Consumers ' willingness to Pay Premium for Carbon-labelled Agricultural Products—An Empirical Analysis Based on CVM

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Abstract. As the global climate crisis continues to intensify, countries have advocated low-carbon development and sustainable development. As a tool to measure carbon emissions quantitatively, carbon label will bring huge economic and social benefits if it is applied to the agricultural products market with huge carbon emissions. This paper takes the Shine Muscat with carbon labels as an example to explore the relevant factors that affect consumers' willingness to pay for it. Through the analysis of the Conditional Valuation Method (CVM) and Logit model, the value evaluation of consumers for the Shine Muscat with carbon labels can be found, then we can obtain consumers' willingness to pay a premium. The empirical results show that the price of agricultural products with carbon labels and consumers' cognition of carbon labels have significant effects on their willingness to pay. On average, consumers are willing to pay 21.33 yuan (the initial price is 18 yuan) for carbon-labelled agricultural products, and their willingness to pay a premium is 3.33 yuan, with a price increase of 18.5%. Finally, based on the problems found in the empirical study, this paper puts forward corresponding suggestions for the agricultural market, the government and consumers, which is conducive to further promoting the development of carbon label certification system and low-carbon agricultural products market.

Keywords: Consumers, Carbon-labelled agricultural products, Willingness to pay premium, CVM

1   Introduction

At present, China is facing severe resource shortage and ecological environment problems, which is especially reflected in the fact that the total carbon emission is increasing and worsens the global climate crisis, which has attracted wide attention from the world. Since 2007, carbon labels, as one of the eco-labels, have been continuously applied to the agricultural market. By conveying GHG emission information about the whole life cycle of products to consumers, carbon emission information of agricultural products can be made transparent and low-carbon consumption behavior can be guided [1].

In the study on carbon labels, Yunjun Yu et al. accurately proposed the relevant definition of the carbon label, believing that the carbon label is to mark the greenhouse gas emissions emitted during the whole life cycle of a product or service with a quantitative index, and inform consumers of the carbon information of a product in the form of a label [2]. In the research on

carbon labels and consumers' willingness to pay, Paul investigated the cognitive attitude of EU consumers towards food carbon labelling, and the results showed that the public has a significant preference for food carbon labelling, but the difficulty in understanding information about carbon labels may reduce the premium they are willing to pay [3]. In relevant domestic studies, Yang Bo found that Chinese consumers' cognition level of carbon-labelled food is low, and their awareness of carbon labels is significantly positively correlated with their willingness to pay carbon-labelled products [4].

This paper will conduct empirical research from the perspective of consumers' actual premium payment willingness to make up for the shortcomings of previous studies. At the same time, in the context of the imperfect development of China's carbon label certification system and the lack of low-carbon economic impetus, this study also aims to point out a new road for the transformation and upgrading of low-carbon consumption in China, and constantly promote the realization of carbon emission reduction targets and sustainable development of agriculture.

This paper will be divided into four parts, the first is the theoretical basis of this research; The second is the research method and design, which is divided into four modules: research method and questionnaire design, model derivation, model setting and variable selection, data source and acquisition. The third is the analysis of the research results, which is separated into descriptive analysis and empirical analysis. Fourth, the conclusion of the research is summarized, and the future research work is prospected.

2 Theoretical Basis

2.1 Hicks Surplus Theory

Consumers' value evaluation and willingness to pay for agricultural products ultimately depend on the utility that such agricultural products can bring to consumers. Hicks surplus, as one of the forms of consumer surplus, can reflect the utility consumers get from products in the form of currency, so it can better show the utility changes of consumers. Under the Compensation Variation (CV) of Hicks surplus, when the price of a product rises, consumers can be compensated with a certain amount of money to keep their situation as good as before the price change.

