Consumers' Preference and Willingness to Pay for Energy Efficiency Labels

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Abstract
Appliance energy labels are gaining global recognition as policymakers increasingly prioritize measures to enhance energy efficiency and reduce carbon emissions. They serve as effective tools in encouraging consumers to choose appliances that are more energy-efficient. This study investigated consumer preferences and their willingness to pay (WTP) for energy efficiency labels on rice cooker specifically. The data was surveyed through a choice experiment (CE) and analyzed using conditional logit (CL) models. The findings of the study revealed that the signs of all attributes (energy efficiency level, size, warranty period, design, and price) are as expected, and highly significant expect SIZE2 and WARR2. Furthermore, a WTP analysis was conducted for each attribute, highlighting that consumers valued improvements in energy efficiency the most. The WTP values were estimated at CNY1091.95 (USD163) for energy efficiency level 1. These findings have significant policy implications for both energy efficiency labeling programs and home appliance manufacturers.
Keywords: Appliance Energy Labels, Choice Experiment, Conditional Logit Model, Willingness to Pay

Introduction
     Global warming has resulted in profound alterations to our environment, encompassing shifts in precipitation patterns, rising sea levels, disruptions in natural food chains. The main cause of global warming is the emission of carbon dioxide (CO_2) through the burning of fossil fuels. The electricity and heating sectors made a significant contribution of CO_2 emissions in China (National Bureau of Statistics of China). Furthermore, Zhang et al (2020) has highlighted the substantial impact of household appliances on a family's carbon footprint, with home appliances accounting for 70% of CO_2 emissions.
     Fan et al (2015) believed promoting the purchase of energy-efficient appliance in China has emerged as a more effective strategy for energy conservation compared to solely

incentivizing manufacturers to produce such appliances. Hence, to understand consumers' preferences and WTP became crucial as they hold the ultimate decision-making power when it came to buying household appliances. Additionally, analyzing consumers' feedback on relevant policies played a vital role in refining energy-saving strategies and fostering the widespread adoption of energy-efficient appliances in China

Commonly, household appliances that consume a significant amount of energy such as refrigerators, washing machines, and air conditioner have been the subject of extensive researches on energy efficiency, as evidenced by studies conducted by (Faure et al., 2021; Jain et al., 2018; Zha et al., 2020). However, there is no research focusing on rice cookers which is one of the primary appliances in Chinese kitchens specifically. The main aim of this study was to examine consumer preferences and their WTP for rice cookers in order to provide valuable insights for policy recommendations that promote energy conservation in household appliances. To gather data on SP, the study employed the CE method and analyzed the collected data using the CL models.

Literature Review

In the field of resource and environmental economics, Mitchell and Carson (1989) suggested the total economic value of environmental resources is widely recognized and can be categorized into use value and non-use value. Non-use value refers to the worth an individual places on a good or service beyond its immediate or future consumption.

The emergence of SP can be traced back to early survey techniques that sought to gauge the importance of social welfare goods, public goods, or the state of the environment as perceived by individuals (Cummings & Taylor, 1999). Bateman et al (2002) highlighted the widespread adoption of CE method as a popular SP approach for estimating the value associated with environmental concerns.

Shen and Saijo (2009) showed a pioneering study in China that focused on examining the impact of energy efficiency labelling on the WTP of Chinese consumers for air conditioners and refrigerators. The data was collected from both face-to-face interviews and online by 1200 observations. The CE model consisted of 48 choice sets for conditioners and refrigerators with six attributes. The findings revealed that consumers exhibited a higher WTP for appliances with labels that corresponded to frequently used products. As a result, consumers favored home appliances equipped with energy indicators that provided significant supplementary information.

