreases as the bid amount increases. Zero additional WTP results in a "no–no" response or a "no–no–no" response, and Table 1 indicates that 480 households (48.0%) revealed zero additional WTP for an eco-labeled LED TV. This means that our strategy of adopting a spike model in the analysis of the OOHB DC CV data is appropriate.

Table 1. Distribution of the responses by the bid amount.

Bid Amount [a]		Lower Bid Is Presented as a First Bid [b] (%)				Upper Bid Is Presented as a First Bid [b] (%)				Sample Size [b]
Lower Bid	Upper Bid	yes–yes	yes–no	no–yes	no–no	yes	no–yes	no–no–yes	no–no–no	
4000	12,000	24 (16.8)	10 (7.0)	5 (3.5)	33 (23.1)	30 (21.0)	8 (5.6)	4 (2.8)	29 (20.3)	143 (100.0)
8000	16,000	25 (17.6)	10 (7.0)	5 (3.5)	31 (21.8)	25 (17.6)	4 (2.8)	3 (2.1)	39 (27.5)	142 (100.0)
12,000	24,000	19 (13.3)	13 (9.1)	7 (4.9)	32 (22.4)	30 (21.0)	5 (3.5)	4 (2.8)	33 (23.1)	143 (100.0)
16,000	32,000	20 (13.9)	11 (7.6)	8 (5.6)	33 (22.9)	27 (18.8)	5 (3.5)	8 (5.6)	32 (22.2)	144 (100.0)
24,000	40,000	18 (12.7)	10 (7.0)	6 (4.2)	37 (26.1)	24 (16.9)	6 (4.2)	9 (6.3)	32 (22.5)	142 (100.0)
32,000	48,000	16 (11.2)	12 (8.4)	11 (7.7)	32 (22.4)	23 (16.1)	3 (2.1)	6 (4.2)	40 (28.0)	143 (100.0)
40,000	60,000	17 (11.9)	9 (6.3)	7 (4.9)	39 (27.3)	18 (12.6)	5 (3.5)	10 (7.0)	38 (26.6)	143 (100.0)
Totals		139 (13.9)	75 (7.5)	49 (4.9)	237 (23.7)	177 (17.7)	36 (3.6)	44 (4.4)	243 (24.3)	1000 (100.0)

Notes: [a] The unit is Korean won; [b] The numbers in parentheses below the number of responses are the percentage of the sample size; At the time of the survey, USD 1.0 was approximately equal to KRW 1171.

4.2. Estimation Results of the OOHB DC Spike Model

Table 2 reports the estimation results. Judging from the *t*-values and the Wald statistic, we can reject both the null hypothesis that each parameter estimate is zero and the null hypothesis that all of the parameter estimates are zero at the 1% level. The estimate for the bid level is negative, which implies that a higher bid amount makes a "yes" response less willing. The estimate for the spike is 0.4820, which is the same as the percentage of the sample having zero WTP responses, as shown in Table 1 (48.0%). This demonstrates that the spike model applied here depicts the sample well. We found that the mean additional WTP is KRW 29,007 (USD 24.8) per product, and that this is statistically significant at the 1% level. For the purpose of accounting for the uncertainties pertaining to the computation of the estimates, we also report a 95% and 99% confidence interval, calculated using the parametric bootstrapping method with 5000 replications [36].

Table 2. Estimation results of the spike model.

Variables	Coefficient Estimates [d]
Constant	0.0720 (1.14)
Bid [a]	−0.0251 (−15.93) *
Spike	0.4820 (30.51) *
Mean additional WTP per product	KRW 29,007 (USD 24.8)
t-value	15.72 *
95% confidence interval [b]	25,701 to 32,969 (USD 22.0 to 28.2)
99% confidence interval [b]	24,827 to 34,158 (USD 21.2 to 29.2)
Number of observations	1000
Log-likelihood	−1200.35
Wald statistic [c] (*p*-value)	247.09 (0.000)

Notes: [a] The unit is Korean won, and USD 1.0 was approximately equal to KRW 1171 at the time of the survey; [b] The confidence intervals are calculated by the use of the Monte Carlo simulation technique of Krinsky and Robb [36] with 5000 replications; [c] The null hypothesis is that all the parameters are jointly zero, and the corresponding *p*-value is reported in the parentheses beside the statistic; [d] The numbers in parentheses beside the coefficient estimates are *t*-values, computed from the analytic second derivatives of the log-likelihood; The symbol * indicates statistical significance at the 1% level.