Considering that the introduction of carbon labels in China's agricultural market is very limited, only agricultural producers with low-carbon certification will consider using carbon labels to reflect product differentiation. Therefore, agricultural products with carbon labels in the market are basically low-carbon and green. As shown in Figure 1, the additional cost of carbon label certification by producers will inevitably lead to an increase in the price of carbon-labelled agricultural products, and the budget constraint line changes from L_1 to L_2. However, the low-carbon environmental protection value of carbon-labelled agricultural products will bring intangible "compensation" to consumers, and the welfare of consumers at this time is no different from that of ordinary agricultural products. Therefore, consumers are willing to pay extra prices for carbon-labelled agricultural products, and the "compensation" (CV) brought by carbon labels precisely measures consumers' willingness to pay premiums [5].
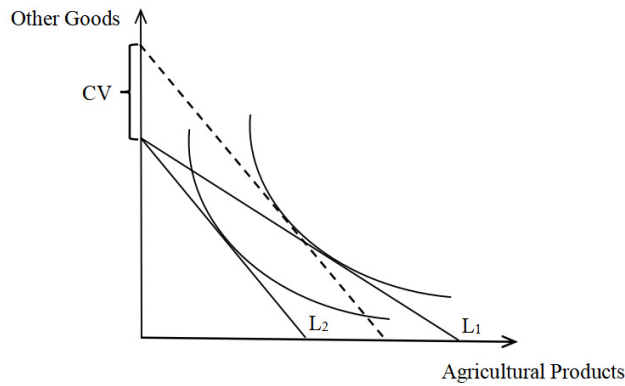
Fig. 1. The CV Form of Hicks Surplus

2.2 MOA Model Theory

In behavioral economics, MacInnis and Jaworski first proposed the MOA model. They believed that consumers' purchasing behavior would be affected by three factors: motivation, opportunity and ability [6]. Due to the increasingly prominent agricultural product quality safety and ecological environment problems, consumers want to know the carbon emission index and other related information of the agricultural products they consume, thus generating the corresponding purchase motivation. Secondly, some low-carbon agricultural products in Chia have used the carbon label logo, providing opportunities for the transparency of agricultural products carbon emission information. Finally, the final purchasing behavior of consumers will be affected by personal ability, and the difference in such ability can actually be attributed to the difference in personal endowment [7], which is mainly reflected in consumers' cognition level of carbon labels, trust level of carbon labels and other personal socio-economic characteristics such as income level and education level.

3 Research Methods and Research Design

3.1 Research Methods and Questionnaire Design

As environmental goods are public goods, externalities and information asymmetry are easy to appear in the environmental market. Therefore, it is impossible to evaluate the value of environmental goods by consumers through conventional market methods. Among unconventional market methods, Conditional Valuation Method (CVM) is a commonly used method. Based on Hicks Surplus theory, CVM can accurately measure consumers' willingness to pay for products with environmental attributes by describing an imaginary trading market to consumers. CVM has many ways for question formulation, including dichotomous choice, payment card, repeated bidding game and open questions. In this paper, the most common dichotomous choice method is adopted. By allowing consumers to make choices in different scenarios set in advance, the value evaluation of consumers on different types of agricultural products can be reached, and then the premium payment willingness is obtained.

In the meantime, this study will carry out the CVM experiment in the form of questionnaire. Before the experiment starts, the scenario hypothesis is carried out on consumers. It is assumed that only two types of Shine Muscat are sold in the market, namely ordinary Shine Muscat and Shine Muscat with a carbon label. By identifying the two-dimensional code on the icon of the carbon label, consumers can know the carbon emission per unit product and other real information of the product in detail. At the same time, information should be permeated to consumers to explain the possible harm caused by excessive carbon emissions of agricultural products.