Zhou and Bukenya (2016) conducted a comprehensive survey in China, involving a sizable sample of 1602 consumers. The primary objective of the survey was to investigate consumer preferences and decision-making factors when purchasing air conditioners. The survey encompassed four key attributes, including brand, price, energy grade, and type of room air conditioners. The findings of the study shed light on the varying effectiveness of energy labels across different types of air conditioners. Particularly, it was observed that variable-speed room air conditioners exhibited a higher sensitivity to energy labels that provided additional information. Furthermore, the study emphasized the crucial role of information in influencing consumers' WTP, particularly when they recognized the energy-saving benefits associated with the labeled air conditioners.

Huh et al (2019) focused on the impact of the South Korean government's refund policy on first-level energy-efficient rice cookers. The results explained that there was heterogeneity in consumer preference for all attributes, and consumers make a great importance on price

attribute. This incentive had a significant influence on consumer purchasing preferences, resulting in a substantial reduction in annual power consumption. The findings highlight the tangible benefits of such measures in promoting energy efficiency and environmental sustainability.

Zha et al (2020) conducted a survey in China, involving 453 respondents, to examine the impact of energy efficiency labelling on refrigerators and washing machines. The survey incorporated five attributes, namely price, brand, energy label, power consumption, and capacity or liter. The study concluded that the energy label program in China was effective in influencing consumer choices. However, the relevance of these results diminished in the presence of an energy efficiency gap. Faure et al (2021) investigated the effects of the energy labels scheme on refrigerators in Germany using the CE model. The findings indicated that households displayed a preference for refrigerators with higher energy efficiency classifications over those with lower classifications.

Study Design and Implementation

This study conducted in China employed the CE method to collect stated SP data on consumer preferences for rice cookers. The CE method is widely recognized as a valuable approach for gathering information about consumer preferences, especially when it comes to hypothetical products. By presenting consumers with a range of options that vary in key attributes and requesting them to make choices, the CE method allows researchers to assess the relative importance of different product qualities. This valuable information aids in making well-informed decisions related to product design and marketing strategies, underscoring the integral role of the CE method in the process of product development (Bateman et al., 2002).

Attributes and Levels

When developing a CE model for rice cookers, it is essential to identify the key attributes and levels that influence consumer purchasing decisions. In this study, a thorough process was undertaken. Firstly, to summarize the pervious researches; secondly, to held of two consumer focus group sessions and three interviews with manufacturers; Finally, to carefully design the final set of attributes and corresponding levels (see **Table 1**).

Table 1

Attributes and Levels Description for Rice cooker

Attributes	Description	Levels	Expected Sign
Energy Efficiency Rank (EER)	The energy-efficient ratings on the labels. Level 1 suggests the most efficient energy saving.	Level 1: High Level 2: Medium Level 3: Low	+
Warranty Period (WARR)	The warranty period for rice cookers	One year Two years Three years	+
Design (DES)	Basic functions: cooking or keeping warm Intelligent: booking, timing, different type of meal	Level 1 (Basic) Level 2 (Intelligent)	+
Size (SIZE)	The capacity of rice cookers	3L 4L 5L	+
Price	Purchase price of rice cooker	CNY200 CNY400 CNY600 CNY800	-

Note: An exchange rate of USD 1 equals CNY6.7 in 2022 (Source: Bank of China, 2023).

Experimental Design

This study identified five attributes for the rice cooker, with 3 levels for EER, 3 levels for WARR, 2 levels for DES, 3 levels for size and 4 levels for price. As a result, the random combinations led to the generation of 216 sets of options ($3 \times 3 \times 3 \times 2 \times 4$). To ensure the practicality of the experiment, this study employed an orthogonal fractional factorial design with the assistance of Statistical Package for Social Science (SPSS) software to generate choice cards. This approach resulted in the development of 16 sets of options specifically designed for the rice cooker, which were then combined into eight choice cards.