4.3. Estimation Results of the Model with Covariates

To examine the impact of a respondent's socio-economic characteristics on the probability of him or her answering "yes" to a given bid, it is necessary to consider the model with covariates. At this point, α in Equation (4) is easily changed to $\alpha + x_i'\gamma$, where x_i and γ are the covariate vector and the parameter to be estimated, respectively. Some related previous studies (e.g., [13,16]) used socio-economic variables, such as gender, age, income, education level, and family size as key factors to determine people's WTP for green appliances. For this reason, we also employ gender, age, income, education level, and so on, as covariates. The socioeconomic variables and the sample statistics used for the covariates are described in Table 3. Almost seventy percent of the respondents did not know about eco-label before the survey, and the mean monthly household income was KRW 4.45 million (USD 3800). Furthermore, respondents spend, on average, 2.52 hours per day watching TV.

Of the eight variables employed in this study, the population values for gender, income, and time variables are available from Statistics Korea (www.kosis.kr). According to Statistics Korea, the ratio of males, the average of household income, and the average number of hours of watching TV in a day are 50.0%, KRW 4.31 million, and 2.77 hours in a day, respectively, at the time of the survey. These values are quite close to the sample means (50.0%, KRW 4.45 million, and 2.52 hours in a day). Our CV survey was implemented using in-person face-to-face interviewing; thus, the response rate was almost one hundred percent. Therefore, it seems that our sample is reasonably representative of the national population.

Table 3. Definitions and sample statistics of the variables.

Variables	Definitions	Mean	Standard Deviation
Income	Monthly household's income before taxes (unit: 1 million Korean won = USD 854)	4.45	2.75
Knowledge	Dummy for prior recognition of information about eco-label before the survey (0 = do not know; 1 = know well)	0.69	0.46
Age	The respondent's age (unit: years)	46.50	9.50
Earner	Dummy for whether the number of person who earn a living in family of the respondent is multiple or not (0 = no; 1 = yes)	0.49	0.50
Child	The number of children in the respondent's family	0.82	0.95
Education	Dummy for educational level of the respondent in years being larger than twelve (0 = no; 1 = yes)	0.62	0.49
Time	The time the respondent spends on watching TV during the day (unit: hours)	2.52	1.37
Gender	The respondent's gender (0 = female; 1 = male)	0.50	0.50

Table 4 presents the estimation results of the model with covariates. A total of ten variables, including constant and bid amount terms, are used. All of the coefficient estimates in the model are statistically significant at the 5% level. The positive sign of the coefficient implies that the higher the value of the variable, the higher the likelihood of stating "yes" to a given bid. Since the LED TV is a normal good, the respondents with higher incomes have a higher tendency to report a "yes" response to a provided bid than others. One who already knows the existence of eco-label before the survey is more likely to say "yes" to a presented bid than others. We found that in order to increase sales of the eco-labeled LED TV, communication with the media that can provide consumers with accurate and objective information about eco-label is needed. The respondent's age has a positive correlation with the likelihood of answering "yes" to an offered bid. That is, older respondents tend to accept additional payment for the eco-friendly LED TV than others. The number of children in the respondent's family has a positive relationship with the possibility of responding "yes" to a suggested bid. For the purpose of environmental education, the parents with children are likely to prefer eco-friendly LED TVs to non-eco-friendly LED TVs. The respondents with higher education levels have a positive relationship with the likelihood of saying "yes" to a presented bid.

Table 4. Estimation results of the spike model with covariates.

Variables [a]	Coefficient Estimates	*t*-Values
Constant	−2.0772	−4.30 *
Bid amount [b]	−0.0275	−15.99 *
Income	0.0834	4.00 *
Knowledge	1.0000	7.22 *
Age	0.0325	3.76 *
Earner	−0.2980	−2.23 #
Child	0.1447	1.96 #
Education	0.4636	3.08 *
Time	−0.1852	−4.16 *
Gender	−0.4116	−3.09 *
Number of observations	1000	
Log-likelihood	−1140.41	
Wald statistic [c] (*p*-value)	357.57 (0.000)	

Notes: [a] The variables are defined in Table 3; [b] The unit is Korean won, and USD 1.0 was approximately equal to KRW 1171 at the time of the survey; [c] The null hypothesis is that all the parameters are jointly zero and the corresponding *p*-value is reported in the parentheses beside the statistic; The symbols # and * indicate statistical significance at the 5% and 1% levels, respectively.