At first time, it is assumed that the price P_0 of ordinary Shine Muscat in the market is the same as the price P_1 of carbon-labelled Shine Muscat ($P_0=P_1=18$), and consumers are asked whether they are willing to buy carbon-labelled Shine Muscat. If the consumer is not willing to buy, stop asking; If the consumer is willing to buy, then we sequentially assume that the price P_1 of carbon-labelled Shine Muscat in the market becomes a random price ($P_1=19,20,21,22,23$) higher than P_0. At this time, the consumer is asked whether he is still willing to buy carbon-labelled Shine Muscat at this random price. If the consumer is still willing to buy, the consumer's willingness to pay this random price is assigned a value of 1. If the consumer is not willing to continue paying for this random price, then the willingness is assigned a value of 0.

3.2 Derivation of Model

Suppose that in the Shine Muscat market, Y represents consumers' choice, Y=1 represents consumers' choice of Shine Muscat with a carbon label, and Y=0 represents consumers' choice of ordinary Shine Muscat.；P_1 represents the price that consumers are willing to pay for carbon-labelled Shine Muscat, P_0 represents the price of ordinary Shine Muscat; Z represents other factors that affect consumers' utility, including consumer cognition, income level, etc；e_1 and e_0 respectively represent the random disturbance terms when consumers choose carbon-labelled Shine Muscat and ordinary Shine Muscat.

Therefore, the utility U_1 obtained by consumers when they choose carbon-labelled Shine Muscat can be expressed as:

$$U_1=\alpha_1+\beta_1*P_1+\gamma_1*Z+e_1 \tag{1}$$

Utility U_0 obtained by consumers when they choose ordinary Shine Muscat can be expressed as:

$$U_0=\alpha_0+\beta_0*P_0+\gamma_0*Z+e_0 \tag{2}$$

Since the price of ordinary Shine Muscat is given, let constant $\alpha_2=\alpha_0+\beta_0*P_0$, then $U_0=\alpha_2+\gamma_0*Z+e_0$, so the utility difference U' that consumers get from carbon-labelled Shine Muscat and ordinary Shine Muscat can be expressed as:

$$U'=U_1-U_0=\alpha_1+\beta_1*P_1+\gamma_1*Z+e_1-（\alpha_2+\gamma_0*Z+e_0）$$

$$=（\alpha_1-\alpha_2）+（\gamma_1-\gamma_0）*Z+\beta_1*P_1+（e_1-e_0） \tag{3}$$

$$=\alpha'+\gamma'*Z+\beta_1*P_1+e'$$

If consumers choose to buy carbon-labelled Shine Muscat, and therefore $U'=\alpha'+\gamma'*Z+\beta_1*P_1+e'＞0$. Consequently, the probability equation of consumers choosing to buy carbon-labelled Shine Muscat is:

$$P（Y=1）=P（U'>0）=P\big[e'>-（\alpha'+\gamma'*Z+\beta 1*P1）\big] \qquad (4)$$

Assuming e' follows a logical distribution, then equation (4) is able to be converted to a linear expression:

$$\ln\big[\frac{P（Y=1）}{1-P(Y=1)}\big] = \alpha'+\gamma'*Z+\beta_1*P_1 \qquad (5)$$

According to Hicks Surplus theory, consumers will get an intangible "compensation" after buying the higher price of carbon-labelled Shine Muscat, which will enable consumers to achieve the same utility as buying ordinary Shine Muscat. Based on the research of Lifen Wu (2012), the utility consumers obtain from the two types of Shine Muscat is equal, then we are able to obtain the average value evaluation of consumers for the carbon-labelled Shine Muscat [8] :

$$\alpha_1+\beta_1*P_1+\gamma_1*Z+e_1 =\alpha_2+\gamma_0*Z+e_0$$

$$\alpha_1 +\beta_1*E（P_1）+\gamma_1*E（Z）= \alpha_2 +\gamma_0*E（Z）$$

$$E（P_1）= \frac{-\alpha'-\gamma'*E（Z）}{\beta 1} \qquad (6)$$

Through subtracting the price P_0 of ordinary Shine Muscat, the consumer's average premium willingness to pay for carbon-labelled Shine Muscat can be obtained:

$$E（Premium\ Pay）= E（P_1）-P_0 \qquad (7)$$

3.3 Model Setting and Variable Selection

In this paper, the Logit model is selected for empirical analysis according to Formula (5) in the Derivation of Model. The specific form of Logit model is as follows:

$$Y = \beta_0 +\beta_1 Price +\beta_2 Cogn_1 +\beta_3 Cogn_2 +\beta_4 Trust +\beta_x*Z +e \qquad (8)$$

