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Can carbon labels shift consumers towards sustainable food? Evidence from Chinese consumers

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ARTICLE INFO	ABSTRACT
Keywords: Carbon-labeled agricultural products Willingness to pay Theory of planned behavior Norm activation model China	Carbon labels are becoming an essential tool for policymakers in many countries to promote low-carbon con- sumption. To assess customers' willingness to pay for five carbon-labeled agricultural products (CAP), we used payment card to conduct a questionnaire survey among 641 respondents in Shanghai, Nanjing, Wuhan, and Xi'an, all located in China. This study quantitatively analyzes the influencing factors and interactive mechanisms of the public's willingness to purchase CAP through the extended Theory of Planned Behavior and Norm Acti- vation Model. The results show that consumers' willingness to pay a premium for carbon-labeled milk, corn, bananas, tomatoes, and eggs is 27.50 %, 29.73 %, 26.86 %, 26.51 %, and 24.26 % respectively. Perceived behavioral control has the strongest positive influence on purchase intention, followed by subjective norms, attitudes toward the behavior, and personal norms. There is a significant mediating effect between awareness of consequences and personal norms, which indirectly influences personal norms through the ascription of re- sponsibility and subsequently affects purchase intention. Additionally, there is a gap between purchase intention and behavior, and risk perception negatively moderates the relationship between the two. Based on the research findings of this paper, practical and effective policy suggestions are proposed for the government to promote carbon labeling policies and reduce carbon emissions.

1. Introduction

There is growing awareness of the impact of food choices on climate change. The food system is estimated to be responsible for 26-34 % of global greenhouse gas (GHG) emissions [1,2]. Recent modeling indicates that even if fossil fuel emissions were to cease immediately, current trends in the world's food system would make it challenging to achieve the IPCC's 1.5 °C objective. By the end of the century, these trends would threaten the 2 °C goal [3]. Though food producers should focus on lessening their environmental impact, consumer behavior changes can also impact production system improvements [2]. Shifting to low-carbon footprint diets has the potential to significantly decrease carbon emissions and alleviate the strain on the environment [4–6]. Accordingly, carbon label products are a good low-carbon consumption orientation, and customers can reduce their carbon footprint by purchasing food that is less harmful to the environment [7,8].

Among the policy tools used to promote the development of low-

carbon economy, carbon labels have been implemented in several countries, such as the United Kingdom, Germany, France, Sweden, and the United States [9]. Carbon labels refer to using quantitative measures on product labels to indicate the amount of greenhouse gas released during production [10]. According to Edwards-Jones et al. [11], carbon labels can help reduce greenhouse gas emissions. Regarding corporate emissions reduction, Shi [12] pointed out that carbon labels can bring economic benefits to companies, such as reducing emissions and achieving cost savings. At the consumer level, providing information to consumers about the carbon content of products through labels can assist them in making informed decisions about purchasing low-carbon products. This, in turn, contributes to the overall reduction of carbon emissions [13]. Despite the need for a significant change in personal food consumption, research indicates that people rarely consider their dietary choices when asked what they can do to help the environment [14] and often underestimate the environmental impact of their food [15,16]. Meanwhile, in some cases, consumers may be reluctant to pay more for carbon-labeled products. The general lack of awareness

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Nomen	clature
Abbrevia	itions
ATT	Attitudes toward the behavior
AR	Ascription of responsibility
AC	Awareness of consequences
CAP	Carbon-labeled agricultural products
CVM	Contingent valuation method
LA	Low-carbon awareness
NAM	Norm Activation Model
PBC	Perceived behavioral control
PN	Personal norms
РК	Personal knowledge of CAP
PB	Purchase behavior
PI	Purchase intention
RP	Risk perception
SEM	Structural equation modeling
SN	Subjective norms
TPB	Theory of Planned Behavior
WTP	Willingness to pay

regarding how dietary decisions affect the environment remains a major obstacle to reducing emissions of greenhouse gases caused by food [17].

Globally, there is a growing body of research on carbon labeling, particularly regarding how it affects consumer purchasing behavior [18, 19]. Several studies have been done on consumers from various geographic and cultural backgrounds [20]. Nevertheless, even if there have been some preliminary investigations of research on Chinese consumers, such as a study of carbon-labeled beef among urban Chinese customers [21], additional empirical research is required to obtain a deeper understanding of the preferences and behavioral patterns of various consumer groups. Currently, governments, producers, and merchants have not been able to receive comprehensive promotional advice or guidance. To achieve the transition to a low-carbon consumption pattern, China should integrate carbon labeling into a wider range of consumer product categories. To address the research gaps mentioned above, this paper aims to investigate Chinese consumers' perceptions of carbon-labeled agricultural products (CAP), including their willingness to pay and the specific amount they are willing to pay for different types of CAP. The innovations are as follows: firstly, this study creates a more thorough explanatory framework, integrates the Norm Activation Model (NAM) and the Theory of Planned Behavior (TPB), and expands the original model by adding external variables (such as risk perception, low-carbon awareness, and personal knowledge). All these enhancements significantly improve the model's capacity to explain the willingness of the CAP and purchasing behavior. In addition to examining the direct effects of respondents' subjective norms, personal norms, and perceived behavioral control on purchase intentions, the study sheds light on the mediating variables these factors use to affect purchase intentions and behavior. Additionally, this study confirms that risk perception moderates the relationship between buy intention and action, providing a more comprehensive explanation for the inconsistency between consumer intention and behavior when purchasing CAP. Secondly, information intervention is included in the experiment. This study uses an experimental design to explore how providing specific information on carbon labeling affects the public's WTP for CAP and how the certainty that respondents will choose to improve the environment changes. Through empirical research in specific cultural and market backgrounds, we propose policies to promote the implementation of carbon labels at all levels, including government and enterprises, to encourage widespread participation in environmental protection and low-carbon activities, ultimately achieving "carbon reduction for all and benefits for all."

