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Consumer willingness to pay for energy conservation: a comparison between revealed and stated preference method

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Abstract

The path of increasing carbon emissions and global warnings has called public attentions to its impacts on economic activity. Much attention has been on the issues of the energy uses. This also leads to concern whether consumers prefer to buy energy efficiency products in the market. In this study, by using the hedonic price method, we estimate the impact of energy efficiency standard as well as energy efficiency label on prices on the demand of air-conditioners in Taiwan. Our empirical results indicate that consumers are willing to pay more amounts on the products with higher energy-efficient ratio or with the energy efficiency label. Furthermore, by using the contingent valuation method, the estimation results of consumer willingness to pay for energy conservations are similar to those estimated by the hedonic price method.

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Keywords: Hedonic Price model, Contingent Valuation method, Energy Conservation

1. Introduction

Global warning and climate change have been the most important issues over the next decades. As the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the possible effects of climate change cover many types including freshwater, food, agriculture, human health, coastal areas and ecosystems. The negative impacts will be substantial if adequate policy interventions do not meet the challenge of growing demand for decreasing greenhouse emissions. One of the policy options is

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attributed to energy uses. The increasing energy efficiency and conservation have long been the majority methods to the issues of the energy uses.

Recently, Gillingham et al. [1] mentioned the importance of information programs in discussing the energy efficiency policy. However, the effectiveness of the information program is varied by their methods and implementations. Levine et al. [2] found that the program of Energy Guide product labelling has little effect in increasing energy-efficient investments. On the contrary, Webber et al. [3] found that the voluntary Energy Star label has significant effect on energy saving by increasing energy efficiency. Howarth et al. [4] found that the Green Light program has shown its effect on increasing energy-efficient investments.

The purpose of this paper is to discuss the effectiveness of voluntary Energy Efficient Label program in Taiwan. By far one of the most widely used methods is the hedonic price method. This method models on an individual's demand for product characteristics by estimating the relationship between the prices of product and its characteristics. It utilizes observed differences in the amounts of characteristics observed across different products and estimates the individual's willingness-to-pay for the product's characteristics. Since the method relies on the market data to elicit the value of willingness-to-pay which implies the individual's choice behaviour, the measure is categorized as the revealed preference method. Beside the hedonic price method, in this paper, we use the contingent valuation method (CVM) as another research methodology to analyze how consumers would be willing to pay for energy reservation. The CVM has been widely used for valuation the non-market good, however, it also can be used for valuation on the market good, for example, Axsen et al. [5] studies the uses of hybrid-electric vehicles. Since the CVM uses the survey technique to observe the individual's choice behaviour under the hypothetical situations, it is categorized as the stated preference method.

Previous studies have examined whether consumers are willing to pay price premium on energy-efficiency products. For example, Wallander [6] examined the price premium for the Energy Star label on residential clothes washers and found that there is no significant eco-label price premium based on the hedonic price function and a 10% positive but statistically insignificant price premium on the quasi-experiment estimation. The results show that Energy Star program may not have its effect on the policy of energy efficiency. Furest and McAllister [7] investigates the effects of LEED and Energy Star program on the US commercial office properties and found that there is approximately 6% rental price premium for the eco-certified buildings. Shen and Saijo [8] conducted a hypothetical experiment analysis on the China Energy Efficiency Label program and found that consumers are willingness to pay more amounts for more energy efficiency refrigerators than those for more energy efficiency air-conditioners.

Although previous studies have examined the effect on the energy efficiency label, however, there are no consistent results about the issue. In addition, to our knowledge, none of the studies has devoted to use both hedonic price model and CVM in studying the Energy Efficiency Label program. In this paper, we will use the air-conditioners data collected in Taiwan to examine whether consumers pay more value on the higher efficiency standard or eco-label products. Furthermore, we use the CVM to find how much the consumers reveal their preference on the energy-saving products. The outline of this paper is as follows. In section 2 we discuss the framework for estimation. Our data is described in more detail in Section 3. Section 4 contains the empirical results. Section 5 gives a brief conclusion of the paper.

