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# On willingness to pay and impact mechanism of green agricultural products: a case of shrimp rice in Hunan, China

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The burgeoning interest in green agriculture represents a pivotal shift towards environmentally friendly farming systems but sales of its products have been poor. Therefore, guiding consumers to pay reasonably can help green agricultural enterprises formulate appropriate marketing strategies and enhance public health and environmental quality. This paper takes shrimp rice (SR) as an example, based on 1,158 consumers in the largest rice province Hunan, and seeks to detect which factors affect the public's willingness to pay (WTP) by adopting the Contingent Valuation Method (CVM) and Heckman two-step Model. After removing biased observations, the results show that most respondents recognize the value of SR, whose premium is 1.47 yuan/kg, with a 25.85% premium rate. Moreover, positive external cognitions (psychology, environment, safety, policy) can moderate consumers' WTP to varying degrees by strengthening their corresponding motivations. In addition, older, highly educated men who are familiar with SR and high-income but small-scale households with children and the elderly are more likely to pay a higher premium. Hence, some recommendations are put forward to enhance consumers' external cognitions, providing an indispensable scientific basis for developing countries to promote the sustainable development of environmentally friendly agriculture.

## KEYWORDS

shrimp rice, WTP, contingent valuation, Heckman two-step model, cognition

## 1 Introduction

Rice serves as a staple food in numerous Asian countries, particularly in China. However, concerns regarding its safety have consistently been paramount for consumers (Sutardi et al., 2023; Vishwakarma et al., 2023). For a long period, public discourse primarily focused on rice supply capacity, emphasizing strategies to increase yields to satisfy the demand of a rapidly growing population. This approach has led to the emergence of "petrochemical agriculture (PA)," which relies heavily on chemical fertilizers, pesticides, and mulching practices. Consequently, the ecological risks associated with this agricultural model have become increasingly evident, manifesting in issues such as irreversible reductions in species diversity, excessive energy depletion, air quality deterioration, and desertification (Mabhaudhi et al., 2018; Borelli et al., 2020; Zhang et al., 2022; Bai and Lin, 2022; Li, 2022; Sun et al., 2023; Xu et al., 2023). The frequent occurrence of food safety incidents has significantly eroded consumer confidence in traditional agricultural products (Albert et al., 2020; Otekunrin et al., 2020; Peng et al., 2022; Lv et al., 2023), prompting researchers and producers to seek safer alternatives (Yu et al., 2014).

In light of these challenges, there is an inevitable trend towards evolving agricultural production methods (He et al., 2023), underscoring the necessity to achieve a balance between rapidly increasing grain output and environmental sustainability (Chen and You, 2021). In this context, the Rice and Fish Co-cultivation System (RFCS), a notable example of green agriculture, has garnered considerable attention (Yang et al., 2023). This system not only prioritizes the health attributes of agricultural products but also emphasizes ecological balance and sustainability during the cultivation process. It advocates for the preservation of natural resources and high levels of biodiversity (Novikova et al., 2024). By reducing reliance on petrochemical inputs, rice and other agricultural products can be cultivated in a manner that is less detrimental to the environment and safer for consumers. The rice produced through this method is commonly referred to as Green Rice (GR). Notably, the primary barrier to the growing demand for GR is its higher cost compared to traditional rice, which renders it a target for unscrupulous merchants engaging in practices such as falsification, misleading labeling, and price manipulation (Smoluk-Sikorska et al., 2023). Therefore, encouraging consumers to accept a reasonable premium for GR is essential for promoting the sustainable development of this environmentally friendly agricultural practice.

Green agricultural products are generally characterized by two primary attributes: environment and safety. However, findings from the preliminary survey indicate that the influences of policy-related and psychological factors are also significant in the Chinese context, although the extent of the effect requires further investigation. On the one hand, the “opportunism” exhibited by producers and operators often results in a lower WTP for green agricultural products, subsequently leading to a stagnant market. This stagnation, in turn, diminishes the enthusiasm of operators and decreases their motivation to promote and sell green agricultural products. On the other hand, consumers’ adverse selection behavior can also contribute to a reduced WTP. Prior to the widespread acceptance of a green agricultural product, consumers often lack adequate information, owing to asymmetric information and other barriers. Consequently, to mitigate perceived risks, they tend to be reluctant to pay a higher premium. Therefore, investigating consumers’ WTP for green agricultural products and guiding them toward accepting reasonable premiums is advantageous for consumers, operators, and producers alike.

Previous research has investigated the factors influencing consumers’ WTP for conventional versus green foods, highlighting elements such as certification marks, quality, and brand reputation. Interestingly, socio-demographic profiles and the external characteristics of organic food appear to have minimal influence (Krystallis and Chrysosoidis, 2005). Similarly, Lifang et al. (2014) elucidated the main factors affecting the purchase of green agricultural products and the underlying mechanisms driving purchasing behavior through Probit regression analysis. Overall, previous research suggests that green foods possess significant market potential, providing crucial support for this study. In addition to traditional variables such as product price and household income, factors such as consumer trust and concern regarding green food also significantly impact their WTP and premium levels (Asioli et al., 2017; Brune et al., 2023). In view of these insights, the questionnaire for this study was designed to include a specific question regarding respondents’ attention to shrimp rice. Furthermore, a brief definition and description of the pro-environmental attributes of shrimp rice were provided to ensure

that respondents possess a fundamental understanding of the product before expressing their WTP.

## 2 Literature review

### 2.1 Theoretical background

Research into consumers’ WTP for green agricultural products has evolved over the years, influenced by environmental, economic, and social factors. This body of work often rests on key theories such as the Theory of Planned Behavior (TPB), self-construal theory, and environmental consciousness, which all attempt to explain the psychological and motivational factors that drive consumer behavior towards green products.

For instance, the theory of planned behavior has been widely adopted in understanding WTP. Xu et al. (2020) extended TPB by incorporating environmental awareness and health consciousness to predict consumer intention to purchase green furniture. The study highlighted that these factors directly influence WTP, demonstrating a robust relationship between environmental as well as health awareness and consumer behavior. Similarly, Singh et al. (2023) utilized TPB to examine how eco-label awareness, environmental concerns, and perceived environmental benefits drive consumers’ WTP for eco-labeled foods. This theoretical approach is fundamental in explaining how attitudes and external influences, such as product labeling, shape purchasing decisions.

Self-construal theory, another key theoretical framework, was employed by Zheng et al. (2022) to examine the role of advertising appeals on consumers’ WTP for green agricultural products. The study found that green advertising, when aligned with consumers’ self-construal, significantly boosts WTP through increased perceived green value. This suggests that tailored marketing strategies could bridge the information gap and improve consumers’ environmental cognition.

Environmental and health consciousness are also central to explaining WTP for green products. The impact of these factors has been explored by some researchers, who examined the role of front-of-pack green labels in increasing consumer WTP for environmentally sustainable foods. Some studies concluded that labeling alone can substantially increase consumers’ WTP by 0.11 pounds on average (Duckworth et al., 2022). Environmental awareness was further identified as a critical determinant by Cao and Xu (2023), who explored how external signals, such as packaging and policy, influence WTP for green packaging. This research underscores the importance of external interventions, such as labeling and governmental policies, in shaping consumer cognitions of green products.

Moreover, socio-demographic factors such as income, education, and household composition have consistently been identified as strong predictors of WTP. Yu et al. (2014) found that Chinese consumers are willing to pay a premium of 47% for green vegetables, with income and age emerging as significant predictors of WTP. Ortega et al. (2016) similarly demonstrated that consumers prioritize food safety and are willing to pay more for organic and green-certified products, particularly in wealthier households. These studies emphasize that WTP is not just a reflection of environmental concern but also socio-economic standing, thus suggesting the need for targeted marketing and educational strategies.

