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Leveraging carbon label to achieve low-carbon economy: Evidence from a survey in Chinese first-tier cities

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ABSTRACT

Carbon label is an important tool for countries to achieve green economy in the context of global climate change. Since the public is the end consumer of carbon-labeled products, understanding their attitudes towards carbon label is crucial for the future development of carbon labeling system. Under this background, we conduct a survey on consumers' perception of carbon-labeled electrical and electronic products (CEP) in Chinese first-tier cities. Consumers' premium willingness to pay for CEP and its influencing factors are explored. After correcting the possible bias by sample selection model, we find that 85.97% of respondents are willing to pay more for carbon-labeled products. Besides, Males, respondents who are younger or richer, or with underaged children at home are more willing to pay a premium for carbon-labeled products. The degree of trust and understanding of carbon label also has a positive impact on the premium WTP. As for the specific value of premium WTP, an additional 7.85% of the original price for CEP is willing to be paid. The above findings can provide targeted reference for policymakers in pricing carbon-labeled products, and also yield effective policy recommendations for the future development of carbon label system.

Keywords: carbon label; carbon-labeled electrical and electronic products; low-carbon consumption; willingness to pay

NONMENCLATURE

Abbreviations	
CEP	carbon-labeled electrical and electronic products
WTP	Willingness to pay

1. INTRODUCTION

In recent years, the world's climate is facing more and more serious problems. According to the report of the National Oceanic and Atmospheric Administration of the United States, the global average temperature broke the record in January 2020, and the Antarctic temperature exceeded 20 degrees for the first time. The increasing greenhouse gas concentration is a serious threat to human living environment and health (Lombardi et al.,2017). Under such a circumstance, carbon label, which is considered as an important tool to advocate green consumption, has attracted the attention of all countries in the world (Zhou et al.,2019).

"Carbon label" is a standard formulated for the increasingly severe environmental situation. It displays the greenhouse gas emissions emitted by the production of commodities in the form of labels, and provides judgment standards for the consumers, thereby encouraging consumers to choose low-carbon and environmental protection products (Thøgersen and Nielsen, 2016). It is very important for the sustainable development of the global environment, since human activities are the main cause of greenhouse gas emissions. Only by changing all aspects of human life, especially people's consumption behavior, can global warming be alleviated.

This is also the case for China. In 2018, China's CO2 emissions reached 10 billion tons, with an increase of 2.3% year on year. As the world's largest carbon emitter,

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China is facing huge pressure of carbon emission reduction.

In the past, governments and companies were the main force of carbon emission mitigation. Specifically, the government controls the fossil energy consumption of enterprises through environmental policies, or encourages to increase the proportion of clean energy in the energy structure to reduce CO2 emissions. However, given China ’s resource endowment characteristics of “rich coal, lack of oil, and low gas”, the adjustment of the energy structure is a slow process. Besides, China's industrialization and urbanization construction have an increasing demand for energy, the mandatory reduction of energy consumption may conflict with economic development in China. Therefore, the change of consumption behavior is the key to China's energy saving and emission reduction. In recent years, environmental problems have seriously affected people's lives and health. As people's awareness of environmental protection has increased, they have become increasingly concerned about low-carbon life. The emergence of carbon label can effectively inform the environmental information of products to consumers directly (Hartikainen et al.,2014). On the one hand, consumers can make rational decisions when they master the information and value of products. On the other hand, the carbon label information makes consumers further realize the potential impact of consumption on climate change, so as to guide low-carbon consumption. In this way, consumers are also included in the system of energy conservation and emission reduction.

Just as figure 1 illustrated, by attaching carbon label information to products, companies can increase consumers' right to know the environment, thereby increasing consumer participation in environmental protection. In turn, consumers' demand for low-carbon products guides enterprises to pay attention to green production and launch low-carbon products, which helps to reduce greenhouse gas emissions. Therefore, the carbon label system improves the information asymmetry between enterprises and consumers, and builds a bridge for the government, enterprises and consumers to participate in the construction of low-carbon economy. China's "carbon label" promotion plan started in 2018. With the release of the group standards of "General Guidelines for the Evaluation of Carbon Labels for Electrical and Electronic Products in China", China's first pilot program of "Carbon Footprint Labeling" has also been determined, which mainly targets electrical and electronic products and services.