2. The Model

Consider the individual demand framework found in Rosen [9], the model assumes that an individual's utility depends on the consumption of the numeraire goods, X, and one unit of purchased goods, Y in a given period of time horizon. The utility function can be described as:

$$U = U(X, Y) \tag{1}$$

where the purchased goods of Y can be further described as a vector of its characteristics, $Q = q_1, ..., q_j$. That is, the utility function is defined as

$$U = U(M - P_Y, q_1, ..., q_j) \tag{2}$$

where M is denoted as the individual's income. The solution of the utility maximization yields that the individual would choose the level of each characteristics to satisfy the first-order condition:

$$(\partial U / \partial q_i) / (\partial U / \partial X) = \partial P_Y / \partial q_j \tag{3}$$

This obtains an indifference curve or bid function, called a hedonic function, that reflects an individual's maximum marginal willingness to pay for q_j, holding utility constant. Under the Rosen (1974) framework, the hedonic price function depends on the determinants of the purchased goods' characteristics markets. The marginal implicit price curve reflects the individual's inverse demand function.

The most general form to estimate the hedonic price function is attributed to the Box-Cox functional form proposed by Goodman [10] and Halvorsen and Pollakowski [11]. The form is:

$$P^{[\lambda]} = \alpha_0 + \sum_{i=1}^{k} \alpha_i z_i^{[\theta]} \tag{4}$$

where i index the characteristics and λ and θ are transformation parameters estimated from the data. The feature of the Box-Cox form gives a flexible functional form that indicates the linear, semi-log, log-log form as λ and θ approach 0 or 1. In this paper, we would provide the estimation results of semi-log form of hedonic price function first, then provide the estimation results of general form of Box-Cox transformation.

The CVM is the method that respondent directly chooses the value of willingness-to-pay or the option of bidding games that can be interpreted as estimates of individual's compensating or equivalent surplus underlying utility-theoretic framework. Hanemann [12] proposed the utility difference model that assumes a respondent's choices on a dichotomous choice question reflecting the individual's maximum process of utility. If individual responds 'yes' which means that

$$U(M - WTP, q^1, D) - U(M, q^0, D) \geq 0 \tag{5}$$

where q^0 represent the initial characteristics of the goods, q^1 is the improved characteristics of the goods. D is the individual's demographic characteristics. WTP represents the individual's willingness-to-pay for the characteristics improvement of the good. Since the researcher only observes the deterministic part of the utility difference, the probability of individual's response to 'yes' is given by

$$\Pr(Y) = \Pr[v(M - WTP, q^1, D) + \varepsilon_1 > v(M, q^0, D) + \varepsilon_0] \tag{6}$$

where the ε is the random and unobserved parts of utility. As Hanemann [12] described, the expected value of the random variable WTP can be calculated by estimating the parameters of the observable components of the utility difference function. When only one bid price is offered in the choice format, called as single-bounded dichotomous choice model, the most popular estimation method is the binary Probit model. When two bid prices are offered in the choice format, called as double-bounded dichotomous choice model, which is considered as an improvement of the statistical efficiency proposed

by Hanemann, et al. [13], an alternative estimation method is the Bivariate Probit model offered by Greene [14].

3. Data

The data used for hedonic price estimation in this study are derived from two public sources. The sale prices and its characteristics of air-conditioner are derived from the PChome online. The energy efficient product data are obtained from the "Energy Efficient Label" program conducted by Bureau of Energy, Ministry of Economic Affairs, Taiwan. A total of 363 observations with full information were employed in the hedonic price estimation. These observations can be separated into two groups by the standard whether the products offered an energy efficient label or not. The energy label group includes 198 observations, whereas the non-energy label consists of 165 observations. Table 1 reports the statistics for selected variables used in the estimation.

Table 1. Descriptive Statistics for Selected Variables Used in Hedonic Price Estimation

	With Energy Efficient Label		Without Energy Efficient Label	
Variables	Mean	Std. Dev.	Mean	Std. Dev.
Price (NT$)	45,033	15,844	41,848	19,859
EER	3.57	0.43	2.68	0.29
AREA(Ping)	8.66	3.23	10.52	5.26
KCAL	3,824	1,576	4,667	2,722
KW	4.20	1.62	5.31	2.76
Observations	165		198	

Note: 1 US$ is about 30 NT$ in 2011.