The remainder of the paper is structured as follows: Section 2 presents the theoretical framework and literature review, Section 3 describes the survey's methodology and data collection, Section 4 presents the model's results, Section 5 discusses the findings, and the final section raises policy implications.

2. Literature review and hypotheses

2.1. Carbon labeling concept

There is increasing research on carbon labeling due to the urgent need to transform the global low-carbon economy. Carbon labels can successfully and effectively raise consumer understanding of the emissions of more environmentally hazardous foods, which can then help consumers choose more environmentally friendly food options [17]. Rating labels are more effective in guiding consumers to more sustainable products than positive and negative labels [22]. Edenbrandt & Lagerkvist [23] investigated consumer willingness to substitute high-emissions meat products with lower-emissions protein products, including blends of meat and vegetables. They found the traffic light carbon label affects choice behavior. In Canada and Argentina, younger consumers in the Americas exhibit differing perceptions of carbon labeling, with those who are more educated demonstrating a preference for the traffic light carbon label [24]. The greatest impact is observed when carbon footprint information is expressed in monetary units and color-coded in a manner analogous to the traffic signal system [25]. Traffic light labels are most effective in reducing carbon emissions, providing empirical support for the design of carbon labels [26,27]. However, there are also studies that carbon labels don't succeed in attracting people's attention when customers are unguided [28]. Carbon labeling has a positive but small impact on sustainable food choices [29]. As consumer trust in the label grows, carbon labeling boosts the perceived environmental sustainability of animal-based products but not that of plant-based products.

Additionally, the "halo effect" of plant-based foods may lessen the effects of carbon labeling [30]. To change consumer behavior, consumers must develop trust in labels and the organizations behind them [31]. This trust and positive attitude remarkably influence the WTP and the positive effect of policy measures on consumers' WTP [32]. Interestingly, family and peer influences are more likely to affect consumers' purchasing decisions than media exposure. This would appear to emphasize the importance of social dynamics in promoting environmentally friendly consumption [33,34].

By combining the results of these studies, we may conclude that carbon labeling may encourage sustainable consumption, but its effects may be affected by cultural, social, and psychological factors. In addition to enhancing our knowledge of the mechanisms underlying the effects of carbon labeling, integrating national and international research offers a solid scientific foundation for creating more focused environmental regulations and marketing strategies. Future research could further explore the best practices of carbon labeling in different cultural contexts and how to combine socio-cultural factors to improve its acceptance and effectiveness in the global market.

2.2. Theory of planned behavior

The TPB model has its roots in psychological and sociological theories and is based on the Theory of Rational Behavior [35]. TPB, proposed by Ajzen [36], is the classic social psychological model for explaining people's behavioral intentions and actions. It is a powerful and widely used tool for evaluating, modeling, and investigating people's behavior about activities, products, or services [36]. According to the Theory of Planned Behavior, attitudes, subjective norms, and perceived behavioral control impact behavioral intentions. Attitudes toward the behavior refer to the degree to which a person has a favorable or unfavorable evaluation or assessment of the behavior under discussion. Subjective norms represent the perceived social pressure to engage in a behavior or refrain from doing so. The third antecedent of intention is the degree of perceived behavioral control, which, as we've seen, refers to how easy or difficult the behavior is regarded to be to carry out. This antecedent is thought to reflect prior experience as well as anticipated impediments. The Theory of Planned Behavior suggests that behavioral performance is influenced by behavioral intentions, which are stronger if the individual has a more positive attitude, feels more pressure from external norms, or feels that he or she has more control over his or her behavior [36]. When a person can clearly understand the objective condition restrictions, such as resources and abilities, that he or she requires to conduct a given behavior, perceived behavioral control can also directly influence the occurrence of an individual's behavior.

The TPB model has been widely deployed to study sustainable food consumption behavior. For example, Vermeir and Verbeke [37] conducted a study with young people in Belgium. They found that personal attitudes, perceived social impacts, perceived consumer effects, and perceived availability were key factors influencing sustainable consumption intentions. In a separate study, Alam et al. [38] employed the extended TPB framework to ascertain the factors influencing sustainable food consumption behaviors in Malaysia. Their findings indicated that social norms, perceived value, and perceived consumer effects and attitudes significantly impacted consumption intentions.