On the other hand, the negative sign of the coefficient indicates that the higher the value of the variable, the lower the likelihood of stating "yes" to a given bid. The bid amount is negatively correlated with the possibility of a respondent's giving a "yes" response. Multiple-earner families are less likely to state "yes" to a given bid than a single-earner family. This is because multiple-earner families mean that the multiple earners' per capita income is less than the single earner's personal income when other conditions are all equal. Earner's lower per capita income seems to negatively contribute to the likelihood of saying "yes" to a bid. The time the respondent spends on watching TV during the day has a negative relation to the possibility of reporting a "yes" response to a presented bid. Korea is quite well equipped with mobile networks and, thus, Koreans are accustomed to watching TV programs such as drama, entertainment, and movies on their mobile devices while working, walking, moving, and taking a rest, even at home. Usually, the respondent who spends much time on watching TV usually spends more time on watching mobile TV and less time on watching an LED TV at home than others. The probability of a male respondent saying "yes" to a provided bid is less than that of a female respondent saying "yes" to a provided bid.

Based on these quantitative and qualitative results, the LED TV producers in Korea could obtain a number of useful implications for manufacturing LED TVs and developing concise, targeted product innovations and marketing strategies. For example, it would be effective to set high-income, older, highly-educated, and female consumers with children as marketing targets. In addition, market planners can easily know the incremental contribution of each variable to accepting a premium for eco-labeled LED TV and define an appropriate marketing policy.

4.4. Discussion of the Results

To examine the consumers' preference for an eco-labeled LED TV in monetary terms, we estimated the mean additional WTP for an eco-labeled 43-inch LED TV over a conventional one. In the course of the estimation, the most important issue was whether or not the sample was representative of the population. As addressed above, the sampling was conducted by a professional survey firm to ensure the randomness of the sampling and its consistency with the characteristics of the population. Another important issue is the response rate in the CV survey. Our CV survey was implemented using in-person face-to-face interviewing; thus, the response rate was almost 100%. Consequently, we cannot deny that our sample is representative of the population.

We use the mean additional WTP estimate from the model with no covariates, since the setting of the covariates may influence the mean additional WTP value if we use the mean additional WTP value from the model with covariates. The mean additional WTP a premium for an eco-labeled 43-inch LED TV over a conventional one is estimated to be KRW 29,007 (USD 24.8) per product, which is statistically meaningful at the 1% level. This value amounts to 3.9% of the price of a conventional 43-inch LED TV (KRW 750,000 or USD 640. 5) and can be interpreted as the external benefit of an eco-labeled LED TV over a conventional one. The corresponding 95% and 99% confidence intervals for the point estimate are KRW 25,701 to 32,969 (USD 22.0 to 28.2) and KRW 24,827 to 34,158 (USD 21.2 to 29.2), respectively. Overall, we can judge that LED TV consumers in Korea are ready to pay a significant premium for an eco-labeled 43-inch LED TV instead of a conventional one.

If the additional production costs of an eco-labeled 43-inch LED TV relative to the production costs of a conventional one are less than the premium, the scheme for eco-labels can be implemented successfully. However, if not, further action is needed to ensure success in implementing the eco-label application. For example, this might involve assigning a yield of a certain rate of the total output and offering a green fund to be operated from the eco-label premium. Moreover, various tax credits and other incentives can be made available by the government to enhance the eco-label. For instance, a sound incentive for manufacturers to develop more eco-friendly and efficient technologies for the production process and to use eco-friendly materials might be the provision of subsidies. Moreover, the information on the premium obtained from our study can be employed in determining the levels of tax reductions, tax credits, or subsidies necessary to foster eco-labeled products.