Compared with other developed countries such as the United Kingdom, the United States, and Japan. China's carbon labeling system started relatively late, and there are still many uncertainties in its development process. And since consumers are the ultimate consumers of carbon-labeled products, their attitudes towards carbon label products are crucial to the promotion of carbon label system. In view of the above background, we conduct a questionnaire survey on consumers' perception of carbon-labeled electrical and electronic products (CEP) and seeks to answer the following questions: (1) What is the consumer's attitude towards CEP? (2) What is the amount of consumers’ premium willingness to pay (WTP) for CEP? (3) what are the factors that affect consumers' choice of carbon label products?

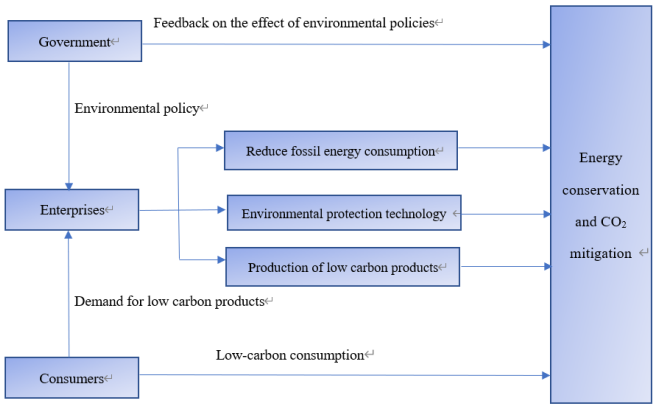

Fig.1. Blueprint of low carbon economy in China

2. METHOD

2.1 Questionnaire design

Survey is an effective tool for understanding respondents' attitudes, and it has a variety of forms including online questionnaires, telephone interviews, face-to-face surveys, and so on (Chu et al.,2020; Cook et al.,2018). Considering that respondents could overcome the psychological pressure of face-to-face or telephone interviews when filling out the questionnaires independently, and express their true ideas, we distributed online questionnaires through the “Questionnaire Treasure” platform. It is an online survey platform based on mobile terminals. Due to the popularity of smartphones, the public can use “Questionnaire Treasure” platform to fill out questionnaires and get corresponding compensation. At

present, the platform has covered more than 1.13 million users and has been used to collect data in the study of Tan et al., (2018) and Xu and Lin, (2020).

The survey was conducted in July 2019 to January 2020 in China's most developed first-tier cities: Beijing, Shanghai, Guangzhou and Shenzhen. The city was selected because it has a certain demonstration and leading role in other cities in terms of low-carbon consumption and environmental governance. A total of 2660 questionnaires were collected in this survey, of which 2209 were deemed as valid questionnaires. 451 samples were deleted due to logical errors in respondents' age and career choice or education level and career choice, as well as contradictory options in their answers. Among the 2209 samples, the proportion of respondents from Beijing, Shanghai, Guangzhou and Shenzhen was 24.40%, 23.36%, 32.19% and 20.05%, respectively. The proportion of males in the total sample was 64.46%, about two times that of females. Respondents' age is mainly concentrated in the age of 21-40, accounting for 83.74% of the total sample. There are 205 people aged at 41-50. Respondents under 20 and over 51 were relatively less, with a sample size of 69 and 83 respectively. As to the children situation, 1385 respondents have underaged children in their family and the remaining 824 families have no underaged children.