In contrast, perceived availability and perceived consumer effects and intentions significantly affected actual behavior. In China, Qi and Ploeger [39] revised and extended the TPB by incorporating face consciousness and group consistency into the model, replacing subjective norms to enhance the model's applicability in Chinese consumers' intentions to purchase green food. They also included confidence and personal characteristics as model components to better reflect the current consumer environment and features. During the COVID-19 pandemic, Qi and Ploeger [40] extended the TPB to include the effects of ethical attitudes, health awareness, and COVID-19 to explain Chinese consumers' green food purchase intentions during the current and post-pandemic periods. According to the findings, Chinese consumers' intentions to purchase green foods are better explained and predicted by the expanded TPB model than by the original TPB model.

In conclusion, the TPB and its extended model provide a solid theoretical foundation for understanding consumers' sustainable food consumption behaviors under different cultural and environmental conditions. However, few studies have used the model to analyze the public's willingness and behavior to purchase CAP and their links with each other. Based on these results, we propose the following hypotheses:

H1. Attitudes toward the behavior (ATT) positively affect purchase intention (PI) in the purchase of CAP.

H2. Subjective norms (SN) have a positive impact on PI for CAP.

H3. Perceived behavioral control (PBC) has a favorable effect on PI in CAP purchasing.

H4. PBC positively influences purchase behavior (PB) in CAP purchasing.

H5. PI positively influences PB in the purchasing of CAP.

2.3. Norm activation model

NAM is a behavioral theory that Schwartz [41] developed to explain and predict individual pro-social behavior. NAM contends that people's pro-social/altruistic intentions and behaviors, such as volunteering their time and helping others, result from their norms, which are inspired by their awareness of problems and obligations [41]. Personal Norms (PN), Awareness of Consequences (AC), and Ascription of Responsibility (AR) are the three primary elements of NAM. The term PN denotes an individual's self-expectations of behaviors in each situation, and AC is the propensity to be aware of the consequences of one's actions on others [41]. The more likely individuals are to perceive situations in terms of the consequences of their actions on others, the more likely they are to attend to the values and norms associated with those interpersonal consequences, creating a sense of obligation to express those norms. AR is a person's sense of whether they are responsible for the consequences of their actions [41].

NAM has become one of the most influential theories [42]. It has been used to study a variety of environmentally friendly behaviors, including drone food delivery services [43], litter reduction and litter picking behaviors [44], and environmentally friendly pest control adoption behaviors [45]. Steg and Groot [46] applied NAM to explain various pro-social and pro-environmental behavioral intentions. They discovered that the interaction between AC, AR, PN, and behavioral intentions is a chain-mediated model, meaning that AC activates PN through AR, leading to PI. According to some researchers, ATT, SN, and PN all indirectly impact consumers' intentions to recycle [47]. Song et al. [48] incorporated SN and environmental concern into an extended NAM, arguing that PN, established by consumers' AC and AR, significantly impacts their behavioral intention. In the context of the topic studied in this paper, consumers' AC and AR may increase their PN, thus leading to support for purchasing CAP.

The study puts out the following hypothesis considering the analyses mentioned above.

- H6. AC has a favorable impact on AR in purchases of CAP.
- H7. AC has a positive influence on PN when purchasing CAP.

H8. AR has a significant positive impact on PN when purchasing CAP.

H9. When consumers buy CAP, PN has a positive effect on PI.

H10. SN has a positive influence on PN when purchasing CAP.

2.4. Extension of TPB and NAM

Applying and expanding theoretical frameworks are essential for a more profound comprehension of consumer behavior within sustainable food consumption. The TPB and NAM frameworks have been extensively utilized to predict and explain the environmental behavior of individuals [49]. Nevertheless, the extension and integration of these theories become especially important as social and environmental challenges become complex. Ajzen [36] states that TPB is an open theory to which additional variables can be added if they capture a significant portion of behavioral differences. Recent studies such as the TPB-NAM integration model have proven superior to the original TPB model when studying factors affecting Vietnamese farmers' intention toward organic agricultural production [50]. He and Sui [51] investigated the willingness of Chinese college students to consume green food by integrating the TPB with the NAM. They found that SN, ATT, and PN were the key factors influencing students' willingness to buy, with ATT having the strongest direct effect on willingness to buy. This work illustrates the function of NAM in promoting the formation of PN while also expanding the application of TPB. The empirical study by Vietnam Le and Nguyen [52] confirms the importance of ATT, social norms, and personal norms in organic food purchase intentions. The study offers new empirical evidence in support of NAM, emphasizing the significant impact of environmental awareness and knowledge about organic food on consumer purchase intentions through attitudes.

Furthermore, Salmivaara et al. [53] provide novel insights into understanding sustainable food choices by delineating the distinction between descriptive and normative social norms. Their research reveals the importance of descriptive norms in actual and expected food choices, while SN fails to show the expected relevance. These findings challenge traditional theories and offer new strategies for influencing consumer behavior through descriptive norms. According to these researches, combining TPB and NAM offers a more thorough analytical framework and highlights the relative significance of various motivating factors in certain cultural and market contexts [54]. We can better understand consumer psychological and behavioral mechanisms when faced with sustainable food choices due to this theoretical extension and in-depth empirical study. This will enable us to develop more useful recommendations and tactics for encouraging sustainable consumption.