## 2.2 Empirical studies

The previous studies have explored various determinants of consumers' WTP for green agricultural products, particularly in emerging markets like China. A major theme is the role of information dissemination and labeling in bridging the gap between consumer awareness and WTP. [Li et al. \(2022\)](#) conducted an information intervention experiment that demonstrated how external information supply significantly raises consumers' WTP for green manure-rice by reducing information asymmetry ([Li et al., 2022](#)). Similarly, [Yuan et al. \(2024\)](#) found that trust in food labels, combined with external information, leads to a substantial increase in WTP for organic rice, highlighting the interaction between information and trust in shaping consumer behavior.

Another key empirical finding is the influence of psychological and motivational factors. Some researchers applied structural equation modeling (SEM) to assess consumers' WTP for aquaponics products and found that environmental awareness and green consumption attitudes significantly affect WTP ([Eichhorn and Meixner, 2020](#)). This reinforces the need to focus on psychological drivers when promoting green agricultural products.

Demographic characteristics, particularly age, gender, and income, consistently appear as significant determinants in literature. For example, [Hwang et al. \(2023\)](#) discovered that females and older adults exhibit a higher WTP for eco-friendly drone food delivery services. Furthermore, some previous studies on sustainable milk found that consumers with children are more likely to pay a premium for products labeled as environmentally sustainable ([Gao et al., 2020](#)). These findings suggest that demographic segmentation could be a crucial factor in enhancing marketing strategies for green products.

Lastly, the role of external cognitions, such as safety concerns and policy influences, has been found to significantly impact WTP ([Cheng et al., 2024](#)). In the case of [Tong et al. \(2020\)](#), subjective environmental knowledge and concerns about food contamination were identified as key drivers of WTP for green rice. This is echoed by other researchers, who reported that safety awareness and trust in product labeling significantly influence consumers' decision-making regarding green-certified vegetables ([Yin et al., 2022](#)). These studies highlight the crucial role of policy and regulatory measures in fostering consumer trust and driving the market for green agricultural products. Furthermore, existing research highlights that an individual's "endowment"—defined as the combination of personal, familial, and social characteristics—serves as a fundamental determinant of purchase decisions ([Li et al., 2019](#); [Han and Liu, 2020](#)).

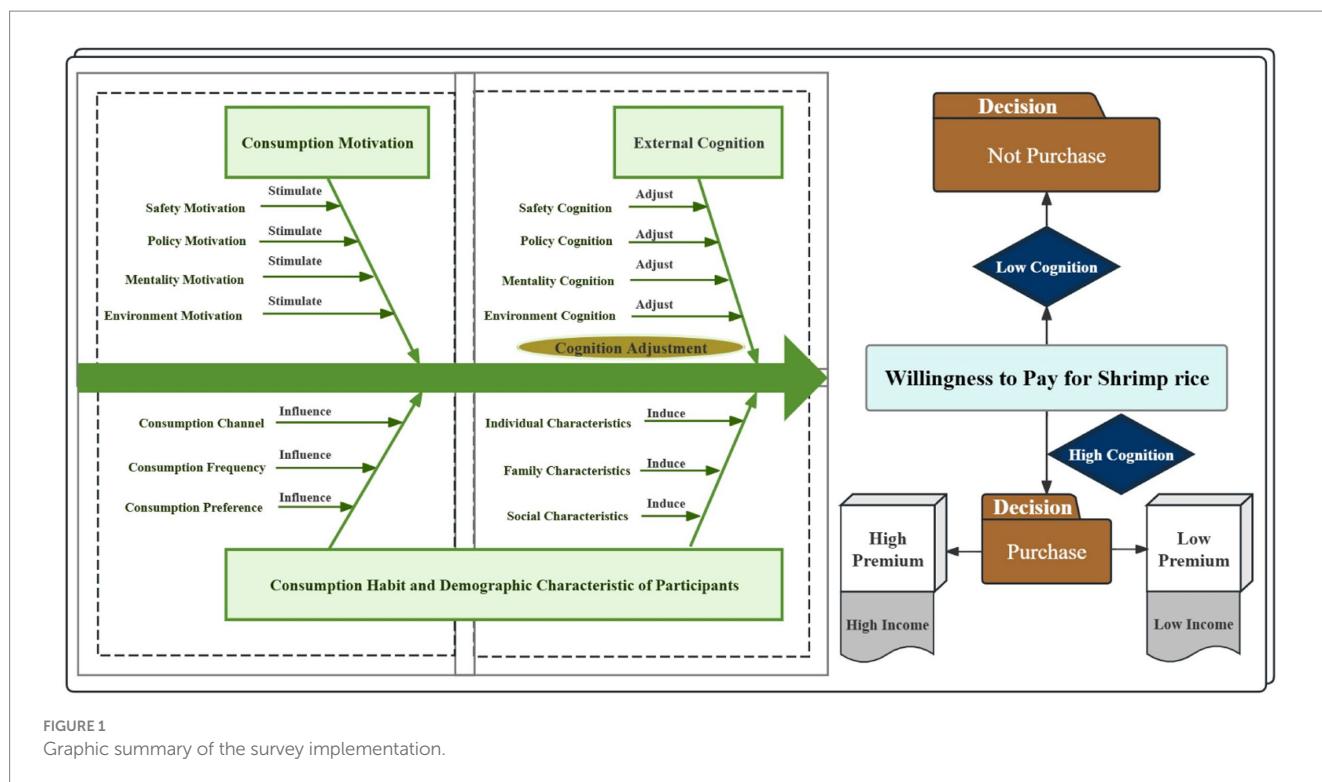
While previous studies provide substantial insights into the determinants of WTP for green agricultural products, they also reveal several gaps that the present research aims to address. First, most prior investigations have concentrated on the broader category of green foods rather than specific products. Additionally, there exists a limited body of literature that comprehensively compares and analyzes the factors influencing consumers' WTP and premium levels within a unified research framework. Accurately assessing WTP and premium levels for any new agricultural product is vital for its successful market acceptance as a staple agricultural commodity ([Cai and Aguilar, 2013](#); [Canavari and Coderoni, 2020](#)). Second, although psychological and environmental factors are well-studied, there is a lack of empirical analysis that incorporates external cognitions such as policy and safety concerns in shaping WTP for green products. Third, the literature

surrounding the RFCS has largely overlooked shrimp rice itself, despite its significant implications for food security. Fourth, many early studies have failed to prioritize the selection of representative geographical areas, a crucial aspect for obtaining accurate and typical data. According to the National Bureau of Statistics (NBS), Hunan Province is recognized as China's breadbasket and the largest rice-producing region in South China, with total grain output rising from 6.4 million tons in 1949 to 30 million tons today. Consequently, selecting Hunan as the survey area enhances the representativeness of the data, thereby offering more valuable decision-making support.

Based on these considerations, this study seeks to fill these gaps by employing a more comprehensive model that includes both internal motivations and external cognitions, using the contingent valuation method and Heckman two-step model to provide a robust analysis. Specifically, this research seeks to address three key questions: (1) What percentage of consumers are willing to pay for shrimp rice? (2) How much are premium consumers willing to pay? (3) What factors affect consumers' WTP and premium levels? Based on the findings, a series of implications will be proposed to inform future policy and practice. The graphic summary of the survey implementation is displayed in [Figure 1](#).

