2011 International Conference on Biotechnology and Environment Management
IPCBEE vol.18 (2011) © (2011)IACSIT Press, Singapoore

Potential Demands of Portable Hydrogen Fuel Cells in a 3C Market

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Abstract. Recently, with global warming worsening, nations are working to develop new energies and technology applications to reduce pollutants and save energy to cope with climate changes and reduce green house gas (GHG) emissions. This paper discusses consumers' willingness to pay for portable hydrogen fuel cells using a contingent valuation method. The results are elaborated as follows. In terms of willingness to pay for portable hydrogen fuel cells, male respondents have higher willingness than females do. Additionally, respondents with a greater income have a higher willingness to pay; significant differences between various occupations were observed. The respondents with higher environmental attitudes and experience have a higher willingness to pay. Generally, consumers have a higher willingness to pay for portable hydrogen fuel cells that provide convenience, environmental protection, and long product life expectancy. The variables of consumers' 3C-related knowledge, interest, and attitudes correlate with their choices and demands of portable hydrogen fuel cells. The study author anticipates the results will provide a strategic reference for the government and relevant manufacturers to promote market competitiveness and product acceptance, stimulating green consumption and sustainable development.

Keywords: non-market valuation, contingent valuation method, portable hydrogen fuel cells.

1. Introduction

With a public consensus on the need for environmental awareness and sustainable development of enterprises, green products, such as transportation fuel cells and stationary power generation facilities, are expected to become mainstream in the market, promoting hydrogen and fuel cell development to reduce pollutants and emissions. Most of the green products are the application of new technologies or innovative products, if the firm didn't do the pre-launch preparations, consumers will not accept the products due to the impractical and high prices. Therefore, the assessment is important and necessary before the product launching. There are many criteria of the product acceptance for the customers, but the WTP is the most important issue.

The green products are non-market goods and do not have the market price, most of the researches applied contingent valuation method to evaluate the non-market goods by the WTP. Liu (2008) investigated public willingness to use and willingness to pay for travelling on a hydrogen-fueled bus in Taiwan. The amount the public in the Taipei and Kaohsiung metropolitan were willing to pay was approximately 12 TWD. Wang (2009) examined the potential demands of carbon labels in the consumer market, attempting to understand consumers' WTP for staple goods with carbon labels. Wu (2009) assessed the per-capita GHG emission of the hotel industry using the concept of carbon neutrality to understand what quantity of carbon credits the public would pay to balance carbon dioxide production.

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According to the background analysis above, this paper aims to evaluate the efficiency and existence value of product applications of hydrogen energy according to the willingness to pay for portable hydrogen fuel cells of different consumer groups using a contingent valuation method. The study author expects the results to provide a strategic reference for the government and relevant manufacturers to promote market competitiveness and product acceptance, stimulating green consumption and sustainable development.

2. Methodology

2.1. Establishing a framework using the Tobit model

This study discussed consumers' WTP toward portable hydrogen fuel cells using a payment card method. The results of this inquiry method may result in vast observations of the value zero (meaning that the WTP of the subjects is zero, or even negative), and thus provide limited information. Therefore, the Tobit model, proposed by Tobin (1958), which combines the probit model with the multiple regression model, is the most widely adopted method (Cheng, 2008; Wang, 2009). Accordingly, this study employed the Tobit model to estimate the probability of the parameters and WTP values. The estimation of the WTP was conducted via the linear expenditure functional form.

2.2. Questionnaire Design and Sampling

This study investigates the WTP for portable hydrogen fuel cells of consumers from five major metropolitan districts (Taipei City, New Taipei City, Taichung City, Tainan City, and Kaohsiung City). The investigating questionnaires comprise three major parts: Part 1 aims to investigate the environmental attitudes and action experiences of subjects. Part 2 investigates the subjects' WTP for portable hydrogen fuel cells. Part 3 questions the socioeconomic background information of the subjects to analyze the differences of between subjects' questionnaire responses and WTPs considering their various socioeconomic characteristics. Considering the objective conditions and convenience, this study employed quota sampling to select subjects according to the demographics of each district. Five-hundred questionnaires were sent. The investigation period was from April to May 2011. Excluding the questionnaires with missing data, 403 effective questionnaires were collected, achieving a return rate of 80.6 %.

3. Empirical Analysis

3.1. Empirical Analysis

This study used progressive learning as an elicitation method for obtaining WTPs via questionnaires. The study authors expect to understand real WTP values more clearly via a two-stage inquiry process. Additionally, the subjects can provide their highest WTP value in the questionnaire. The established initial inquiry amounts of the first and second stage of the questionnaire were derived from the pretests. This study used an open-ended elicitation method to obtain the WTPs directly from the subjects, and set prices based on the results of the pretests.