Awareness is realizing or comprehending a situation or fact [55]. Resident acceptance and behavioral implementation are positively impacted by their general perception, satisfaction, and positive attitudes [56]. According to Xia et al. [57], raising consumer knowledge of low carbon emissions is advantageous for carbon reduction. Personal knowledge can be defined as the extent to which a consumer is aware of a specific product, service, or situation [58]. Consumers' level of personal knowledge regarding a product can influence their attitudes. For example, Li et al. [10] found that consumers with in-depth knowledge of low-carbon products are more likely to hold positive attitudes, which is consistent with the "ATT" component of the theoretical planned behavior (TPB) proposed by Ajzen [36]. In the context of sustainable consumption, Ding et al. [49] conducted a comprehensive review of the role of personal knowledge in influencing consumer choices towards environmentally friendly products. Studies by Xu and Lin [59] and Qi and Ploeger [39] have demonstrated that personal knowledge is a pivotal factor influencing consumer purchasing intentions, particularly in green and healthy products. In this study, "personal knowledge" describes the respondents' knowledge and understanding of CAP. This knowledge can potentially influence their attitudes, decision-making processes, and, ultimately, their purchasing behavior. According to research on consumer behavior and willingness to pay, risk perception and risk preference are significant factors of food acceptability, which has profound implications for consumer behavior and their willingness to pay [58,60,61]. Bhatti and Ur Rehman [62] examined the relationship between different factors, including perceived benefits, perceived risks, and online shopping behavior, with the mediating role of consumer purchase intention. The findings show that risk perception harms online shopping behavior and that these risks must be minimized to increase their sense of security.

Based on the above theories, this paper integrates the original TPB and NAM models. It adds three external variables (i.e., personal knowledge, low-carbon awareness, and risk perception) to analyze the environmentally friendly behavior of the public's behavioral willingness to purchase CAP. The following hypotheses have emerged, and the research framework is depicted in Fig. 1.

H11. Consumers' ATT is positively impacted by personal knowledge (PK) of CAP.

H12. Low-carbon awareness (LA) among consumers influences their AC to buy CAP.

H13. The association between WTP and PB for CAP is moderated by risk perception (RP).

3. Material and methods

3.1. Contingent valuation method

There are several approaches to elicit individuals' willingness to pay: contingent valuation, choice experiment, and experimental auction [63-65]. The contingent valuation method (CVM) was initially employed in 1958 to analyze non-market prices for recreational services in the Delaware River Basin region of the United States [66]. CVM has been utilized in various applications [59,67]. Typically, CVM employs questionnaires that let respondents explicitly express their preferences for specific goods in monetary terms [68]. The monetary value reported by respondents is generally expressed in terms of willingness to pay, i.e., the maximum monetary value that an individual would be prepared to pay for a hypothetical improvement program [68]. Alternatively, willingness to pay can be the minimum amount an individual will accept as compensation for the change [68]. Also, CVM has mostly been used to measure "preferences for goods or services for which a conventional market does not exist" [69]. The use of CVM is deemed appropriate, and hence, CVM has been chosen for this study.

3.2. Econometric model

Structural Equation Modeling (SEM) is a statistical method for analyzing complex relationships among variables, combining factor and path analysis. Originating in the 1970s, SEM has become popular in economics [70]. It consists of two parts: the measured model, which links observed and latent variables, and the structural model, which connects latent variables. Observed variables are directly measurable,



Fig. 1. Research framework.

while latent variables cannot be measured directly and must be measured with the help of observed variables. The equation of the measurement model is as follows:

$$X = \Lambda_x \xi + \delta \tag{1}$$

$$Y = \Lambda_{\rm v} \eta + \varepsilon \tag{2}$$

The equation of the structural model is as follows:

$$\eta = B\eta + \Gamma \xi + \zeta \tag{3}$$

Table A1 displays the symbols and explanations for the three equations above. Eight latent variables influence consumers' purchase intention and purchase behavior, and a structural equation model is established to study this influence.

3.3. Questionnaire design

Questionnaires are commonly utilized data collection survey tools within contingent valuation method studies [71]. The methodology measures the value consumers place on non-market products and enables researchers to determine attitudes and views. Consequently, this research uses a questionnaire as a data collection instrument.

The questionnaire is split into four blocks. The first part is an introduction to the survey, which introduces the respondents to the topic of the questionnaire, the research organization, and the goal and relevance of the study. Step 1 asks respondents to complete individually a series of questions that captured their initial preferences and willingness to pay without entering any information. In Step 2, terms involved in the questionnaire are explained to improve the comprehensibility of the questionnaire. Based on the theoretical framework of TPB-NAM and combined the current market situation for agricultural products with past research findings ([72]; Oteng-Peprah et al. [73,74]), we have designed a total of 35 measurement questions. All questions were measured on a five-point Likert scale ranging from "completely disagree" to "completely agree" regarding low carbon awareness, ascription of responsibility, perceived behavioral control, perception of risk, and so on (Table 1).