Questionnaire Design

The questionnaire consisted of four parts which were introduction, the participants' attitudes and perceptions towards rice cookers, CE choice cards（**see Figure 1**）and socio-demographic characteristics

	Option 1	**Option 2**	**Option 3**
Energy Efficiency Rank	Level 1	Level 1	I would NOT purchase either
Size	3L	5L	
Warranty Period	One Year	One Year	
Design	Intelligent	Basic	
Price	CNY800	CNY600	
Your choice	√		

Note: An exchange rate of USD 1 equals CNY6.7 in 2022 (Source: Bank of China, 2023).
Figure 1: An example of a choice card

Sampling and Data
The surveys were carried out in many shopping malls and appliance stores during September and October in 2022 in China. The study managed to gather a total of 325 respondents while 285 participants were ultimately chosen for inclusion in the final study, resulting in a final effective response rate of 87.69%.

Econometric Specification
The CL model is commonly used for assessing CE case. McFadden (1974) suggested that if the random error term is independent and identically distributed (IID) with type one extreme-value distribution, and added the random utility model, the CL mode can be obtained, which is the basic form of the Logit model. As a result, the likelihood of the consumer n selecting option i can be stated as:

$$P_{ni} = \frac{\exp{(\mu V_{ni})}}{\Sigma_{J=I}^{J} \exp{(\mu V_{nj})}} \qquad (1)$$

Where, the alternative i probability to be chosen by the respondent n can be expressed by logistic distribution (Hanley et al., 2001). With the assumption that the utility in the model is linear, after added the parameter matrix, the certain part of the utility is determined as $V_{ni} = \beta' X_{ni}$, then the probability in equation 1 can be expressed as the following form:

$$P_{ni} = \frac{\exp{(\mu \beta' X_{nj})}}{\Sigma_{J=I}^{J} \exp{(\mu \beta' nj)}} \qquad (2)$$

Where P_{ni} is the respondent n choice probability of alternative i; X_{ni} and X_{nj} are the vectors describing the attribute of i and j, and β is vector of coefficient.

The coefficients derived from the CL model indicated the incremental contribution of each attribute to utility, but their units are arbitrary, making it difficult to establish their economic significance. Consequently, it became necessary to calculate the marginal willingness to pay (MWTP) for each attribute based on the estimation results. Consequently, Whitehead et al. (2008) and Shin et al. (2014) suggested that WTP can be defined as follows:

$$WTP = -\beta_i / \beta_{cost} \qquad (3)$$

β_i represented the coefficient of any attributes in the model and β_{cost} is the cost coefficient.

Results and Discussion
Socio-demographic Characteristics of the Consumers
Table 2 showed the socio-demographic characteristics of the respondents. Among the 285 participants, the age of majority respondents was between 25 to 45. In terms of gender,

females accounted for 49.47%, while males represented 50.53% of them. The majority of respondents possessed a high level of education, with 40.35% holding at least a bachelor's degree.

Table 2
Socio-demographic characteristics of the consumers

Demographic variables	Categories	Frequency	Percentage %
Age	25 and under	57	20
	26-35	91	31.93
	36-45	100	35.09
	46-55	22	7.72
	Above 56	15	5.26
Gender	Female	141	49.47
	Male	144	50.53
Level of Education	Junior high school and under	7	2.46
	High school	31	10.88
	Junior College	69	24.21
	Undergraduate degree	115	40.35
	Postgraduate degree	63	22.71
Monthly Income	Less than CNY3,000	48	16.84
	CNY3,001—CNY5000	76	26.67
	CNY5001—CNY8,000	73	25.61
	CNY8,001—CNY15,000	64	22.46
	CNY15,001—	18	6.32
	CNY30,000More than CNY30,	6	2.11
Family size	001	5	1.75
	1	19	6.67
	2	116	40.7
	3	91	31.93
	4	32	11.23
	5	22	7.72
	6 or more		

Note: An exchange rate of USD 1 equals CNY6.7 in 2022 (Source: Bank of China, 2023).