In general, the questionnaire can be divided into three parts. The first part is about the socio-economic characteristics of the respondents, including age, gender, monthly family income and children's status of the family. The second part consists of three scenarios including respondents' views on local air quality, respondents' trust in carbon label information and respondents' awareness of carbon label. The last part is the two-part sequential questions regarding consumers' WTP for CEP. It is composed of sample selection question and elicitation question. The former is to ask if the market has implemented carbon-labeled products to guide low-carbon consumption, and the implementation of carbon label needs to verify the greenhouse gas emissions in the production process, which will bring additional costs to manufacturers. Are you willing to pay more for the purchase of CEP? If the answer is "yes", the next elicitation question is posed to ask how much she/he wants to pay extra for CEP. The premium amount is divided into five ranges, which are below 5%, 5% -10%, 10%-15%,15%-20% and above 20%. If the interviewee answers "no" to the sample selection question, she/he will be asked to state the reason for refusing to pay more.

2.2 Sample selection model

In addition to using two-part sequential questions about consumers' WTP for carbon-labeled products, a sample selection model is also employed to eliminate possible biases in WTP estimation.

3. EMPIRICAL RESULTS

3.1 Descriptive statistics

In table 1, we list the descriptive statistics of variables used in this paper. Among the 2209 valid questionnaires, 1899 respondents are willing to pay more for carbon-labeled electronic products, accounting for 85.97% of the respondents. For the remaining 310 respondents who are not willing to pay more, they are asked to state the reasons. As Table 2 illustrated, there are 74 consumers have genuine zero responses, accounting for 23.97% of the overall zero answers. In which, 22.9% of the respondents ascribe that their income is too low to afford the expense. 0.97% of the respondents believe that the air quality is good enough, so they do not think it is necessary to promote low-carbon consumption by purchasing carbon label products.

The other 76.03% of consumers stated genuine zero. Among them, 36.77% of the respondents deem that the government should pay for advocating low carbon consumption, which is also the main reason for refusing premium payment. 17.1% of the respondents think they are accustomed to buying commonly used products and do not want to try carbon-labeled products. 12.9% consider carbon label certification and information displayed may not be authentic. 9.35% believe that even if they purchase carbon-labeled products, it will not have a significant positive effect on the environment.

3.2 Estimation results

Using the sample selection model introduced in section 3.2, the parameter estimates for the selection equation and elicitation equation are listed in Table 3. In model 1, we investigate the influence of variables including gender, age, children situation, income, respondents' views on local air quality, respondents' trust in carbon label information. In model 2, we added variables of respondents' awareness of carbon label. As observed, the log likelihood in model 2 is greater than that in model 1, and the significance level and symbol of the coefficients of other variables are basically unchanged after adding the variable "awareness", which proves the robustness of the results. Region fixed effects are also added to the model to exclude the effect of

unique but unobservable features in different cities. From the results of the selection function in model 2, the children status of responders has a significant and positive effect on their willingness to pay. When respondents have underaged children in their family, the probability of willing to pay for carbon label products is higher. The reason may be that families with children care more about the living environment of the future generation, and they are more willing to achieve low-carbon life through green consumption to create a good living environment for their posterity. Besides, interviewees' views on local air quality, their trust in carbon label information and their awareness of carbon label all have a significant positive impact on the probability of respondents willing to pay more for carbon label products. Regarding the elicitation function in model 2, Males, respondents with underaged children in their family, and higher family incomes are more willing to pay a premium on carbon label products. Younger people also have a higher willingness to pay premiums than older group. This is because carbon labels have not been implemented in China for a long time. It is easier for young people to obtain information about emerging issues from the Internet and other media. Also, young people are more interested in electronic products such as mobile phones and tablet computer, so they have a higher acceptance of carbon-labeled electronic products. The variable of "air_quality" has a positive effect on premiums WTP, it indicates that when respondents think the local air quality is good, they are willing to pay more for carbon-labeled electronic products. This finding is consistent with Tan and Lin (2019). When residents live in a better environment, they may be less able to withstand environmental pollution, so they are more willing to contribute to the transformation of low-carbon life. Responders' trust and awareness of carbon label are also positively and significantly related to their willingness to pay a premium for carbon-labeled electronic products, which is in line with our expectation. When consumers deem that the information disclosed by carbon label is true and reliable, or when they know more about carbon label, they are willing to pay more.