In this model, the dependent variable is Y, representing consumers' willingness to pay for carbon-labelled Shine Muscat. The core independent variables are Price, Cogn1, Cogn2 and Trust. Price represents the price of carbon-labelled Shine Muscat, and this paper assumes that the price of ordinary Shine Muscat is P0=18 yuan, and P1=19, 20, 21, 22, 23 yuan as the random price of carbon-labelled Shine Muscat; Cogn1 and Cogn2 represent consumers' cognition level of carbon labels; Trust represents consumers' trust level of carbon labels. The control variable is Z, including other factors affecting consumers' willingness to pay. The specific definitions and descriptions of all variables involved in this paper are shown in Table 1.

Table 1. Variable Specific Definition and Related Description

Classification	Name of variable	Definition of variables
Dependent variable	Y	1=Be willing to buy; 0=Be unwilling to buy
	Price	One random price of 19, 20, 21, 22, 23
	Cogn$_1$	1=Haven't heard much about it; 2=Don't know much about; 3=General; 4=Know better; 5=Know it well

Core independent variable	Cogn$_2$	1=Very unimportant; 2=Unimportant; 3=General; 4=Important; 5=Very important
	Trust	1=Very distrustful; 2=Distrustful; 3=General; 4=Trustful; 5=Very trustful
Variable of control	Sex	1=male; 0=female
	Age	Discrete variable
	Edu	1=Primary School and below; 2=Junior high school; 3=senior high school; 4=Technical or Mechanical Degree; 5=Bachelor degree or above
	Income	1=Below 3000 yuan; 2=3001 to 6000 yuan; 3=6001 to 8000 yuan; 4=8001 to 10000 yuan; 5=Above 10000 yuan
	House	Discrete variable, expressed in terms of the number of people in a household
	Place$_1$	Whether used to buying fruit at the supermarket: 1=accustomed; 0=unaccustomed
	Place$_2$	Whether used to buying fruit at the farmer's market: 1=accustomed; 0=unaccustomed
	Place$_3$	Whether used to buying fruit on the Internet: 1=accustomed; 0=unaccustomed

3.4 Data Source and Acquisition

The data in this paper are from the field research in Nanjing, Suzhou and Yangzhou of Jiangsu Province in July 2022, and the questionnaire survey is conducted around supermarkets and farmers' markets in accordance with the principle of randomness. Before the formal investigation, the writer first conducted a preliminary survey on consumers in Nanjing, and improved the questionnaire according to the survey results. Due to the limitations of the epidemic and other conditions, 180 questionnaires were collected in this study, among which 151 were valid, with an effective recovery of 83.9%.

4 Results and Analysis

4.1 Analysis of Descriptive Statistical Results

Consumers' cognition Level of Carbon Labels. This study measures consumers' awareness of carbon labels based on their understanding of carbon labels and the importance of carbon labels to environmental protection. The specific statistical results are shown in Figure 2 and Figure 3.
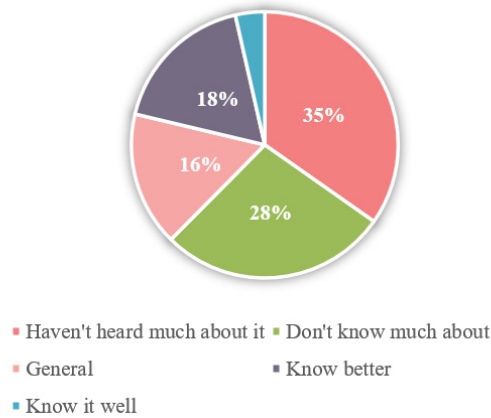
Fig. 2. Consumers' understanding of Carbon Labels