The purpose of the survey was to elicit the consumer's willingness-to-pay for energy consumption. The structure of the questionnaire consists of four sections except the individual demographic characteristics. In the first section, a series of questions were designed to ask respondents' opinions about environment and energy issues. Next, respondents were asked several questions related the energy efficiency label and eco-label systems that are currently enforced. In the third section, each respondent was asked the determined factors of purchasing air-conditioner and the current uses of air-conditioner. Finally, the most important section, three separate stated contingent valuation questions were asked to elicit the amounts of willingness-to-pay. The first question is described how much the consumer's willingness-to-pay for purchasing air-conditioner with "energy efficient label" compared to that without the label. Next, the respondent was asked the willingness-to-pay for purchasing air-conditioner that is labelled as the energy efficiency level 4 (the more energy saving) instead of level 5 (the most energy consuming level). Finally, the respondent was asked the willingness-to-pay for purchasing air-conditioner with the energy efficiency level 4 and with the "energy efficient label" compared to that without the label. All three questions were used the double-bounded choice model in which the amounts of willingness-to-pay were offered twice. The types of questionnaire and amounts of willingness-to-pay are summarized in Table 2.

Table 2. Survey Question Type and the Bidding Prices Offer

Question	I & III			II		
Questionnaire	First Bid	Second Bid		First Bid	Second Bid	
		Yes	No		Yes	No
Type A	$3,000	$5,000	$2,000	$5,000	$7,000	$3,000
Type B	$4,000	$6,000	$2,000	$6,000	$8,000	$4,000
Type C	$5,000	$7,000	$3,000	$7,000	$9,000	$5,000

Note: The amounts are in Taiwanese dollars (NT$).

This study adopts a randomly interview survey for the shoppers at the select stores around Taiwan during the January-March, 2011. Three kinds of questionnaires, based on the different starting values of the contingent valuation questions, were used for the survey. A total of 925 shoppers were successfully contacted, there were 300, 270 and 285 valid responses for each type of the questionnaire after deleting 70 respondents who were incorrectly to answer the contingent valuation questions.

Table 3 shows the number of respondents corresponding to the three questions in different type of questionnaires. The number of respondents in questionnaire type B and C have higher ratio toward the "no-yes" response, which means that they are not willingness to pay higher amounts of prices.

Table 3. Results of the Survey based on the Question Type

	Q. Ⅰ				Q. Ⅱ				Q.Ⅲ				Total Responses
Type	YY	YN	NY	NN	YY	YN	NY	NN	YY	YN	NY	NN	
A	78	83	86	53	38	50	128	84	72	79	98	51	300
B	48	51	138	33	25	33	105	107	39	54	129	48	270
C	45	43	139	58	36	21	87	141	49	37	141	58	285
Total	171	177	363	144	99	104	320	332	160	170	368	157	855

Note: YY, YN, NY, NN denoted the "yes" or "no" answer for the first and second bidding prices.

4. Empirical Results

Estimates of the parameter and the associated t-values of the hedonic price equations by using the OLS estimation method are presented in Table 4. The hedonic price equations were estimated as the semi-log form in the regression. Four specifications of the model were estimated. Those models were separated by the brand dummies and energy-efficient standard. Model (1) of Table 4 shows the results for including the variables of energy-efficient ratio (EER) and Japanese-related brand dummy (JAP). All parameter estimates were significantly different from zero. As expected, the coefficient of EER is positive and of the square term is negative. The results indicate that the higher the EER the higher the prices but the slope is decreased. It implies that consumers are willingness to pay NT$23,700 for an additional unit of energy-efficient ratio. The value of the coefficient of the inverter type of air-conditioners is 0.15, which means that consumers are willingness to pay an additional NT$7,360 to buy such products. Comparing with the window type air-conditioners, the positive coefficient of split variable indicates that prices of split-type products are higher about NT$18,000. The air-conditioners with warm function also have the higher prices on average NT$4,000. In addition, the products with Japanese brand have the higher prices on average NT$10,000.