The correlation coefficients "lambda" is also listed in Table 3. It shows a statistically significant value in the two model, which provides evidence for the existence of sample selection bias, and the positive value of "lambda" indicates that ignoring sample selection deviation will overestimate the premium willingness to pay.

3.3 Consumers' willingness to pay premium for carbon-labeled electronic products

Taking sample selection bias into consideration, consumers' willingness to pay a premium for carbon-labeled electronic products is calculated to be 7.85%. In other word, consumers are willing to pay a premium of 7.85% on the original price to buy carbon-labeled electronic products. The result is relatively higher than the measurement in Wong et al., (2020), which considers that consumers in Hongkong are willing to pay a premium of 5% for carbon labeled beverage. Further, the calculation results of consumers' premium WTP in different groups are presented in Table 4. For groups with different children status, respondents with underaged children in their family are willing to pay 1.39% more than those without underaged children. This also proves that intergenerational issues of the environment influence consumers' choices of low-carbon lifestyles. For groups with different levels of trust in carbon label, when consumers believe that the information disclosed by carbon label is completely credible, their willingness to pay a premium for carbon-labeled electronic products reaches 9.61%. Conversely, if consumers completely mistrust the information on the carbon label, their willingness to pay a premium will be reduced by 3.07%. And the premium willingness to pay for carbon-labeled products also rises with the increase of consumers' trust in the information disclosed by carbon label. For groups with different levels of awareness of carbon label, respondents with professional knowledge in carbon label have the highest premium WTP of 11.77%. Followed by respondents with comprehensive knowledge of carbon label, who are willing to pay an additional 11.28% for carbon-labeled electronic products. The reason is that carbon label is an important tool for achieving low-carbon transition through guiding low-carbon consumption. When consumers understand the positive role of carbon label development in mitigating climate warming and improving environmental quality, they are willing to pay more for carbon-labeled products.

4. CONCLUSIONS AND POLICY IMPLICATIONS

Carbon labeling plays an important role in guiding the low-carbon economy. While China's carbon labeling system is still in its initial stage of development and is mainly oriented to electronic products and services. Therefore, understanding consumers' acceptance of carbon-labeled electronic products is of great significance for the future development of carbon label

in China. Under this background, we conduct a contingent valuation survey in four first-tier cities in China, and adopt a sample selection model to explore the consumers' willingness to pay a premium for carbon-labeled electronic products as well as its influencing factors. Based on the empirical results, four main conclusions can be drawn: (1) 85.97% of respondents are willing to pay more for carbon-labeled electronic products. Among the remaining respondents who refused to pay premiums, 23.97% are genuine zero respondents, and 76.03% stated protest answers. The selectivity bias does exist in the sample, and neglecting it will overestimate the premium WTP. (2) The biggest reason behind the refusal to pay is that people believe that the government should bear the cost of advocating low-carbon consumption. This indicates that the subject of responsibility for public environmental issues is not clear, and consumers do not think they are responsible for public environmental problems. (3) Males, respondents who are younger or richer, or with underaged children at home are more willing to pay a premium for carbon-labeled electronic products. Besides, those who believe the local air quality is good have a higher premium WTP, because they are more sensitive to air pollution, so they are more willing to contribute to environmental protection (Lin and Tan,2017). The degree of trust and understanding of carbon label also has a positive impact on the premium WTP. (4) Consumers are willing to pay an additional 7.85% of the original price for carbon-labeled electronic products. Consumers who have full trust in the information disclosed by carbon label and those with professional knowledge of carbon label have the highest premium willingness to pay, which are 9.61% and 11.77%, respectively. Those conclusions also yield important policy implications.

First, since the public is the end-consumer of carbon label products, it is of great significance for policymakers to understand consumers' the attitude towards carbon label products. The reasons behind consumers' refusal to pay cannot be ignored. As the environment belongs to public resources, it is difficult to define the subject of responsibility. Low carbon consumption is the key to promote the transformation of low-carbon economy. Therefore, it is necessary for the government to increase publicity and establish consumers' awareness of environmental protection. For instance, it is necessary to add the current situation and importance of the ecological environment into the education system, making the public realize that consumers should work together with the government and enterprises to effectively achieve low-carbon economic development in China.