This study investigates four dimensions of motivations and cognitions: safety, policy, environment, and psychology. Previous research has consistently shown that consumers' primary motivation for purchasing green agricultural products stems from concerns over food safety ([Barlagne et al., 2015](#); [Paffarini et al., 2021](#); [Wang et al., 2023](#)). When consumers are apprehensive about the quality of conventional agricultural products, their WTP for green alternatives may increase. In addition to safety concerns, supportive government policies play a crucial role in shaping consumer behavior. These policies, through mechanisms such as tax incentives and subsidies, can reduce the price of green agricultural products and simultaneously enhance consumer cognition and familiarity. As a result, confidence in the quality of these products is bolstered, thereby increasing the likelihood of purchase ([Sakagami et al., 2006](#); [Atinkut et al., 2020](#)). Beyond safety concerns and policy influences, environmental protection serves as another significant driver of green product consumption. Consumers motivated by environmental concerns engage in pro-environmental behaviors, driven by a desire to contribute to environmental improvement ([Schmit et al., 2013](#); [Fonte, 2013](#); [Boehm et al., 2019](#)). This environmental consciousness often aligns with their purchasing decisions. Additionally, often overlooked factor is the role of herd mentality in the purchasing process. This psychological phenomenon, wherein individuals' behaviors, attitudes, and opinions are influenced by others, drives consumers to align with the choices of the majority ([Wilk et al., 2022](#); [Wu et al., 2022](#); [Wang et al., 2023](#)). For instance, when consumers observe friends, family, or public figures endorsing and purchasing a specific green agricultural product, they are more likely to follow suit. This social influence is further magnified by the asymmetry of information between producers, retailers, and consumers, creating fertile ground for herd behavior to thrive.

In addition, this study also explores the demographic characteristics and consumption habits of the respondents, focusing on factors such as income, educational attainment, and purchasing preferences. These elements are essential in understanding consumers' WTP for green agricultural products ([Dlamini, 2015](#)). In terms of consumption habits, three dimensions are particularly important:



consumption frequency, consumer preferences, and purchasing channels. Higher purchase frequency has been shown to positively influence WTP in the previous literature (Yu et al., 2018; Migliore et al., 2020; Vapa-Tankosić et al., 2020; Dogan and Adanacioglu, 2021). More frequent purchases provide consumers with repeated opportunities to try new products, accumulate experiences, and develop deeper familiarity with their characteristics, creating a virtuous cycle that enhances WTP. Additionally, consumer preferences—such as attention to brand reputation or product flavor—also play a significant role in shaping WTP (Hustvedt and Bernard, 2008; Yang et al., 2023). Packaging forms, whether in bulk or bagged, also influence consumer decision-making. For instance, the tactile and sensory experience of bulk rice can enhance consumer trust and satisfaction, which may, in turn, increase their WTP. Furthermore, the rapid expansion of the Internet, particularly in China, has made online shopping an integral part of daily life, providing consumers with more comprehensive information and recommendations. Online platforms allow for more informed purchasing decisions, while offline shopping offers immediacy and convenience, bypassing the waiting times associated with logistics. These contrasts suggest that both online and offline purchasing channels contribute differently to consumer behaviors.

In summary, enhanced external cognition, including concerns about food safety, supportive policies, environmental awareness, and social pressures, may help consumers better understand green agricultural products and ultimately stimulate their consumption behaviors.

### 3 Materials and methods

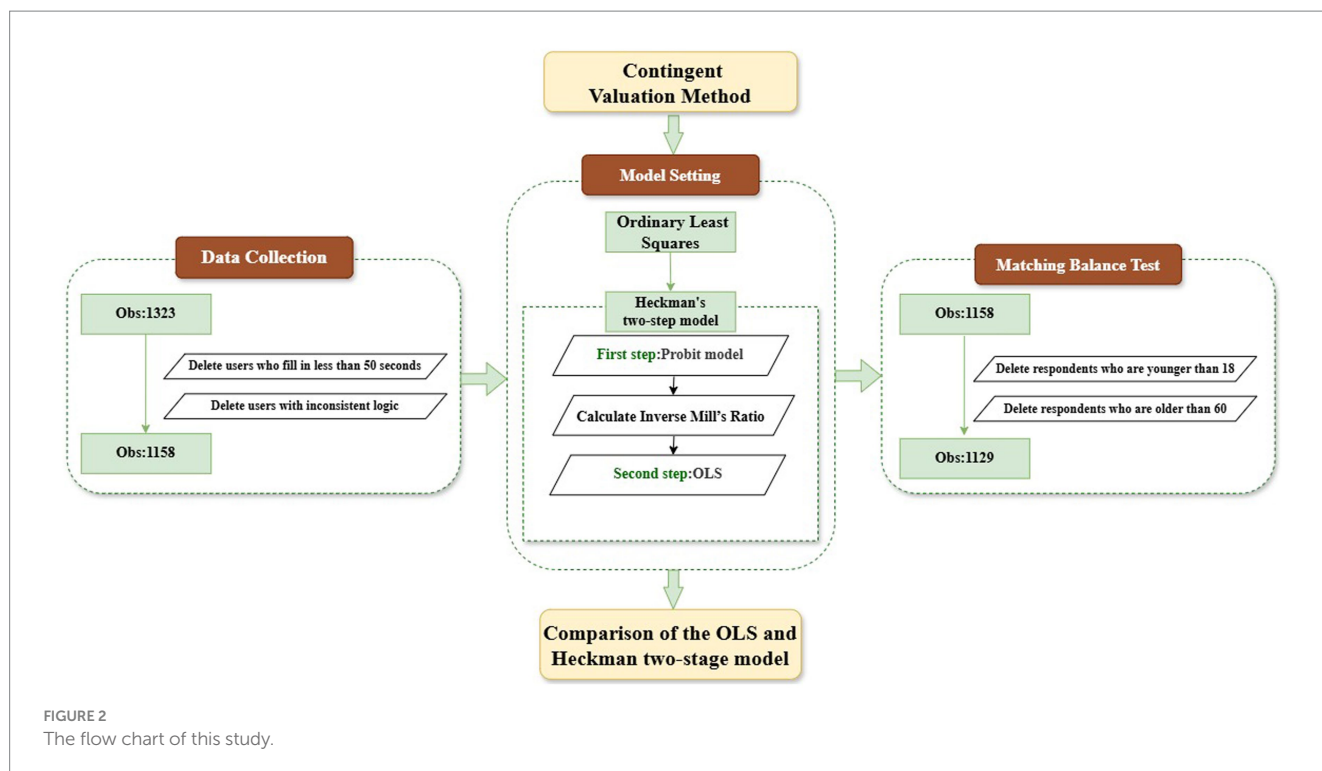
The research process is outlined in several stages, each represented in Figure 2.

We began with an initial dataset of 1,323 observations. To ensure data quality, we excluded respondents who completed the survey in less than 50 s or displayed inconsistent logical responses, resulting in a refined dataset of 1,158 observations. Then, using the CVM framework, we employed both OLS and Heckman’s two-step model to analyze the data. The Heckman model’s first step involved a Probit model to calculate the Inverse Mills Ratio (IMR), followed by a second-step OLS with the calculated IMR to address potential selection bias. To further test the robustness of our model, we applied age-based inclusion criteria, removing respondents under 18 and over 60 years old, resulting in a final sample size of 1,129 observations. In the final analysis, we compared the results from the OLS model and Heckman’s two-stage model to validate our findings.

#### 3.1 Research area and data collection

This study was conducted in Hunan province, located in the central-southern region of China. Hunan is a key agricultural hub, particularly for rice production, thanks to its favorable climate and fertile soils. Hunan Province has *Dongting Lake*, the second-largest freshwater lake in China. It boasts abundant water resources that nurture the RFCS, integrating rice paddies with shrimp farming. The study focuses on consumer behavior regarding SR, an environmentally friendly agricultural product, with data collected from 1,158 respondents between March and July 2023. Stratified random sampling was employed to ensure that the sample is representative of both urban and rural populations. The specific location of Hunan is illustrated in Figure 3.