CVM is the main topic of the third section, which concentrates on how to evaluate consumers' willingness to pay and behavior. After examining and contrasting several WTP bootstrapping techniques, we choose to employ the payment card as a bootstrapping mechanism to prevent non-reflective bias in the questionnaire. We also create a survey with two questions to account for protest answers. It consists of sample selection questions and heuristic questions as follows. Regarding "carbon neutral" milk-currently offered for sale in China's agricultural market-respondents are informed that labeling the goods would necessitate measuring greenhouse gas emissions during production and obtaining certification from a third-party organization, which would come at an extra expense to the manufacturer. Next, we asked respondents if they would pay more for CAP. If the answer is "yes", the next leading question is to ask how much extra they/he would like to pay for each CAP. The poll indicates that there are currently carbon-labeled agricultural products on the market, such as "zero-carbon" vegetables and carbon-neutral milk. We choose the representative type of agricultural products among many varieties and talk with the participants in the interviews, considering factors like the types of agricultural products, the availability of each type in different regions, and the frequency of daily consumption by consumers. Using the price data already collected, we inform each respondent about the country's average market price of several agricultural products. At the same time, based on the price, we give specific amounts in percentage increments that the respondents chose their largest willingness to pay. If a respondent answers "no" to the sample selection question, respondents who indicate they are unwilling to pay will be given a series of reasons to explore their intentions. The average willingness to pay in the payment card questionnaire can be determined for discrete variables using the

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Table 1

Definition and description of variables.

Variable	Code	Item	References
Awareness of	AC01	Purchasing high carbon dioxide	[75]
Consequences		emissions from agricultural	
		products will cause serious	
		damage	
	AC02	Purchasing carbon-labeled	
	11002	agricultural products can reduce	
		environmental pollution.	
	AC03	Purchasing carbon-labeled	
		agricultural products can ensure	
		the quality and safety of	
		agricultural products, which	
		benefits us all.	
Ascription of	AR01	As a consumer, I should bear some	[76]
Responsibility		dioxide emissions	
	AR02	I feel responsible for	
	11102	environmental issues caused by	
		not purchasing carbon-labeled	
		agricultural products.	
	AR03	I would feel guilty if I didn't buy	
		agricultural items with carbon	
		labels, contributing to increased	
		carbon dioxide emissions.	
	AR04	I believe that every consumer	
		bears some responsibility for the	
		environmental and social	
		production and consumption of	
		agricultural products	
Attitudes toward	ATT01	I believe that purchasing carbon-	[77]
the Behavior	111101	labeled agricultural products is	[,,]
		beneficial for the environment.	
	ATT02	I believe purchasing carbon-	
		labeled agricultural products is a	
		wise choice.	
	ATT03	Purchasing carbon-labeled	
		agricultural products will make	
		me feel physically and mentally	
		pleasant.	[20]
Low-carbon	LA01	when shopping, I keep plastic	[78]
awareness	LA02	When printing Lactively use both	
	102	sides of each sheet of paper	
	LA03	I often pay attention to articles or	
		reports related to environmental	
		issues.	
Perceived	PBC01	issues. The price of carbon-labeled	[73]
Perceived Behavioral	PBC01	issues. The price of carbon-labeled produce significantly influences	[73]
Perceived Behavioral Control	PBC01	isues. The price of carbon-labeled produce significantly influences my decision to purchase it.	[73]
Perceived Behavioral Control	PBC01 PBC02	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it	[73]
Perceived Behavioral Control	PBC01 PBC02	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a	[73]
Perceived Behavioral Control	PBC01 PBC02	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high	[73]
Perceived Behavioral Control	PBC01 PBC02	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices.	[73]
Perceived Behavioral Control	PBC01 PBC02 PBC03	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have applied	[73]
Perceived Behavioral Control	PBC01 PBC02 PBC03	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits	[73]
Perceived Behavioral Control Purchase	PBC01 PBC02 PBC03 PI01	The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon-	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01	The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled aericultural products.	[73] [73,76]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02	The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon-	[73] [73,76]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02	The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02	The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future.	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02 PI03	The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02 PI03	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02 PI03	The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the future.	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02 PI03 PI04	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the future. I would recommend carbon-	[73] [73,76]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02 PI03 PI04	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the future. I would recommend carbon- labeled agricultural products to	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02 PI03 PI04	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the future. I would recommend carbon- labeled agricultural products to my relatives and friends.	[73]
Perceived Behavioral Control Purchase Intention	PBC01 PBC02 PBC03 PI01 PI02 PI03 PI04 PK01	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the future. I would recommend carbon- labeled agricultural products to my relatives and friends. I understand the concept of	[73]
Perceived Behavioral Control Purchase Intention Personal knowledge of	PBC01 PBC02 PBC03 PI01 PI02 PI03 PI04 PK01	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the future. I would recommend carbon- labeled agricultural products to my relatives and friends. I understand the concept of carbon-labeled agricultural meduct (such as "accessible")	[73]
Perceived Behavioral Control Purchase Intention Personal knowledge of CAP	PBC01 PBC02 PBC03 PI01 PI02 PI03 PI04 PK01	issues. The price of carbon-labeled produce significantly influences my decision to purchase it. I think that consumers find it difficult to purchase items with a carbon label because of the high prices. I am willing to buy carbon-labeled products when I have confidence in their environmental benefits. I am glad to purchase carbon- labeled agricultural products. I am likely to purchase carbon- labeled agricultural products in the future. I plan to buy more carbon-labeled agricultural products in the future. I would recommend carbon- labeled agricultural products to my relatives and friends. I understand the concept of carbon-labeled agricultural products (such as "zero-carbon" weetables, carbon-neutral milt	[73]