Comparing with Model (1), Model (2) shows the results for including corporation brand dummies. Five major corporation brands are employed, including TATUNG, SANYO, HITACHI, PANASONIC and TECO. All characteristics variables are statistically significant from zero except the square term of capacity (Cap^2) and the volume of product ($\log(Involume)$). The magnitudes of coefficients are slightly different from the estimates in Model (1), however, all values are as expected. For those brand dummies, we found that the variables of HITACHI and PANASONIC, two famous Japanese brands, have positive and significant coefficients. The results indicate that consumers are willingness to pay addition NT$ 13,000 and NT$4,000 to buy HITACHI and PANASONIC air-conditioners. The results are as expected, the HITACHI products are the most welcomed air-conditioners in Taiwan although the products not only have the highest prices but also have the highest energy-efficient ratio with high quality.

Model (3) and (4) show the results based on the use of the variable of energy efficiency label. The positive and highly significant coefficients of the variable LABEL indicate that consumers pay more values on the air-conditioners with the Energy Efficient Label. With the label, consumers are willingness to pay more on the average of NT$ 3,500~NT$3,700.

Furthermore, we also estimate the model based on the Box-Cox transformation. For the briefing, the results are not shown here but can be obtained on request. We found that all estimated parameters are also expected although the coefficients obtained from the non-linear form gave slightly different magnitudes of the parameters comparing with those in OLS estimation. However, the estimated consumer's willingness to pay for the product characteristics does not change a lot. For example, consumers are willingness to pay more on the average of NT$ 3,220~NT$3,800 with the Energy Efficiency Label.

Table 4. OLS Estimation Results for the Hedonic Price Model

	Model (1)		Model (2)		Model (3)		Model (4)	
Variable	coefficient	T-value	coefficient	T-value	coefficient	T-value	coefficient	T-value
Constant	5.88	6.00***	7.2	6.84***	5.955	5.69***	7.323	6.72***
EER	0.549	4.47***	0.343	2.55**				
EER2	-0.065	-3.78***	-0.045	-2.39**				
Label					0.082	3.17***	0.078	2.84***
Inverter	0.157	5.31***	0.19	5.86***				
Ping	0.047	2.49**	0.084	4.09***	0.082	3.52***	0.130	-3.62***
Ping2	-0.001	-1.72*	-0.002	-2.31**	-0.002	-2.65***	-0.003	5.31***
Cap	0.145	4.44***	0.06	1.67*	0.09	1.96*	-0.023	-1.27
Cap2	-0.005	-2.44**	-0.002	-1.02	-0.001	-0.32	0.006	-1.56
log (Involume)	0.123	2.36**	0.077	1.38	0.173	3.03***	0.100	1.68*
Heat	0.088	3.42***	0.122	4.52***	0.197	7.70***	0.232	9.04***
Split	0.339	4.97***	0.361	5.01***	0.483	6.56***	0.467	6.20***
Split×Many	0.28	7.23***	0.215	4.89***	0.233	5.16***	0.156	3.22***
JAP	0.214	10.71***			0.211	9.51***		

TATUNG			0.006	0.18			0.014	0.38
SANYO			-0.002	-0.03			0.075	1.29
HITACHI			0.262	8.26***			0.298	9.04***
PANASONIC			0.093	2.54**			0.105	2.64***
TECO			-0.037	-0.69			0.031	0.54
F-value	145.02		97.83		110.24		81.55	
R^2	0.8398		0.8268		0.7975		0.7972	
Adj-R^2	0.834		0.8183		0.7902		0.7874	
Obs.	345				349			

Table 5~7 report the estimation results for the double-bounded and single-bounded choice format based on the Bivariate Probit and Binary Probit estimation. Due to the page limitation, we only report the estimates of WTP and income variables, the estimates of other demographic characteristic variable can be obtained by author on request. The results show that the variable of WTP has the expected sign and statistically significant for all estimates in the first bid equation. However, using the Bivariate Probit model does not have a consist estimate with the expected sign for the variable of WTP in the second bid equation even the likelihood ratio tests reflect that there is correlation on error terms between the two equation. In addition, the income variables have the expected signs and statistically significant for all three estimates in the first bid equations which support the theoretical assumption that the higher income the more willingness-to-pay.