Based on the Figure 2, we know that consumers' understanding of carbon label is low, and more than one-third of consumers say they have not even heard of carbon label. This article thinks that the reasons for this phenomenon are as follows: First, the certification system of Chinese agricultural carbon label is not perfect, and the carbon label for agricultural products is still a rare technology; Second, Chinese consumers lack the corresponding low-carbon knowledge, and their sensitivity to carbon labels is low. Most consumers will not take the initiative to understand the carbon emission information of agricultural products
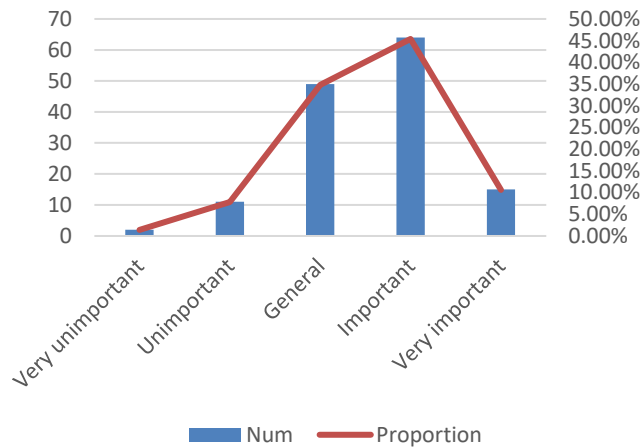

Fig. 3. Consumers' perception of Carbon Labels' importance for Environmental Protection

At the same time, Figure 3 shows that consumers believe that carbon labels are of high importance for environmental protection, which may be because the severe situation of carbon emissions increasing year by year has sent a "signal" to consumers. Even if consumers do not

know carbon labels very well, they will associate carbon labels with environmental protection [9]. In general, most consumers lack a clear definition of carbon labels, and their awareness of carbon labels needs to be improved.

Consumers' trust in Carbon Labels. In this study, consumers' trust in carbon labels was obtained through their subjective evaluation. The specific statistical results are shown in Figure 4.
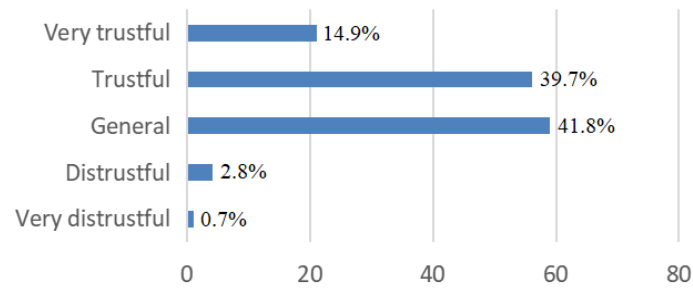

Fig. 4. Consumers' trust in Carbon Labels

As can be seen from Figure 4, consumers' trust in carbon labels is at a relatively high level, with more than half of them "trusting" or "very trusting" carbon labels. This may be because the certification of organic food and green food is relatively strict in our country before, and the quality of food with the organic label or green label is better. Therefore, the analogy effect of the consumer on the carbon label will also be generated. In addition, because our agricultural products carbon label certification has just started, the government will invest a lot of funds in it, and the quality of carbon label certification will be ensured accordingly, increasing the consumers' trust in carbon labels.