Table 1 (continued)

Variable	Code	Item	References
	РК02 РК03	I understand the quality characteristics of carbon-labeled agricultural products (such as "zero-carbon" vegetables, carbon- neutral milk, etc.). I am familiar with the costs associated with carbon-labeled agricultural products (such as "zero-carbon" vegetables, carbon-	
Personal Norms	PN01	neutral milk, etc.). To safeguard the environment, I should limit the number of agricultural items I buy that	[75]
	PN02	release much carbon dioxide. I feel morally obligated to contribute to reducing carbon dioxide emissions by purchasing carbon-labeled agricultural	
	PN03	products. I consider it a moral duty to society to purchase carbon- labeled agricultural products to reduce carbon dioxide emissions.	
	PN04	Everyone is responsible for considering the environmental impact when purchasing agricultural products.	
Risk Perception	PR01	I worry that I might be wasting money when buying carbon- labeled agricultural products.	Martinho et al., 2022; [80]
	PR02	I am concerned that carbon- labeled agricultural products may not provide the necessary benefits.	
	PR03	I worry that carbon-labeled agricultural products may not perform as well as advertised.	
	PR04	Considering various factors, I think there are risks associated with purchasing carbon-labeled agricultural products.	
Subjective Norms	SN01	I prefer carbon-labeled agricultural products because my friends and family approve nurchasing them	[77]
	SN02	My friends and family hope I will buy agricultural items with a carbon label, so I would like to do	
	SN03	I prefer to buy carbon-labeled agricultural products because the	
	SN04	I prefer to buy carbon-labeled agricultural products because of the environmentally friendly examples.	

mathematical expectation formula.

$$E(WTP) = \sum_{i=1}^{n} P_i b_i \tag{4}$$

where E(WTP) is the maximum average value of willingness to pay for each CAP; P_i is the probability of respondents selecting each bid value; b_i is the bid amount. The maximum average willingness of respondents to pay can be calculated by Eq. (4). In this paper, we combine the relevant literature [81] to measure consumers' actual purchase of CAP using two measures, i.e., whether they purchased CAP in the past year and the exact frequency of consumption. The last part is the socioeconomic characteristics of the respondents, including gender, age, current residence, education level, monthly income, etc.

3.4. Data collection

To correct inaccurate or readily misconstrued content, a pilot poll was carried out with 60 randomly chosen participants in Oct. 2022. The formal survey was conducted from April to June 2023 in Shanghai, Nanjing, Wuhan, and Xi' an, China. The researchers are highly trained graduate and doctoral students. Target respondents are 18 years of age or older. A total of 641 respondents agreed to participate in the research. After excluding questionnaires with missing values or outliers based on the variables required for this research, 580 valid samples were recovered, with an effective recovery rate of 90.48 %. The demographic characteristics of the sample data are as follows. In terms of gender, there is an equal distribution of males and women (51.72 % and 48.28 %, respectively); in terms of age, the proportion of those aged 28 and below reaches 70.86 %; and in terms of education, 90.69 % of the samples have a high school diploma above. Table 2 presents a brief overview of demographic data.

4. Results

4.1. Willingness to pay for carbon-labeled agricultural products

This section examines respondents' WTP for five distinct CAP. Descriptive statistics are then used to further explore disparities in respondents' WTP and possible reasons for consumers' reluctance to purchase CAP. Only 29.83 % of the 580 respondents are unwilling to pay the CAP premium, leaving 70.17 % eager to do so. This suggests that there is already some basis for moving forward with the carbon labeling system in terms of initial willingness to do so.

As shown in Table 3, the results demonstrate that female respondents have slightly higher WTP on carbon-labeled milk and corn than male respondents. In contrast, male respondents have a higher premium WTP on carbon-labeled fruits, vegetables, and eggs than female respondents, indicating that WTP does not appear to be influenced by gender. Respondents under 40 have the highest WTP for most of CAP, and

Table 2

Descriptive	statistics of	f socio-economic	characteristics	of respond	ents

Characteristic	Frequency	Percent (%)
Gender		
Female	280	48.28
Male	300	51.72
Age		
[18,28]	411	70.86
[29,39]	112	19.31
40 and above	57	9.83
Occupation		
Vocational or blue-collar workers	30	5.17
Civil servant	50	8.62
Company staff	172	29.65
Student	264	45.52
Freelancer	35	6.04
Not working/Retired	29	5
Region		
East	301	51.90
Middle	243	41.90
West	36	6.20
Monthly Income (CNY)		
5000 or below	323	55.69
5001–10,000	107	18.45
10,001–20,000	101	17.41
20,000 above	49	8.45
Education		
High School and below	54	9.31
Undergraduate	372	64.14
Master or above	154	26.55
Household Size		
Two people or below	55	9.48
3–4 people	404	69.66
Over five people	121	20.86

Table 3

Willingness to pay for carbon-labeled agricultural products.