Table 8 provides the mean estimates of the willingness-to-pay for the different hypothetical questions. The results indicate that consumers are willingness to pay additional amounts of NT$2,696~NT$3,203 if the air-conditioner has the Energy Efficient Label. The estimates are very closely with those obtained from the hedonic price estimation.

Table 5. Selected Estimated Results for the Question Type I

	Bivar Probit Model		Probit Model	
	（1）	（2）	（1）	（2）
Dep. / Ind. Dep.	First Bid	Second Bid	First Bid	Second Bid
WTP	-0.0003*** （0.0001）	0.0025×10^{-2} （0.0001）	-0.0003*** （0.0001）	-0.0002*** （0.00003）
Income	0.0032*** （0.0010）	-0.0049×10^{-2} （0.0011）	0.0032*** （0.0010）	0.0008 （0.0010）
N		838	838	838
Log likelihood		-1038.9747	-524.4749	-515.8969
Likelihood-ratio test of rho=0		0.0946*		

Table 6. Selected Estimated Results for the Question Type II

	BivarProbit Model		Probit Model	
	（1）	（2）	（1）	（2）
Dep. / Ind. Dep.	First Bid	Second Bid	First Bid	Second Bid
wtp	-0.0002*** （0.0001）	-0.0002*** （0.0001）	-0.0002*** （0.00006）	-0.00004* （0.00002）
income	0.0029*** （0.0010）	0.0013 （0.0010）	0.0028*** （0.0010）	0.0008 （0.0010）
N		839	839	839
Log likelihood		-1005.8147	-444.1270	-564.3455
Likelihood-ratio test of rho=0		0.0211**		

Table 7. Selected Estimated Results for the Question Type III

	BivarProbit Model		Probit Model	
	（1）	（2）	（1）	（2）
Dep. / Ind. Dep.	First Bid	Second Bid	First Bid	Second Bid
wtp	-0.0002*** （0.0001）	0.0001 （0.0001）	-0.0003*** （0.0056×10^{-2}）	-0.0001*** （0.0026×10^{-2}）
income	0.0038*** （0.0010）	-0.0008 （0.0011）	0.0040*** （0.0010）	0.0008 （0.0010）
N		836	836	836
Log likelihood		-1040.1169	-513.4248	-530.8748
Likelihood-ratio test of rho=0		0.0038***		

Table 8. Summarized Mean Estimates of WTP based on the CVM and Hedonic Price Method unit: NT$

	CVM					
	Question I		Question II		Question III	
	First Bid	Second Bid	First Bid	Second Bid	First Bid	Second Bid
Bivar Probit	3,060	-	1,829	4,843	2,696	1,616
Probit	3,203	5,766	1,372	4,616	2,896	5,864
	Hedonic Price Method					
	OLS semi-log model				Box-Cox model	
	3,500~3,700				3,220~3,800	

5. Conclusion

The path of increasing carbon emissions and global warnings has called public attentions to its impacts on economic activity. Much attention has been on the issues of the energy uses. This also leads to concern whether consumers prefer to buy energy efficiency products in the market. Estimating the relationship between product prices and the demand for the energy efficiency characteristics not only provide the evidence for product makers as part of information for decision-making, but also offer the useful measure for policy makers to design available instruments for the issue of global warming.

In this study, we use the air-conditioners market data to estimate the impact of energy efficiency standard as well as energy efficiency label on prices on the demand of air-conditioners in Taiwan. We also use a CVM approach to elicit the consumer's willingness-to-pay for the energy efficiency program. Our empirical results indicate three major findings: First, consumers are willingness to pay more amounts on the products with higher energy efficient ratio or with the energy efficiency label. Second, the estimates obtained form the hedonic price model are very close to those obtained from the CVM for the purchases of air-conditioner with "energy efficiency label" which provide another evidence that the stated preference model may have a consistent result with the revealed preference model. Third, the Japanese-type brands or manufacturers of air-conditioners, in particular for HITACHI, have the highest price premium in Taiwan market.

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