The Price of Carbon-labelled Agricultural Products and the Willingness of Consumers to Pay. Based on previous CVM research methods, we can derive the relationship between the price of the products and the demand of consumers in the market. The specific statistical results are shown in Figure 5.
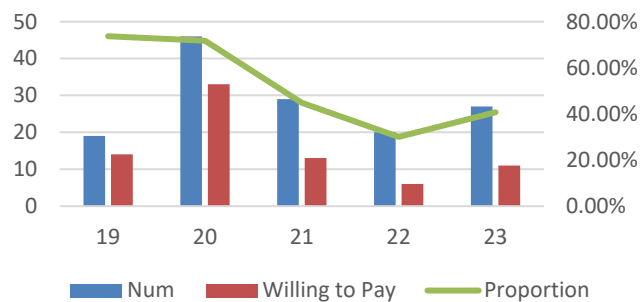

Fig. 5. Consumers' willingness to Pay for Carbon-labelled Shine Muscat at Different Prices

As we can see from the data in Figure 5, in general, consumers' willingness to pay for carbon-labelled agricultural products decreases with the increase of their price. Therefore, carbon-labelled Shine Muscat is a normal commodity. However, when the price of carbon-labelled Shine Muscat rose from 22 to 23, the proportion of consumers willing to pay decreased, which may be because these two prices are relatively high, consumers have little difference in sensitivity to these two prices, so their purchasing behavior is more susceptible to personal factors. As a result, this abnormal phenomenon may be caused by sample selection, and it doesn't affect the overall market rules.

4.2 Analysis of Empirical Results

Since this study is about consumers' willingness to pay premium for carbon-labelled agricultural products, when the prices of ordinary Shine Muscat and carbon-labelled Shine Muscat are the same in the market, consumers who choose ordinary Shine Muscat should be excluded. In this paper, the remaining sample size is 141 after excluding the valid questionnaires that meet the characteristics of such consumers. For the remaining samples, this paper has obtained the correlation variable values of the independent variable and dependent variable in the Logit model, and then used STATA software to process and analyze the data. Meanwhile, in order to more intuitively judge the impact of independent variables on dependent variables, this study also obtained the marginal impact value dy/dx of each independent variable. All the regression results are shown in Table 2.

Table 2. Logit Model Regression Results

Variable	Logit Coef	Std.Err	P>|z|	dy/dx
Price	-1.116***	0.309	0.000	-0.092***
$Cogn_1$	1.610***	0.478	0.001	0.134***
$Cogn_2$	1.917***	0.549	0.000	0.159***
Trust	0.137	0.426	0.747	0.011
$Place_1$	1.644**	0.640	0.010	0.136***
$Place_2$	3.154***	0.891	0.000	0.262***
$Place_3$	1.077	0.695	0.121	0.089
Sex	0.721	0.653	0.269	0.060
Age	-0.0113	0.0945	0.904	-0.001
Income	0.192	0.298	0.519	0.016
Edu	0.617	0.542	0.255	0.051
House	-0.416	0.317	0.190	-0.034
Constant	7.413	6.901	0.283	
Observations		141		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to the regression results, the price of carbon-labelled Shine Muscat has a significant negative impact on consumers' willingness to pay, which confirms the law that consumers' willingness to pay for carbon-labelled agricultural products decreases with the increase of their

price. Meanwhile, consumers' awareness of carbon labels has a significant positive impact on their willingness to pay, which is consistent with the expectation of this paper. Consumers' trust in carbon labels is positively correlated with their willingness to pay, in the same direction as expected. However, from the perspective of marginal effect, if other variables remain unchanged, consumers' trust in carbon labels increases by one unit, their probability of choosing to buy carbon-labelled Shine Muscat will increase by 0.011. This positive influence is relatively insignificant. From the perspective of the influence direction and degree of other control variables, its influence on consumers' willingness to pay can be reasonably explained from economics. Therefore, on the whole, the model adopted in this study can better explain the relationship between consumers' willingness to pay for carbon-labelled agricultural products and its influencing factors. It lays a foundation for measuring consumers' willingness to pay premium.