5. Conclusion and Policy Implications

Although the production costs and prices of eco-labeled products are higher than those of conventional ones, the use of greener products can lead to better environmental outcomes. Thus, the consumers' preferences for eco-labeled products should be investigated to understand the potential of markets with green products. In this study, we chose a 43-inch LED TV as the item to be valued, because it is a common home appliance in Korea. We attempted to assess the consumer's WTP a premium for an eco-labeled 43-inch LED TV using the CV approach. The survey was implemented using person-to-person interviewing by a professional polling firm. An OOHB DC question was used to reduce the response bias as well as to increase the statistical efficiency, and the spike model was applied to handle, explicitly, the zero additional WTP data.

The results provided us with various interesting insights in terms of both research and policy. First, the study gave us research insights concerning the application of the CV approach to measuring a premium for an eco-labeled home appliance. Extensive evaluation of CV methods in experimental settings suggests they are quite reliable. These survey instruments are becoming increasingly popular and show considerable promise for assessing the market potential of eco-labeled products. Overall, judging from the interviewers' comments, the CV survey was successful in eliciting the additional WTP values from the respondents. All the parameter estimates were statistically significant at the 1% level. The OOHB DC spike model fit our data well. Moreover, we found that the mean additional WTP for an eco-labeled 43-inch LED TV per product is KRW 29,007 (USD 24.8), and this value is significantly different from zero at the 1% level. Our results show that use of data from the OOHB DC CV survey is a reasonable way to provide information on a premium for eco-labeled LED TV over non-eco-labeled one. Thus, we can conclude that a combination of the CV method and the OOHB DC spike model is suitable for assessing a premium for an eco-labeled product.

Second, several policy implications emerge from the results. Our analysis provided a preliminary indication of the consumer's value of eco-labeled LED TV. The main finding is that consumers' concerns about eco-labeled LED TVs are on the rise, and that people are willing to shoulder some additional financial burden to purchase one. This finding is consistent with the findings of previous studies [3,12]. The OOHB DC CV techniques are based on the premise that the maximum amount of money an individual is willing to pay for a product is an indicator of the value to him/her of that product. Use of the OOHB DC CV technique would imply that the provision of eco-labeled LED TV should be encouraged when the total value of the product, defined as the sum of the price of non-eco-labeled LED TV and the premium for eco-labeled LED TV, outweighs the cost.

It is necessary to estimate the additional WTP for an eco-labeled LED TV in the early stages of development or the production of it. The premium amounted to 3.9% of the average price of a conventional 43-inch LED TV (KRW 750,000 or USD 640.5) at the time of the survey (June 2016). This value can be also interpreted as the external benefit of an eco-labeled 43-inch LED TV. It appears that LED TV consumers in Korea are ready to pay a significant premium for an eco-labeled 43-inch LED TV. Therefore, if the difference between the production costs of eco-labeled LED TV and those of non-eco-labeled one is less than 3.9% of the price of non-eco-labeled one, developing and selling eco-labeled LED TVs is profitable. If not, developing and selling eco-labeled LED TVs is not profitable and, thus, a government's subsidy or tax credit program for eco-labeled LED TVs can be introduced to promote the production and consumption of eco-labeled LED TVs.

Some more findings stem from our CV survey. First of all, a number of households were concerned about eco-labels and wanted a strong governmental introduction of eco-labeling for all home appliances. A next step is to clearly set the standard and range of eco-labeling. Therefore, it is necessary to find the optimal standard and range of eco-labeling after carefully examining the benefits and costs involved in the eco-labeling policy. Information on the public WTP for the eco-labeling policy is needed because it can be utilized for doing so. Evaluating the public WTP for expanding the range of eco-labeling to all home appliances is required as a second stage of this study. In the case that consumers were already familiar with the eco-label, they were more likely to state "yes" to a presented bid than other

consumers. Eco-label promotion to the public can help consumers to think favorably. The logo is easy to recognize and can be found on the packaging of every product manufactured through an eco-friendly course of production. It is meaningful to place eco-labels on products because they give consumers useful information. We also found that in order to secure the success of the eco-labeling we need to communicate with the media that can provide consumers with accurate and objective information about eco-labeled products.