The survey was conducted online, using structured questionnaires administered in local markets and community centers. The structured questionnaire captured demographic,



socioeconomic characteristics, consumption motivations, and external perceptions. Prior to data collection, enumerators received rigorous training, and a pre-test was conducted to enhance the questionnaire's clarity and relevance, as suggested by [Perman et al. \(2003\)](#). This approach is particularly crucial in avoiding common pitfalls observed in CVM studies in developing countries, where poorly designed scenarios and surveys can significantly skew outcomes ([Whittington, 2002](#)). The survey yielded 1,158 valid responses, enabling a comprehensive analysis of the factors influencing consumers' WTP for SR.

Specifically, 283 respondents were selected from Changsha, the provincial capital, representing the urban stratum, where consumers are typically more familiar with environmental issues and have a higher ability to pay. The remaining respondents were drawn from rural and semi-urban regions across Hunan, capturing a broader demographic to ensure a comprehensive understanding of consumer behavior towards SR.

### 3.2 Variables selection

This study involves two dependent variables. The first is the consumers' payment decision for shrimp rice, i.e., whether they would be prepared to spend more on shrimp rice. The second is the level of payment, i.e., the amount of premium that buyers are prepared to pay. WTP serves as the dependent variable for the selection model, while the premium level functions as the dependent variable for the outcome model. To explore the factors affecting consumers' WTP for SR, we selected variables based on existing literature and the specific characteristics of green agricultural products. A total of 27 explanatory variables were selected and analyzed, details of which are shown in [Table 1](#).

In terms of demographic characteristics, age, gender, education level, household income, and family composition (number of children or elderly) were included, as these factors have been shown to influence consumer behavior in previous studies ([Yu et al., 2014](#); [Ortega et al., 2016](#)). Variables such as environment, safety, psychology and policy were incorporated to capture the moderating effects of positive external cognitions on WTP. These external factors are critical in understanding consumers' motivations toward green products ([Li et al., 2022](#)). Additionally, respondents' familiarity with the SR was also measured, as prior knowledge has been found to positively correlate with WTP for green agricultural products ([Bromley, 1995](#)).

## 3.3 Methodology

### 3.3.1 Contingent valuation method

The Contingent Valuation Method, first introduced by [Davis \(1963\)](#), has rapidly become a prominent tool for assessing the value of environmental goods. This method is particularly suited for non-market goods, as it enables researchers to quantify the value that consumers place on environmental benefits and other externalities that are not fully captured by market prices ([Bromley, 1995](#); [Bateman and Willis, 2001](#); [Adams et al., 2008](#); [Senyolo et al., 2014](#); [Johnston et al., 2017](#)). While shrimp rice is traded as a commodity, its environmentally friendly attributes, such as reduced pesticide usage and sustainable farming practices, generate non-market benefits. These attributes are externalities that improve environmental and public health but are not fully reflected in its market price. Thus, the environmental benefits associated with shrimp rice can be classified as non-market goods, and the CVM is appropriate for estimating consumers' WTP for these non-market benefits.

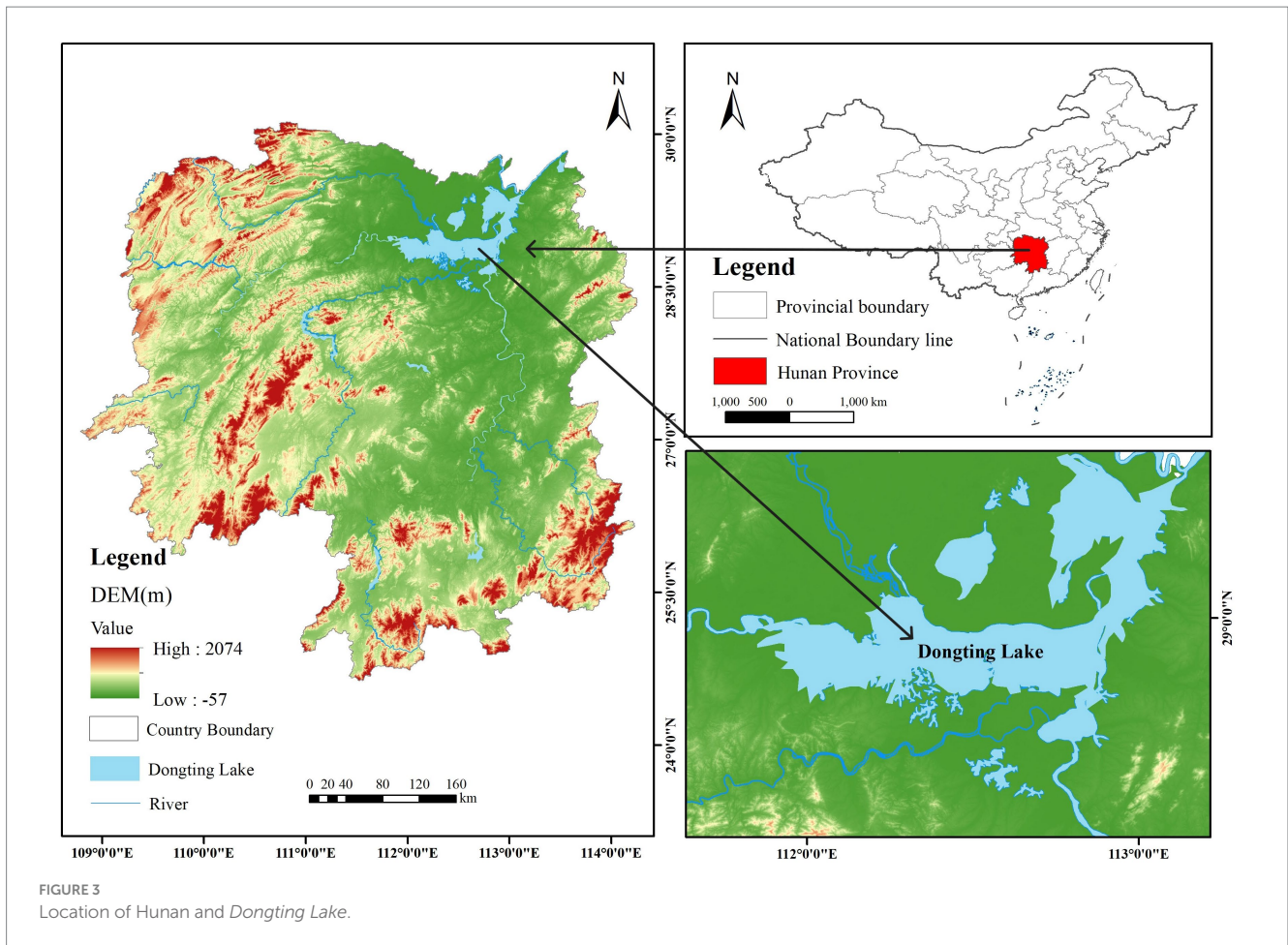


FIGURE 3 Location of Hunan and Dongting Lake.

The effectiveness of CVM in accurately capturing respondents' WTP largely depends on the elicitation techniques and question design employed (Senyolo et al., 2014). Existing literature categorizes these techniques into two types: continuous CVM and discrete CVM. Continuous CVM can be further subdivided into three specific approaches: repetitive auction, open-ended questions, and payment card formats (Chen, 2020). Among them, the payment card format is particularly prevalent, as it presents participants with a range of potential premiums they might be willing to pay. From these options, participants select the amount that most closely aligns with their WTP (Fu et al., 1999). In addition, this approach also offers participants predetermined premium amounts, effectively reducing the likelihood of rejection (Gil et al., 2000; Boccaletti and Nardella, 2000; Masud et al., 2015; Denant-Boemont et al., 2018; Neckel et al., 2020; Ke et al., 2022; He et al., 2022). Therefore, this study has adopted the payment card technique to measure consumers' premium for SR, ensuring a robust assessment of consumer attitudes toward this innovative agricultural product.