Second, the government should establish relevant measures to improve the transparency of information disclosed by carbon label. For example, the carbon label accounting standards and accounting process of electronic products can be disclosed through the official website media. It is also necessary to set up a public service platform to answer consumers' doubts about carbon label. Only when consumers trust the information disclosed by carbon label can it be beneficial to the promotion of carbon label products.

Third, it is important to strengthen the public's awareness of carbon label since the public is willing to support carbon label products only when they have a better awareness of carbon label. Specifically, the government can increase the publicity of carbon label and its role in promoting low-carbon environmental protection through mass media, such as radio, television, newspapers, etc. thereby guiding consumers to establish the awareness of low-carbon consumption.

Finally, 85.97% of people are willing to pay more for carbon-labeled electronic products, which indicates that carbon label products have a certain market in China. The average premium WTP of consumers is 7.85%, which can provide a reasonable reference for the pricing of carbon-labeled electronic products in the future.

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Table 1

Descriptive statistics of the variables

variable	description	N	mean	sd	min	max
gender	female=0 male=1	2209	0.645	0.479	0	1
age	age of the respondents	2209	2.673	0.892	1	7
income	Monthly household income. scale from 1 to 6	2209	2.838	1.199	1	6
children	do not have= 0 have= 1	2209	0.627	0.484	0	1
air quality	Views on local air quality. Scale from 1 to 5	2209	3.088	0.809	1	5
awareness	awareness of carbon label. scale from 1 to 5	2209	2.653	0.639	1	5
trust	Trust in carbon label information. Scale from 1 to 5	2209	3.264	0.793	1	5

Table 2
Reasons for refusing premium payments

Reason for refusing to pay more		Number
The environment is good enough that no improvement is needed	Genuine zero responses	3
Family income is too low to afford it		71
Get used to buying common products and don't want to try new ones	Protest responses	53
The government should pay for advocating low carbon consumption		114
The environmental impact of carbon-labelled products will not be significant		29
Carbon label certification and information displayed may not be reliable		40
Total		310

Table 3
Estimation results of sample selection model

	Model1		Model2	
	Selection	Elicitation	Selection	Elicitation
gender	0.061	0.557***	0.051	0.539***
	(0.458)	(6.103)	(0.372)	(5.933)
age	-0.125**	-0.164***	-0.093	-0.126**
	(-1.989)	(-3.075)	(-1.460)	(-2.401)
children	0.507***	0.548***	0.436***	0.395***
	(3.930)	(5.068)	(3.324)	(3.950)
income	0.050	0.250***	0.024	0.224***
	(0.820)	(5.863)	(0.403)	(5.237)
air_quality	0.371***	0.408***	0.276***	0.271***
	(3.667)	(5.437)	(2.729)	(3.842)
trust	0.597***	0.317***	0.521***	0.150**
	(6.816)	(3.803)	(5.955)	(2.160)
Region fixed effect	Y	Y	Y	Y
lambda		2.391***		1.241**
		(3.615)		(2.277)
awareness			0.907***	0.654***
			(7.156)	(5.802)
_cons	-0.632*		-1.616***	
	(-1.789)		(-4.161)	
N	2209.000	1899.000	2209.000	1899.000
ll	-835.1	-2472.3	-808.5	-2456.8

Notes: t statistics in parentheses; * p<0.1, ** p<0.05, *** p<0.01.

Table 4
Consumers' premium willingness to pay in different groups

	Premium WTP
Children status	
have no underaged children	6.98 %
have underaged children	8.37 %
Trust in carbon label information	
total mistrust	6.54%
little trust	6.91%
general trust	7.52%
relatively trust	8.52%
full trust	9.61%
awareness of carbon label	
Do not know	5.53%
know little	6.56%
know something	8.45%
Have comprehensive knowledge	11.28%
Have professional knowledge	11.77%
Total	7.85%

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