The results are a useful starting point in understanding the possible implications of eco-labeled LED TVs. It is desirable for the government and the industry to know how potential consumers of eco-labeled LED TVs perceive its premium. For example, the policy decision is to encourage more production of eco-labeled LED TVs, knowing the consumers place higher value on eco-labeled LED TVs than non-eco-labeled LED TVs. Moreover, the study contributes to the existing literature because the start of the labeling program supports to set the standard and range of new certification in a timely manner. If an eco-labeling policy is implemented, a consumer's additional WTP or premium for eco-labeled products will be conveyed through higher prices, thereby providing incentives for producers to produce more environmentally-friendly goods.

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References

1. Kemme, M.R.; Lateulere, M. *Reducing Air Pollutant Emissions from Solvent Multi-base Propellant Production*; CERL Technical Report 99/71; US Army Corps of Engineers, Construction Engineering Research Laboratory: Champaign, IL, USA, 1999.
2. Hartikainen, H.; Roininen, T.; Katajajuuri, J.; Pulkkinen, H. Finnish consumer perceptions of carbon footprints and carbon labeling of food products. *J. Clean. Prod.* **2014**, *73*, 285–293. [CrossRef]
3. Milovantseva, N. Are American households willing to pay a premium for greening consumption of information and communication technologies? *J. Clean. Prod.* **2016**, *127*, 282–288. [CrossRef]
4. Ministry of Government Legislation. 2011. Available online: http://www.moleg.go.kr (accessed on 1 July 2016).
5. Korea Environmental Industry & Technology Institute. Eco-label certification in Korea. Available online: http://el.keiti.re.kr/service/index.do/ (accessed on 31 July 2016).
6. Kennedy, P.W.; Laplante, B.; Maxwell, J. Pollution Policy: The Role for Publicly Provided Information. *J. Environ. Econ. Manag.* **1994**, *26*, 31–43. [CrossRef]
7. EU. Directive 2002/95/EC of the European parliament and of the council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. *Official Journal of the European Union 13*, 19e22. Available online: http://www.niagara-video.com/images/rohs/suppliers-RoHS.pdf (accessed on 10 July 2016).
8. Sammer, K.; Wüstenhagen, R. The influence of eco-labelling on consumer behavior—Results of a discrete choice analysis for washing machines. *Bus. Strat. Environ.* **2006**, *15*, 185–199. [CrossRef]
9. Austgulen, M.H. Consumer Perspectives on Eco-labelling of Textiles: Results from five European Countries. Available online: http://www.hioa.no/eng/About-HiOA/Centre-for-Welfare-and-Labour-Research/SIFO/Publications-from-SIFO/Consumer-perspectives-on-eco-labelling-of-textiles (accessed on 26 April 2017).
10. Arrow, K.; Solow, R.; Portney, P.R.; Leamer, E.E.; Radner, R.; Schuman, H. Report of the NOAA panel on contingent valuation. *Fed. Regist.* **1993**, *58*, 4601–4614.
11. Mitchell, R.C.; Carson, R.T. *Using Surveys to Value Public Goods: The Contingent Valuation Method*; Resources for the Future: Washington, DC, USA, 1989.