Given the hypothetical nature of the market, it is essential to acknowledge the potential discrepancies between this setting and actual market conditions, a phenomenon known as hypothetical bias (Seip and Strand, 1992). To mitigate this bias, researchers have implemented several strategies. First, a pre-survey is conducted to better understand the characteristics of the virtual market, allowing for the optimization of questionnaire design based on these insights

(Thapa et al., 2021). Second, the use of illustrated pamphlets has been employed to create a more tangible representation of the market for respondents. Consequently, at the beginning of the formal questionnaire, we provided a concise introduction to shrimp rice and adjusted the payment card's premium range accordingly based on the pre-test.

The payment card technique does not necessitate advanced statistical methods, as the survey data directly measures respondents' premium level. The average premium level is typically calculated using the median of the intervals presented (Feng et al., 2018; Bamwesigye et al., 2020). The formula (Equation 1) utilized to measure consumers' premium is outlined below.

$$E(WTP) = \sum_{k=1}^n D_k P_k \tag{1}$$

E denotes the anticipated premium that buyers are prepared to spend,  $D_k$  denotes the choice  $k$  chosen by a consumer, and  $P_k$  denotes the probability that the consumer chooses  $k$ .

### 3.3.2 Model setting

The Ordinary Least Squares (OLS) was first adopted for analyzing the factors that affect consumers' WTP and premium. The formula (Equation 2) is as follows:

TABLE 1 Description of explanatory variables used in the model.

Variables	Description
<b>Dependent variables</b>	
Willingness to pay	Dummy; 1 if willing, 0 otherwise
Premium level	The amount of premium that buyers are prepared to pay (Continuous)
<b>Demographic characteristics</b>	
Familiarity	Knowledge of shrimp rice (Continuous)
Age	Number of years (Continuous)
Gender	Dummy; 1 if the respondent is male and 0 if otherwise
Educational status	Degree of education (Continuous)
Marital status	Dummy; 1 if the respondent is married, 0 otherwise
Income	Level of Income (Continuous)
Household size	Number of family members (Continuous)
Children	Dummy; 1 if yes, 0 otherwise
Elder	Dummy; 1 if yes, 0 otherwise
<b>Consumption habits</b>	
Purchase frequency	Level of purchase frequency (Continuous)
Packaging preference	Dummy; 1 if packaging in bulk, 0 otherwise
Purchase preference 1 (Brand)	Dummy; 1 if yes, 0 otherwise
Purchase preference 2 (Price)	Dummy; 1 if yes, 0 otherwise
Purchase preference 3 (Date)	Dummy; 1 if yes, 0 otherwise
Purchase preference 4 (Flavor)	Dummy; 1 if yes, 0 otherwise
Purchase channel 1 (Supermarket)	Dummy; 1 if yes, 0 otherwise
Purchase channel 2 (Online)	Dummy; 1 if yes, 0 otherwise
<b>External cognitions</b>	
Safety cognition	Level of safety cognition (Continuous)
Policy cognition	Level of policy cognition (Continuous)
Environment cognition	Level of environment cognition (Continuous)
Psychology cognition	Level of psychology cognition (Continuous)
<b>Consumption motivations</b>	
Safety motivation	Level of safety motivation (Continuous)
Policy motivation	Level of policy motivation (Continuous)
Environment motivation	Level of environment motivation (Continuous)
Psychology motivation	Level of psychology motivation (Continuous)

$$y_i = \beta_0 + \alpha_1 X_i + \mu_i \tag{2}$$

where  $y_i$  denotes the specific premium buyers are prepared to shell out. For the  $i$ th number of consumers,  $X_i$  is the observable variable that affects the premium, and  $\mu_i$  stands for random error terms. Generally, ensuring complete randomness in the sample selection is challenging, resulting in a sample that may not adequately represent the broader population. This inadequacy can lead to biased model

estimates (Lee, 1978). We refer to this phenomenon as sample selection bias, which can be effectively addressed using Heckman's two-step model (Fisunoğlu and Şengül, 2011; Heckman, 1979).

Heckman's two-step model comprises two components: the selection equation and the outcome equation (Certo et al., 2016). This methodology offers two primary advantages. First, as previously mentioned, it effectively addresses the issue of sample selection bias (Song et al., 2020; Qian et al., 2016). By employing Probit model in the first stage and OLS in the second stage, errors in the model are minimized. Second, this approach enhances the representation of the underlying data generation process, thereby improving the model's fit. The integration of the selection equation in the initial step and the payment equation in the subsequent step creates a cohesive research framework, making it more intuitive to capture variations in the data and thus enhancing the accuracy of estimation results.

Moreover, given that rice is a staple food in the surveyed region, characterized as a necessity, the quantity of shrimp rice purchased is minimally influenced by price fluctuations. In the first phase, a binary selection Probit model is employed to assess whether consumers are willing to pay for shrimp rice, which can be formulated as Equation 3.

$$P(0,1) = C_0 + C_1 X_1 + C_2 X_2 + \dots + C_n X_n + \varepsilon_i \tag{3}$$

$P$  stands for the likelihood that a customer will pay more for shrimp rice.  $p = 1$  indicates that customers are willing to pay a premium. Otherwise,  $p = 0$ .  $C_0, \dots, C_n$  are constants, representing the regression coefficients. The random error term is represented by  $\varepsilon_i$ , and the explanatory variables are denoted by  $X_1, \dots, X_n$ . The OLS technique, which is the second step of the model, aims to explain the elements influencing the premium level if the public displays WTP for shrimp rice. For the second step, the formula (Equation 4) can be expressed as follows.

$$Y_i | P > 0 = C_0 + C_1 X_1 + C_2 X_2 + \dots + C_n X_n + C_{n+1} \lambda + \varepsilon_i \tag{4}$$

$Y_i$  stands for the explained variable of the second step regression model, which is the premium of consumers.  $\lambda$  represents the IMR. Introducing  $\lambda$  into the outcome equation can overcome the selectivity bias. If  $\lambda$  is significant, it indicates that there is an obvious bias in sample selectivity, which means that it is appropriate to use Heckman two-step model for this study. Additionally, this study involves many variables, which may lead to multicollinearity problems. Therefore, this study conducted a multicollinearity test. The mean VIF is 1.78 and the maximum and minimum VIF values are 4.32 and 1.02, respectively, all less than 10. Therefore, there is no multicollinearity among the variables in this study.

## 4 Results

### 4.1 Demographic characteristics of respondents

The selection of the variables utilized in this study is shown in Table 2. Of the 1,158 respondents surveyed, 61.5% were female. This gender distribution may reflect the traditional division of labor within

TABLE 2 Descriptive statistics of the participants.

Variable		Frequency	Percentage (%)	Range	Mean (S.D)
Familiarity	Familiar	333	28.8	1–3	1.92
	Less familiar	582	50.3		
	Unfamiliar	243	21.0		
Age	<18	12	1.0	1–5	2.98
	18–35	370	32.0		
	36–45	421	36.4		
	46–60	338	29.2		
	>60	17	1.5		
Gender	Male	446	38.5	0–1	0.39
	Female	712	61.5		
Education	Elementary school or below	70	6.0	1–6	3.51
	Junior high school	204	17.6		
	Senior high school	193	16.7		
	College	523	45.2		
	Graduate	91	7.9		
	Ph.D. or above	77	6.6		
Marriage	Married	810	69.9	0–1	0.7
	Single	348	30.1		
Income	<3,000	131	11.3	1–7	3.07
	3,000–4,999	271	23.4		
	5,000–10,000	408	35.2		
	10,000–15,000	196	16.9		
	15,000–20,000	78	6.7		
	20,000–30,000	31	2.7		
	>30,000	43	3.7		
Household size	1	19	1.6	1–6	3.98
	2	90	7.8		
	3	286	24.7		
	4	402	34.7		
	5	218	18.8		
	> = 6	143	12.3		
Obs	1,158				

Chinese households. This is consistent with findings from Di Vita et al. (2022), who observed that women are often more attuned to health and environmental benefits of food products, leading to a higher WTP for green food. Additionally, over 70% of respondents were familiar with SR, suggesting a high awareness and recognition of this product among consumers and consumers under the age of 45 dominate our sample at nearly 70%.