Variables	Category	WTP-Milk (%)	WTP-Corn (%)	WTP-Banana (%)	WTP-Tomato (%)	WTP-Egg (%)
Total		27.50	29.73	26.86	26.51	24.26
Gender	Male	27.06	29.59	27.15	27.33	24.91
	Female	27.96	29.88	26.55	25.63	23.56
Age	[18,28]	27.83	29.59	26.74	26.22	24.01
	[29,39]	27.22	31.36	27.55	27.60	24.55
	40 and above	25.70	27.65	26.63	26.57	25.62
Occupation	Vocational or blue-collar workers	31.45	30.46	30.19	31.07	29.12
	Civil servant	24.78	27.04	39.52	26.80	23.92
	Company staff	27.83	25.70	27.03	26.84	24.29
	Student	26.18	27.98	25.65	24.82	22.67
	Freelancer	32.46	35.59	32.70	32.68	31.43
	Not working/Retired	32.09	33.38	29.53	27.21	25.50
Region	East	28.85	31.53	27.74	27.24	25.01
	Middle	26.38	28.17	26.39	26.24	23.76
	West	23.71	25.20	22.71	22.16	21.34
Monthly Income (CNY)	5000 or below	26.57	28.02	26.00	25.13	23.21
	5001–10,000	29.66	32.44	27.86	27.61	25.25
	10,001–20,000	27.66	29.99	27.59	28.49	25.56
	20,000 above	28.55	34.57	28.86	29.09	26.38
Education	High School and below	28.70	31.69	26.73	28.57	28.45
	Undergraduate	27.74	29.80	27.01	26.45	23.94
	Master or above	26.48	28.87	26.57	25.92	23.56
Household Size	Two people or below	30.48	33.18	28.61	28.44	26.06
	3–4 people	27.28	29.55	27.05	26.50	24.50
	Over five people	26.85	28.76	25.46	21.35	22.64

respondents over 40 have the highest WTP regarding the premium for exclusively carbon-labeled eggs. This might be because different age groups have different opinions on the same issue. Eastern Chinese respondents have the greatest premium WTP, followed by central and western Chinese respondents. This may be because the eastern part of the country is economically developed, and its residents have relatively stronger financial resources and higher incomes. The household location is an important geographical factor for consumers, and it is related to the formation of their perceptions, beliefs, etc., which in turn are related to food consumption behavior.

Meanwhile, respondents with monthly incomes of ¥ 20,000 or more have the highest premium WTP for 80 % of CAP mentioned in the survey. It is not difficult to understand that price is one of the main factors influencing consumers' decisions to buy products. According to the study, the family dimension appears to impact consumers' WTP, with respondents with smaller family sizes reporting higher WTP. A one-way analysis of variance (ANOVA) was performed to explore whether sociostatistical characteristics have a role in residents' WTP for CAP. Six independent variables, such as gender, age, and education, and one dependent variable, willingness to pay, were examined. The analysis's findings reveal that three variables-respondents' place of residence, degree of education, and occupation-substantially impact their WTP for CAP. In contrast, the remaining variables failed to pass the test. This implies that an individual's inclination to buy a CAP is somewhat influenced by their place of residence's traits, level of education, and line of work.

Among the respondents who are not willing to pay a premium for CAP, the most common answer (almost 20 %) is that they cannot pay for personal financial reasons but would be willing to pay if their income increased. This is followed by a reluctance to spend more money (16 %) and a belief that the government should shoulder more responsibility for reducing emissions than the respondents should (11 %). More than 9 % of participants feel that agricultural products had no significant environmental impact at any point along the supply chain, from production to consumption, and another 8 % states that the reason for their refusal is that they are unwilling to try new things. Some participants offer "others" justifications for declining to pay a premium for CAP, with a significant portion citing their belief that agricultural products are necessary for our daily lives, that they shouldn't be excessively priced, and that we should look for ways to cut costs. Currently, there aren't

enough options on the market, and the carbon labeling market should be expanded. Some respondents also note that their decisions would be impacted if they didn't know the authenticity and safety of CAP available on the market.

4.2. Measurement model testing

As seen through the results in Table 4, all the factor loadings have values in the range of 0.631-0.913, which meets the criteria proposed by Hair et al. [82]. After analyzing the factor loadings, the reliability and validity of the questionnaire were analyzed. Cronbach's alpha was used to confirm the reliability of the factors, and 0.7 was chosen as the standardized critical value, as indicated by Nunnally and Bernstein [83]. The overall Cronbach's alpha for all latent variables was 0.960, and the estimates for the factors' Cronbach's alpha ranged from 0.722 to 0.928, all of which were above 0.7. This suggests that the respondents' internal consistency in assessing the observed variables reached an acceptable level, as did the reliability of the factors. Additionally, the study conducted KMO and Bartlett's tests on the factors (Table 5). KMO estimations greater than 0.7 implied good adequacy of the sample collected [84]. The average extracted analysis of variance (AVE) ranged from 0.479 to 0.766, with nearly all of them being greater than 0.5, and the composite reliability (CR) for all latent variables ranged from 0.733 to 0.929, all of which were greater than 0.7. The study demonstrates good validity and reliability in examining the proposed hypotheses as all the indicators met the criteria [82].