12. Mostafa, M.M. Egyptian consumers' willingness to pay for carbon-labeled products: A contingent valuation analysis of socio-economic factors. *J. Clean. Prod.* **2016**, *135*, 821–828. [CrossRef]
13. Ward, D.O.; Clark, C.D.; Jensen, K.L.; Yen, S.Y.; Russell, C.S. Factors influencing willingness-to-pay for the ENERGY STAR label. *Energy Policy* **2011**, *39*, 1450–1458. [CrossRef]
14. Lanzini, P.; Testa, F.; Iraldo, F. Factors affecting drivers' willingness to pay for biofuels: The case of Italy. *J. Clean. Prod.* **2016**, *112*, 2684–2692. [CrossRef]
15. Gaspar, R.; Antunes, D. Energy efficiency and appliance purchases in Europe: Consumer profiles and choice determinants. *Energy Policy* **2011**, *39*, 7335–7346. [CrossRef]
16. Murray, A.G.; Mills, B.F. Read the label! Energy Star appliance label awareness and uptake among U.S. consumers. *Energy Econ.* **2011**, *33*, 1103–1110. [CrossRef]
17. Taufique, K.M.R.; Siwar, C.; Chamhuri, N.; Sarah, F.H. Integrating general environmental knowledge and eco-label knowledge in understanding ecologically conscious consumer behavior. *Procedia Econ. Financ.* **2016**, *37*, 39–45. [CrossRef]
18. Park, J.Y. Is there a price premium for energy efficiency labels? Evidence from the introduction of a label in Korea. *Energy Econ.* **2017**, *62*, 240–247. [CrossRef]
19. Park, S.-Y.; Lim, S.-Y.; Yoo, S.-H. The economic value of the national meteorological service in the Korean household sector: A contingent valuation study. *Sustainability* **2016**, *8*, 834. [CrossRef]
20. Lim, S.-Y.; Kim, H.-Y.; Yoo, S.-H. Public willingness to pay for transforming Jogyesa Buddhist temple in Seoul, Korea into a cultural tourism resource. *Sustainability* **2016**, *8*, 900. [CrossRef]
21. Kim, H.-Y.; Park, S.-Y.; Yoo, S.-H. Public acceptability of introducing a biogas mandate in Korea: A contingent valuation study. *Sustainability* **2016**, *8*, 1087. [CrossRef]
22. Brent, R.J. *Applied Cost-benefit Analysis*, 2nd ed.; Edward Elgar: Cheltenham, UK, 2006.
23. Hanemann, W.M.; Loomis, J.; Kanninen, B.J. Statistical efficiency of double-bounded dichotomous choice contingent valuation. *Am. J. Agric. Econ.* **1991**, *66*, 1255–1263. [CrossRef]
24. McFadden, D. Contingent valuation and social choice. *Am. J. Agric. Econ.* **1994**, *76*, 689–708. [CrossRef]
25. Bateman, I.J.; Langford, I.H.; Jones, A.P.; Kerr, G.N. Bound and path effects in double and triple bounded dichotomous choice contingent valuation. *Resour. Energy Econ.* **2001**, *23*, 191–213. [CrossRef]
26. Carson, R.T.; Groves, T.; Machina, M.J. Incentive and informational properties of preference questions. *Environ. Resour. Econ.* **2007**, *37*, 181–210. [CrossRef]
27. Cooper, J.C.; Hanemann, M.; Signorello, G. One-and-one-half-bound dichotomous choice contingent valuation. *Rev. Econ. Stat.* **2002**, *84*, 742–750. [CrossRef]
28. Kwak, S.-Y.; Yoo, S.-H.; Kim, C.-S. Measuring the willingness to pay for tap water quality improvement: Results of a contingent valuation survey in Pusan. *Water* **2013**, *5*, 1638–1652. [CrossRef]
29. Lim, K.-M.; Lim, S.-Y.; Yoo, S.-H. Estimating the economic value of residential electricity use in the Republic of Korea using contingent valuation. *Energy* **2014**, *64*, 601–606. [CrossRef]
30. Yoo, S.-H.; Kwak, S.-Y. Willingness to pay for green electricity in Korea: A contingent valuation study. *Energy Policy* **2009**, *37*, 5408–5416. [CrossRef]
31. Cameron, T.A.; James, M.D. Efficient estimation methods for 'closed-ended' contingent valuation surveys. *Rev. Econ. Stat.* **1987**, *69*, 269–276. [CrossRef]
32. Cameron, T.A. A new paradigm for valuing non-market goods using referendum data: Maximum likelihood estimation by censored logistic regression. *J. Environ. Econ. Manag.* **1988**, *15*, 355–379. [CrossRef]
33. Kriström, B. Spike models in contingent valuation. *Am. J. Agric. Econ.* **1997**, *79*, 1013–1023. [CrossRef]
34. Yoo, S.-H.; Kwak, S.-J. Using a spike model to deal with zero response data from double bounded dichotomous contingent valuation survey. *Appl. Econ. Lett.* **2002**, *9*, 929–932. [CrossRef]
35. Kwak, S.-Y.; Yoo, S.-H. The public's value for developing ocean energy technology in the Republic of Korea: A contingent valuation study. *Renew. Sustain. Energy Rev.* **2015**, *43*, 432–439. [CrossRef]
36. Krinsky, I.; Robb, A.L. On approximating the statistical properties of elasticities. *Rev. Econ. Stat.* **1986**, *68*, 715–719. [CrossRef]