In terms of educational attainment, 59.7% of respondents held a bachelor's degree and 16.7% had completed senior school, with these categories collectively accounting for almost 76.4% of the sample. Educational level plays a critical role in shaping household socioeconomic status as well as awareness of environmental and food safety issues (Babar et al., 2010). Regarding marital status, approximately 70% of the respondents were married. Household size data showed that 59.4% of families consisted of 3 to 4 members, with another 18.8% comprising 5 members.

In terms of income distribution, 58.63% of respondents reported a household income between 3,000 and 10,000 yuan per month, and nearly 30% had a household income of 10,000 yuan or more. The estimated *per capita* income in Hunan was RMB 8,815.5 (approximately US\$ 1,214.06). These demographic factors are pivotal in understanding consumer behaviors, providing a foundation for further analyzing the determinants of WTP and the associated premium.

## 4.2 Willingness to pay

Figure 4 illustrates that nearly half of the surveyed consumers are willing to pay a premium for shrimp rice. Among those who indicated a willingness to pay, the majority (77.4%) are inclined to accept a premium within the range of 1 to 50%. This is followed by 18.4% of



consumers who are prepared to pay a premium ranging from 51 to 100%, while only a small proportion, 1.6%, are willing to pay a premium between 101 and 150%. These results reflect consumers' preference for environmentally friendly agricultural products, in line with findings from other studies in similar contexts. For instance, a study by Wang et al. (2022) on low-residue vegetables in China found that consumers had a positive WTP for products with fewer pesticides.

Moreover, only 22.6% of consumers pay more than 50%, which means that the market for SR in Hunan Province, China, remains not yet well-developed. The premium for SR can be calculated as Equation 5.

$$E(WTP) = \sum_{k=1}^n D_k P_k = 25.5\%P_1 + 75.5\%P_2 + 125.5\%P_3 + 175.5\%P_4 + 225.5\%P_5 + 275.5\%P_6 + 325.5\%P_7 = 25.85\% \quad (5)$$

As demonstrated in Table 3, the average premium rate stands at 25.85%, which can be comparable to the 20% premium reported in studies on improved pork quality in Vietnam, where consumers were willing to pay for enhanced food safety (Ngo et al., 2023).

Furthermore, the premium rate is also within the range of premiums reported for similar green products in various markets, such as the 28-cent premium for organic edamame in the U.S. market (Lord et al., 2021). This translates to an actual WTP of 7.17 yuan per kilogram for SR, including a premium of 1.47 yuan per kilogram. Given that the annual per capita rice consumption in Hunan is 75.6 kilograms, this results in an additional annual expenditure of 111.13 yuan per person for purchasing SR. These figures highlight the current limitations in consumer adoption and the potential for further market expansion.

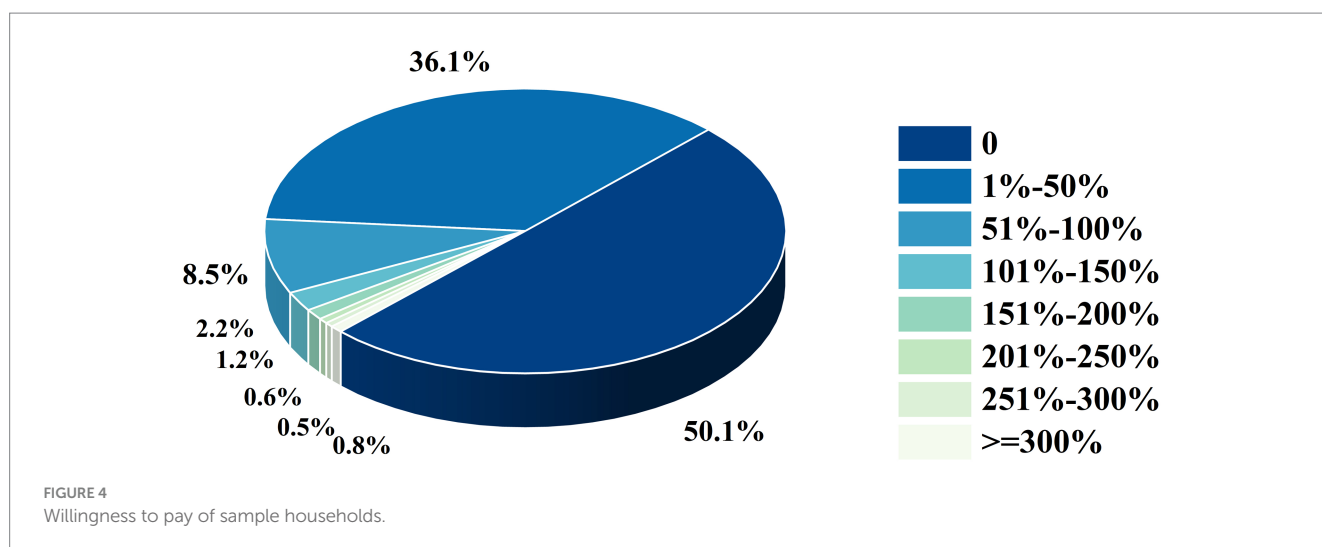
### 4.3 Consumption habits of the respondents

Our results reveal that taste remains a critical factor in consumer preferences, with 37.74% of consumers prioritizing flavor when selecting rice. This finding is supported by studies like Petrontino et al. (2024), which found that sensory attributes such as taste were key drivers of consumer choice for sustainable products. The preference

for certification marks (31%) further emphasizes the importance of trust and quality assurance in driving WTP, a factor similarly highlighted by Puteri et al. (2022) in their research on suboptimal organic fruits. Similarly, consumers increasingly value brands or certification labels to ensure that the product meets their standards for quality and sustainability. Additionally, studies from other regions, such as Germany and Thailand, also show that consumers exhibit a WTP for traceable, eco-friendly labels on products like rice and vegetables. For instance, Boonkong et al. (2023) reported that Chinese consumers were willing to pay a significant premium for green certifications on rice, a trend that resonates with our findings on shrimp rice. This preference reflects the awareness of and demand for agricultural products that are not only safe and nutritious but also contribute to environmental preservation.

From the perspective of purchase channels, the majority of consumers (65.5%) prefer to buy rice from supermarkets, while only 3.5% choose to purchase online, as illustrated in Table 4. Supermarkets are often favored for their convenience and the variety of products they offer. Typically located in urban or town centers, supermarkets provide consumers with the ability to purchase a wide range of food and household items in one place, which is a crucial factor for those with busy modern lifestyles. Moreover, supermarkets offer a diverse selection, including ordinary rice, brown rice, glutinous rice, and other specialty types, allowing consumers to tailor their purchases to their specific tastes and needs. This extensive variety enhances shopping flexibility and caters to the preferences of different households. Despite the growing popularity and success of online shopping across various sectors in China, many consumers still prefer traditional offline channels when purchasing staple foods like rice. This preference is mainly driven by concerns regarding product quality, as consumers may feel less confident about assessing the quality of rice through online platforms, where they cannot physically inspect the product (Peng et al., 2022).