Extreme values were found in 5 of the 403 collected samples. The study author defines extreme values as "the highest WTP values larger than 5000 TWD." The collected questionnaires contained 62 protest samples, which are defined as a "refusal to purchase" with WTP values of zero. However, these responses do not necessarily mean portable hydrogen fuel cells are meaningless to the subjects. The reasons for the protest samples could be uncertainty regarding the payment tools or concerns of product prices increasing after entering the market. The WTPs would be underestimated if the protest samples were included in the WTP evaluation. However, the WTPs would be underestimated or overestimated by improper definitions of the protest samples if the protest samples were deleted. Therefore, this study applied different analytical methods to manage the protest samples, developing a suitable sample structure to reduce the influence of protest samples and determine reasonable WTPs.

Table 1 shows each coefficient symbol of the regression and expectations of positive/negative values, which are almost alike. Both the "INCOME (income)" and "EDUCATION (education levels)" fields have positive values. The economic significance indicates that with higher income and educational levels, the subjects' WTPs also increase. The values of "AGE (ages)" are negative. The economic significance indicates

that when subjects' age increases, the real WTPs reduce. The values of "AGE" differ from the expected value. Positive values are observed in the "MARITAL STATUS (marital status)," "TAI (living areas)," and "SEX (gender)" categories. The economic significance indicates that consumers who are male, married, and living in northern Taiwan have higher WTPs. The values estimated by both occupation types (01, 02) are negative, and influential degrees are not statistically significant. The "BIDO (initial amounts)" value of the first inquiry is positive, which indicates that the higher initial amount of the first inquiry results in higher WTPs, meaning that initial bias exists.

Table 1. Comparison of values of the CVM model

Variables	Expectation Symbol	Estimation Symbol	Average Value	Standard Deviation
INCOME	+/—	+	46.1584	41.9758
EDUCATION	+	—	15.8236	2.6130
AGE	+	—	35.7496	11.1590
MARITAL STATUS	+/—	+	0.5126	0.4633
TAI	+/—	+	0.8142	0.3560
SEX	+/—	+	0.5081	0.4792
01	+/—	—	0.4782	0.5000
02	+/—	—	0.2105	0.4105
BIDO	+	+	532.1915	279.8129

Source: Data obtained during the investigations of this paper.

3.2. Value Estimation

The CVM used a maximum likelihood method to estimate the parameters, substituting the means of all the independent variables to calculate the economic benefits. The means of each variable are shown in Table 1. Table 2 shows the average WTPs of the samples. WTP data from Table 1 was calculated and organized into Table 2. This research discovers that the structure of Sample A can result in a serious underestimation of WTPs. In contrast, the expectation values are very similar to the estimation values using the structures of samples B, C, and D. This study believes that regeneration of the insignificant protest samples is a more appropriate method compared to deleting. Therefore, the WTP for portable hydrogen fuel cells of each subject is 915.17 TWD based on the first structure (Sample C) using the regeneration method.

Table 2. Values of CVM-estimated WTPs with a 95 % Confidence Interval

Sample Type		Sample A	Sample B	Sample C	Sample D
WTPs		750.96	849.74	915.17	901.12
95 % Confidence Interval	Low Limit	745.84	893.03	904.71	896.48
	High Limit	756.08	806.45	925.62	905.76

Source: Data obtained during the investigations of this paper.

4. Conclusion and Suggestion

According to the results, the following conclusion is obtained. Approximately 67.4 % of the subjects had no knowledge of portable hydrogen fuel cells. Of these uninformed subjects, 80 % wanted more information on portable hydrogen fuel cells. Over half the subjects support the government's promotion of portable hydrogen fuel cells; however, over 60 % knew absolutely nothing of portable hydrogen fuel cells. These consumers could potentially oppose portable hydrogen fuel cells in the future. Therefore, before promoting portable hydrogen fuel cells, product-related information must be offered to consumers to enhance future promotion.

Male subjects demonstrate a higher WTP value and are more interested in portable hydrogen fuel cells than females are. Subjects with a greater income also express higher WTPs, and do subjects with better environmental attitudes and action experience. In a broader sense, consumers have higher WTPs for portable hydrogen fuel cells that provide convenience, environmental protection, and long product life expectancy. The variables of consumers' 3C-related knowledge, interest, and attitudes are correlated with their choices and demands of portable hydrogen fuel cells.

During the CVM evaluation, this study discovered that sample structures which used the deleting method to eliminate extreme values and protest samples could cause serious underestimation of WTPs. In contrast, sample structures using the regeneration method on protest samples can obtain more accurate and non-biased results compared to those obtained via the deleting method. Therefore, the WTP for portable hydrogen fuel cells of each subject is 915.17 TWD based on the first structure (Sample C) using the regeneration method.

5. References

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