Through Formula (2) in the model derivation part, this study calculates that the average value evaluation E (P1) of consumers for carbon-labelled Shine Muscat =21.33 yuan, then the average willingness to Pay E (Premium pay) of consumers =21.33-18=3.33 yuan, that is, compared with ordinary Shine Muscat, On average, consumers are willing to pay an extra 3.33 yuan for carbon-labelled Shine Muscat, with prices rising 18.5 percent. From the perspective of agricultural prices in the current market, carbon labels can bring 18.5% premium for agricultural products, indicating that consumers are willing to pay premium at a high level, and producers of carbon-labelled agricultural products can obtain higher earnings from it. However, it should be noted that due to the limited research scope of this study, homogenization among samples is inevitable. Therefore, when evaluating consumers' willingness to pay premium, regional and socio-economic factors will also have an impact.

To sum up, the research method of this paper shows great superiority. Firstly, compared with the statistical test method, this paper builds a concrete empirical model, which can explore more influencing factors and make corresponding predictions. Secondly, compared with the linear probability model (LPM), the Logit model can constrain the value range of dependent variables and avoid the heteroscedasticity problem, which makes the corresponding coefficient interpretation more reasonable. Thirdly, although the OLS regression model can deal with the heterogeneity among consumers by adding fixed effects into the model, it may bring about endogeneity problems. However, the CVM method adopted in this paper can decrease other potential factors that may affect the dependent variables as much as possible through scenario assumptions. In addition, using the Heckman model for two-stage estimation can indeed reduce the bias brought by sample selection, but the relevant instrumental variables (IV) are uncertain. Although the sample bias problem is not dealt with separately in this paper, the data acquisition scope is expanded to the provincial range during the research design, so the accuracy of the model estimation can be improved to some extent in this study.

5   Conclusion

The agricultural sector is an important focus of energy conservation and emission reduction in the whole economic sector. It is of great significance to study the issues related to the carbon emission of agricultural products. This paper adopts Conditional Valuation Method (CVM) and Logit model to conduct descriptive and empirical analysis on consumers' willingness to pay for

carbon-labelled agricultural products, and finally obtain the premium consumers are willing to pay for the products.

The main conclusions of the study are as follows: First, consumers' cognition of carbon labels needs to be improved; Second, consumers have a high degree of trust in carbon labels; Third, consumers' willingness to pay for carbon-labelled agricultural products decreases with the increase of price in general; Fourth, consumers' cognition level of carbon labels and the price of agricultural products has a significant impact on their willingness to pay. There is a positive correlation between consumers' trust in carbon labels and their willingness to pay, but the impact is not significant; Fifth, the average value evaluation of consumers for carbon-labelled agricultural products is 21.33 yuan, and the average premium of the products is 3.33 yuan, with a premium level of 18.5%. Generally, consumers' willingness to pay premium is at a relatively high level.

Of course, there are still some defects in this study. For example, this paper only considers consumers' willingness to pay premium from the perspective of consumers; Non-sampling errors such as sampling box error and answer error may occur in variable assignment; The CVM method only assumes the trading market without giving consumers real choices, which may lead to selection bias. The following paper will look forward to the future research work in order to continuously make up for the shortcomings of the previous research.

First of all, in the follow-up study, we can shift the perspective from consumers to producers. Previously, it was concluded that consumers have a high willingness to pay premium for carbon-labelled agricultural products, but can this compensate producers for the production cost of carbon label certification? In fact, we can conduct quantitative research on producers of certain agricultural products with carbon labels in a certain region to reveal consumers' compensation for the cost of carbon label certification from a micro level. Secondly, we will further expand the sample selection scope in the follow-up study, and incorporate the time dimension into the model to investigate the time trend of consumers' willingness to pay premium, so as to further verify the conclusions of this study. Finally, considering the limitations of CVM itself, we can adopt different research methods to more accurately measure the premium level of carbon-labelled agricultural products in subsequent studies, such as selection experiment method and experimental auction method.

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