In terms of packaging preferences, over 90% of consumers opt for pre-packaged rice, with only 9.8% choosing to buy rice in bulk. This trend could also be attributed to the fast-paced nature of contemporary life, where consumers tend to favor packaging that offers convenience and ease of transport, aligning with consumer expectations for a more streamlined and efficient shopping experience.



### 4.4 Motivation and cognition of the respondents

Model 1 serves as the baseline model, only incorporating demographic characteristics of respondents as independent variables. Model 2 expands upon these by integrating seven consumer preference variables. Model 3 is further developed by including 8 motivational and cognitive variables. Model 4 is derived by adding an interaction variable that captures the interplay between motivation and cognition based on Model 3. This interaction variable is calculated as the product of the mean values of four motivational variables and four cognitive variables. This approach accounts for the moderating effect of consumer cognition on their motivations, thus providing a more realistic representation of the decision-making process. As presented in Table 5, the interaction variable meets the 1% significance threshold, and Model 4 exhibits the lowest IMR (1.775), indicating that the influence of cognitions on motivations is significant and that our research framework is appropriate. Therefore, this paper proceeds to analyze

the factors influencing consumers' WTP and premium based on the findings from Model 4.

In the decision equation of Model 4, several variables demonstrate a significant positive impact on consumers' WTP for SR at the 1% level. These include familiarity with shrimp rice, education, income, safety motivation, and psychological motivation. Conversely, the price variable exhibits a significant negative effect at the same level. In addition, variables of purchase frequency, policy motivation, purchase channel 1, and environmental motivation have a positive impact on WTP at a significant level of 5% and variables of gender, children, the elderly, and policy cognition at a significant level of 10%.

Turning to the payment equation in Model 4 (Tables 5, 6), several variables continue to exert significant positive influences on the premium. Specifically, variables of familiarity with shrimp rice, gender, age, education, children, the elderly, income, purchase frequency, purchase channel 1, policy cognition, psychological cognition, safety motivation, environmental motivation, policy motivation, and psychological motivation have a positive impact on premium at a significant level of 1% and at the same time, variables of safety cognition and environmental cognition at the 5% level and the 10% level, respectively. Conversely, the price variable, along with household size, purchase preference 1, purchase preference 3, and purchase preference 4, demonstrates a significant negative impact on premium at the 1% significance level and packaging variable at the 5% significance level.

The demographic characteristics of respondents indicate that older, highly educated men with familiarity with SR are more likely to pay a higher premium. Research suggests that men tend to focus more on product attributes and performance during shopping, making them more inclined to understand the health benefits of SR (Sanlier and Karakus, 2010), in line with the previous conclusion that men

TABLE 3 Estimated results of consumers' premium for shrimp rice.

Item	Value
Premium ratio (%)	25.85
Price of conventional rice (¥/kg)	5.70
Premium of shrimp rice (¥/kg)	1.47
WTP for shrimp rice (¥/kg)	7.17
Per capita rice consumption (kg)	75.60
Value added in payment of shrimp rice (¥)	111.13

Data from OECD-FAO Agricultural Outlook, World Bank, and World Development Indicators.

TABLE 4 Descriptive statistics of consumption habits.

Variables	Frequency		Ratio (%)	
	Yes	No	Yes	No
<b>Purchase frequency</b>				
0–1	660	498	56.99	43.01
2–3	421	737	26.65	73.35
4–5	52	1,106	4.51	95.49
>5	25	1,133	2.16	97.84
<b>Purchase preference</b>				
Purchase preference 1 (Brand)	359	799	31.00	69.00
Purchase preference 2 (Price)	183	975	15.80	84.20
Purchase preference 3 (Date)	101	1,057	8.72	91.28
Purchase preference 4 (Flavor)	437	721	37.74	62.26
<b>Purchase channel</b>				
Purchase channel 1 (Supermarket)	758	400	65.50	34.54
Purchase channel 2 (Online)	40	1,118	3.50	96.50
<b>Packaging preference</b>				
In bulk	113	1,045	9.80	90.20
In bags	1,045	113	90.20	9.80

TABLE 5 Regression estimation results of Heckman two-step (Model 4).

Variables	OLS		WTP I		Premium II	
	Coefficient std. err.	t value	Coefficient std. err.	z value	Coefficient std. err.	t value
Purchase frequency	0.257***	5.98	0.171**	2.56	0.395***	8.42
	0.043		0.067		0.047	
Packaging	-0.023	-0.25	-0.180	-1.25	-0.251**	-2.58
	0.093		0.143		0.097	
Brand	-0.234**	-1.99	-0.187	-1.01	-0.420***	-3.54
	0.117		0.185		0.119	
Price	-0.521***	-4.07	-0.645***	-3.22	-1.214***	-7.45
	0.128		0.200		0.163	
Date	-0.423***	-3.00	-0.295	-1.37	-0.706***	-4.88
	0.141		0.216		0.145	
Flavor	-0.394***	-3.38	-0.268	-1.47	-0.631***	-5.27
	0.117		0.182		0.120	
Supermarket	0.035	0.56	0.216**	2.31	0.304***	4.19
	0.062		0.093		0.073	
Online	-0.082	-0.52	0.076	0.32	0.041	0.26
	0.157		0.237		0.155	
Safety cognition	0.057	1.46	0.024	0.41	0.079**	2.07
	0.039		0.059		0.038	
Environment cognition	0.054	1.61	0.015	0.31	0.063*	1.92
	0.033		0.051		0.033	
Policy cognition	0.015	0.52	0.082*	1.84	0.093***	3.06
	0.029		0.045		0.031	
Psychology cognition	0.075***	2.63	0.044	1.01	0.122***	4.23
	0.029		0.043		0.029	
Safety motivation	0.248***	5.01	0.371***	4.90	0.629***	8.40
	0.049		0.076		0.075	
Policy motivation	0.061	1.20	0.155**	2.03	0.226***	4.08
	0.051		0.076		0.055	
Environment motivation	0.053	1.09	0.175**	2.41	0.271***	4.66
	0.049		0.072		0.058	
Psychology motivation	0.090**	2.31	0.190***	3.18	0.275***	5.82
	0.039		0.060		0.047	
Cognition * motivation	0.237***	3.7	0.110	0.36	0.206***	3.27
	0.064		0.121		0.063	
Marriage			0.091	0.506		
			0.136			
IMR					1.775***	6.69
					0.265	
Cons	0.647***		-1.370***	0.00	-2.261***	-4.58
	0.238		0.380		0.493	

\*, \*\* and \*\*\* indicate significance at 10, 5 and 1% levels, respectively.

TABLE 6 Basic characteristics of respondents.

Variables	OLS		WTP I		Premium II	
	Coefficient std. err.	t value	Coefficient std. err.	z value	Coefficient std. err.	t value
Familiarity	0.136***	3.15	0.171***	2.64	0.303***	6.17
	0.043		0.065		0.049	
Gender	0.171***	2.89	0.171*	1.90	0.354***	5.51
	0.059		0.090		0.064	
Education	0.030	1.17	0.133***	3.35	0.161***	5.07
	0.025		0.040		0.032	
Age	0.068*	1.93	0.040	0.55	0.139***	3.84
	0.035		0.073		0.036	
Children	0.062	1.02	0.155*	1.65	0.249***	3.78
	0.061		0.094		0.066	
Elder	0.118**	1.97	0.167*	1.84	0.300***	4.63
	0.060		0.091		0.065	
Income	0.153***	7.01	0.104***	3.06	0.258***	9.72
	0.022		0.034		0.027	
Household size	-0.043	-1.59	-0.066	-1.63	-0.119***	-4.15
	0.027		0.041		0.029	

\*, \*\* and \*\*\* indicate significance at 10, 5 and 1% levels, respectively.

typically show a greater willingness to pay a premium for green products compared to women (Hustvedt and Bernard, 2008; Kostakis and Sardianou, 2012; Djahini-Afawoubo and Atake, 2018; Sarmiento and El Hanandeh, 2018). As we all know, health concerns tend to increase with age (Mioche et al., 2004; Wolfe et al., 2008; Robu et al., 2021; Liu and Ma, 2016), and older individuals often have greater financial stability, enabling them to afford a higher premium for SR. Additionally, higher education is linked to stronger information processing capabilities, which allows educated individuals to better appreciate the value-added aspects of SR. Higher education also correlates with higher socioeconomic status and income (Cuñado and De Gracia, 2012), making these individuals more accepting of higher premiums.