In terms of income, most participants reported earning between CNY3,000 and CNY15,000 monthly. The majority of households in China have either three (40.7%) or four members (31.93%). This finding aligns well with China's historical implementation of the "one child" policy from 1980 to 2016. Regarding occupation, the results indicated that the majority of respondents were employed in enterprises (40.7%), followed by those in public institutions (31.93%).

CE Results
The results in this section were divided into two main parts. The first part focused on the estimation of CL model. The second part centered on determining the WTP for CL models. The estimation was conducted using version 5 of the Nlogit software.

The Basic CL Result

Table 3 presented the findings of basic CL model. In the basic CL model, the Pseudo-R^2 was to 0.047 and all attribute coefficients reached statistical significance except for WARR2. The price attribute demonstrated a significant negative at the 1% level. Consistent with expectations, both EER1 and EER2 displayed significant positive coefficients at the 1% level, indicating the utmost importance of energy efficiency. This observation provides evidence that consumers prioritize higher energy efficiency labels at more affordable prices.

The attribute SIZE2 showed a statistically significant negative effect at the 5% level. On the other hand, SIZE3 displayed a highly significant positive effect at the 1% level. This implies that consumers preferred lager size than medium size. Furthermore, the DES2 and WARR3 variable demonstrated a significant positive effect at the 1% level in the study.

Table 3
The CL model results

Variable	Coefficient	T-stat
EER1	1.07497***	0.07544
EER2	0.69348***	0.07407
SIZE2	-0.20970***	0.10310
SIZE3	0.91169***	0.09266
WARR2	-0.06653	0.10067
WARR3	0.45017***	0.09737
DES2	0.80634***	0.06152
PRICE	-0.00098***	0.00014
Summary Statistics		
Log-likelihood function	-2131	
Log-likelihood	-2236	
Pseudo-R2	.0471	
Adjusted-R2	.0454	
Number of observation	2280	

Note: *** is significant at 1%, ** is significant at 5%, and * is significant at 10%.

Estimation of WTP

The WTP indicates the monetary value that consumers assign to each attribute. **Table 4** displayed the estimated marginal WTP values for all attributes in the CL model. The findings revealed that consumers had the highest WTP value of CNY1091.95 for attribute EER1, followed by CNY926.093 for SIZE3, CNY819.077 for DES2, and CNY704.430 for EER2.

Table 4
Marginal WTP estimation for CL model

Variable	Coefficient	Std. error
EER1	1091.95***	163.4577
EER2	704.430***	113.7141
SIZE2	-213.012*	109.3952
SIZE3	926.093***	161.4166
WARR2	-67.5852	107.5825
WARR3	457.276***	86.95818
DES2	819.077***	98.83162

Note: *** significant at 1%, ** significant at 5% and * significant at 10%

Conclusions and Policy Implications

This study examined consumer preferences and their WTP for energy efficiency labels on household appliances effectively. The survey gathered 285 respondents in Shandong, China successfully and the data was analysed by CL model. In the context of China, previous studies primarily concentrated on washing machines, refrigerators, and air conditioning, this is the first study was basic on rice cooker.

The findings of the CL model revealed that consumers assigned a positive and significant implicit value to energy efficiency labels of Levels 1 and level 2. Furthermore, the variables DES2 (intelligent design), SIZE3 (5L), and WARR3 (three-year warranty) also exhibited positive and statistically significant effects. These outcomes indicated that energy efficiency ratings significantly influenced consumers' choices when selecting rice cookers, possibly due to the growing environmental awareness in China.

Finally, CE method offers a theoretical framework that can test respondents'' preferences and WTP of non-use value goods. It offers vital information for developing policies and managing environmental issue. Policymakers may make informed decisions by consumers' preferences toward different attributes. For example, the contribution of this study suggested the manufactures consider improving the energy-efficient rice cookers with intelligent design and long warranties. Further, the importance of this study is beneficial to the improvement of the energy efficiency labeling design in China. The labels could be added more information, such as energy savings of the lifetime..

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