The study also found that households with high income but smaller size, particularly those with children and elderly members, exhibit a higher WTP. High-income families generally have more financial capacity and environmental awareness, and purchasing green products like SR may also be seen as fulfilling social responsibilities. Larger households tend to include more economically dependent members, such as children and the elderly, reducing disposable income *per capita*. At the same time, due to their weaker immune systems, they are more vulnerable to food safety risks, making green foods a better choice for their needs. In examining consumption habits, it is evident that consumers who purchase rice more frequently are more likely to encounter SR, thereby increasing their likelihood of purchasing this product with higher prices. However, if the brand image of SR fails to convey high quality and added value, price-sensitive consumers may prefer lower-priced traditional rice. Additionally, consumers who favor purchasing rice from supermarkets tend to exhibit a greater willingness to pay a higher premium for SR,

likely due to their heightened expectations regarding product quality. From the perspective of consumer motivations and cognitions, safety and environmental cognitions appear to be more prominent than policy and psychological ones. Consumers may lack sufficient information to fully understand the cultivation and farming processes associated with SR. This lack of knowledge can lead to misconceptions, such as the belief that mixed farming practices may result in contamination or disease transmission, which can breed skepticism towards new agricultural models. Recurring food safety incidents may also engender a cautious attitude among consumers toward all food products, including innovative agricultural offerings. Meanwhile, if consumers remain unaware of current environmental challenges, they may fail to connect their purchasing decisions with the broader imperative of environmental protection, which may cause consumers to prioritize immediate economic advantages over long-term environmental considerations.

In comparing the decision equation with the payment equation, it becomes evident that several variables, including gender, the children, the elderly, purchase frequency, purchase channel 1, safety cognition, policy cognition, psychological cognition, policy motivation, and environmental motivation, exert a more substantial influence on the premium than on the WTP. Conversely, variables of age, household size, packaging, purchase preference 1, purchase preference 3, purchase preference 4, purchase channel 2, safety cognition, environmental cognition, and psychological cognition demonstrate significance in the payment equation but no significance in the decision equation. This distinction implies that these variables play a lesser role in determining whether consumers are willing to pay for SR, but they are crucial in influencing the specific premium.

After addressing both endogeneity and sample selection issues, the interaction variable exhibits a positive impact on the premium, achieving significance at the 1% level. Additionally, the coefficient of IMR in model 4 shows a slight decrease following the inclusion of the interaction variable. This suggests that the bidirectional causality between cognition and motivation may lead to an underestimation of the influence that cognitions exert on motivations. These findings highlight the complexity of consumer behaviors in relation to SR, indicating that different factors may have different effects at different stages of purchasing. Understanding this nuanced difference is essential for effectively targeting marketing strategies and enhancing consumer cognition regarding the value of SR.

#### 4.5 Comparison of the OLS and Heckman two-stage model

This study conducts a comparative analysis of the anticipated outcomes derived from both the OLS method and the Heckman two-step estimation to validate the rationality of the expected impacts of various variables on the public's WTP and premium for SR. Both [Tables 5, 6](#) present a comparison of results obtained through OLS and Heckman two-step estimation, highlighting partial inconsistency in the significance of various variables.

From the perspective of demographic characteristics and socio-economic attributes, the OLS method underestimates the significance of age and the elderly variables in determining premium and the variables of education, children, and household size achieve significance at the 1% level within the Heckman model. When examining consumption habits, the variables of packaging and purchase channel 1, which fail to reach significance in the OLS estimation, demonstrate significant results in the Heckman two-step model. Additionally, purchase preference 1 exhibits a significant negative impact at the 5% level in the OLS model but 1% level in the Heckman model.

In terms of cognition and motivation, variables such as safety cognition, environmental cognition, policy cognition, policy motivation, and environmental motivation do not pass the significance test in the OLS framework. However, after applying corrections through the Heckman model, these variables reveal varying degrees of significance.

#### 4.6 Matching balance test

This study systematically excluded respondents younger than 18 and older than 60 to further assess the robustness of the measurement results. This exclusion helps ensure that the model's outcomes are not unduly influenced by specific sample characteristics or outliers but instead reflect authentic relationships within the broader population. Upon removing these extreme values, the results of the model (as detailed in [Appendix 7](#)) remain basically consistent with the result of Model 4. This consistency bolsters confidence in the study's findings and underscores the robustness of the results. Thus, the analysis effectively captures the dynamics of consumer behavior regarding WTP for SR.

## 5 Conclusions and implications

### 5.1 Conclusion

In our research, we estimated consumers' WTP, and premium associated with shrimp rice in Hunan, China, employing the CVM and the Heckman Two-Step model. The findings are as follows. First, approximately half of the consumers expressed a willingness to pay a premium for shrimp rice, with an average premium rate of 25.85% and a monetary premium of 1.47 yuan per kilogram. Second, older, highly educated men, as well as high-income, small-scale households with children and elderly members, demonstrates a greater propensity to pay a higher premium for this product. These insights provide a valuable basis for identifying key consumer segments for targeted marketing and promotion of shrimp rice. Third, consumer preferences indicate a strong inclination towards purchasing rice in bags from supermarkets, with those who buy rice more frequently exhibiting a higher WTP. Finally, various cognitive and motivational factors significantly influenced the premium to varying degrees. Specifically, policy cognition, psychological cognition, safety motivation, policy motivation, environmental motivation, and psychological motivation all positively impacted the premium at a significant level of 1%. Additionally, safety cognition and environmental cognition were found to significantly affect the premium at significance levels of 5 and 10%, respectively. Importantly, our study reveals that consumers' motivations can be amplified by their cognition, thereby increasing their premium level.

### 5.2 Implications

The findings from this research highlight several strategic imperatives for stakeholders involved in environmentally sustainable agriculture, particularly regarding shrimp rice. The following recommendations aim to enhance the marketability and sustainability of this product. First and foremost, it is crucial to establish reasonable pricing for shrimp rice to ensure that it remains affordable for consumers while also ensuring the economic viability of producers. A fair pricing strategy is essential for the long-term success of shrimp rice, facilitating the transition to sustainable agricultural practices and contributing to national food security. Secondly, collaboration between enterprises and government entities is imperative to improve consumers' cognition and understanding of shrimp rice. This can be achieved through community-based initiatives and educational programs designed to build trust and foster brand loyalty among consumers. Third, operators should leverage multimedia platforms, such as short videos and popular science articles, to engage younger audiences in discussions about environmental protection and sustainable agricultural practices. Establishing and regularly updating official websites and social media accounts dedicated to shrimp rice will facilitate direct interaction with consumers, allowing for timely responses to their needs and feedback. Fourth, it is important for operators to strategically select distribution channels that effectively promote shrimp rice to the target consumer demographic. Utilizing digital platforms will broaden outreach, while marketing strategies should be tailored to resonate with consumer preferences and behaviors. Finally, industry stakeholders should encourage consumer engagement through initiatives such as sample tastings and feedback

rewards. This approach not only helps in establishing a robust customer service system but also maximizes exposure to shrimp rice and enhances its market penetration.

## Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/ participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

RZ: Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. YY: Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2024.1465425/full#supplementary-material>

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