4.3. Structural model assessment

Several key metrics for determining model fit are the NC value (CMIN/DF), root mean square of the approximation error (RMSMA), goodness-of-fit index (GFI), comparative fit index (CFI) and normative fit index (NFI). In general, a reasonable fit can be defined as having NC values between 1 and 5, RMSEA <0.08, and GFI, CFI, and NFI greater than 0.8 [85–87]. Table 6 shows that, following a few model modifications, all fitness indicators perform well, demonstrating that the model of the purchasing behavior of consumers of CAP and the collected data fit well.

The study's hypotheses are put to the test based on the structural modeling. Fig. 2 displays the specific visualization findings. The study

Validity and reliability of the study.

Variable	Coding	Factor loading	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Awareness of Consequences	AC01	0.631	0.796	0.804	0.581
-	AC02	0.795			
	AC03	0.845			
Ascription of Responsibility	AR01	0.649	0.851	0.857	0.602
	AR02	0.831			
	AR03	0.826			
	AR04	0.784			
Attitudes toward the Behavior	ATT01	0.855	0.890	0.892	0.735
	ATT02	0.889			
	ATT03	0.826			
Low-carbon awareness	LA01	0.660	0.730	0.733	0.479
	LA02	0.735			
	LA03	0.678			
Perceived Behavioral Control	PBC01	0.668	0.722	0.762	0.519
	PBC02	0.66			
	PBC03	0.822			
Purchase Intention	PI01	0.859	0.928	0.929	0.766
	PI02	0.87			
	PI03	0.891			
	PI04	0.88			
Personal Knowledge of CAP	PK01	0.795	0.874	0.8772	0.705
	PK02	0.913			
	PK03	0.806			
Personal Norms	PN01	0.822	0.886	0.889	0.666
	PN02	0.86			
	PN03	0.805			
	PN04	0.776			
Risk Perception	PR01	0.686	0.877	0.879	0.647
	PR02	0.85			
	PR03	0.855			
	PR04	0.816			
Subjective Norms	SN01	0.907	0.905	0.909	0.715
	SN02	0.912			
	SN03	0.82			
	SN04	0.73			

Table 5

KMO and Bartlett's test results of factor analysis.

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin Measure of S Bartlett's Test of Sphericity	Sampling Adequacy. Approx. Chi-Square Degree of freedom	0.958 16,148.911 630
	Significance	0.000

Table 6

Results of model fitness test.

Measure	Threshold	Estimate	Interpretation
CMIN/DF (NC)	1 < NC < 5	4.957	Acceptable
RMSEA	< 0.1	0.083	Acceptable
GFI	>0.8	0.810	Acceptable
CFI	>0.8	0.878	Acceptable
NFI	>0.8	0.852	Acceptable
PCFI	>0.5	0.765	Acceptable
PNFI	>0.5	0.742	Acceptable

results indicate that ATT significantly and positively influences PI (β =0.219, *P* < 0.001) within the theoretical framework of TPB, thus supporting **H1**. SN positively influences PI (β =0.404, *P* < 0.001) and **H2** is supported. **H3** is confirmed, with a significant positive effect of PBC on PI (β =0.408, *P* < 0.001). Among them, the standardized path coefficient of PBC is significantly higher than that of ATT and SN, indicating that the main factors influencing consumers' WTP about CAP are their control over relevant resources like money, time, knowledge, and skills, as well as their access to information about CAP. PBC has a significant positive effect on PB (β =0.261, *P* = 0.002), and **H4** is valid. This suggests that PBC can also directly influence the occurrence of a consumer's

behavior when he or she can perceive the objective constraints, such as resources and capabilities, that he or she needs to perform a certain behavior. The significance test refuses H5 with the result that PI harms PB (β =-0.307, *P* < 0.001). In the framework of NAM, consumers' AC of purchasing CAP positively affects their AR (β =0.683, *P* < 0.001) and PN (β =0.435, *P* < 0.001), supporting H6 and H7. Consumers' AR positively affects PN (β =0.389, *P* < 0.001), implying that a consumer's sense of responsibility for the adverse consequences of failing to purchase CAP activates his or her sense of moral obligation to purchase them, and H8 is validated. The positive effect of consumers' PN on PI passes the significance test (β =0.113, p = 0.002); thus, **H9** holds, meaning that people with greater ethical obligations have a higher CAP purchase intention. In the extended TPB-NAM theoretical framework, the hypothesized relationships of SN positively affecting PN (β =0.164, P < 0.001), consumers' perceptions of CAP affecting their ATT (β =0.6, *P* < 0.001), and consumers' low-carbon awareness affecting their AC (β =0.903, P < 0.001) all pass the significance test, and H10, H11, and H12 are confirmed, indicating that pressure from society positively affects their sense of moral obligation towards the act of purchasing CAP and that the level of consumers' knowledge of the background and existential significance of the proposed CAP significantly and positively affects their ATT. At the same time, the more environmentally conscious customers themselves are, the more they are aware of the harm that not buying CAP can do to the environment.

4.3.1. Moderating effects

The SEM results indicate that purchase intention negatively influences purchase behavior. To understand the mechanism of RP's influence in the process of PI's effect on consumers' CAP purchase, structural equation modeling with latent variable interaction terms was constructed using AMOS 26.0, and the moderating effect of the intention-behavior gap was analyzed based on the theory of likelihood.



Fig. 2. Result of SEM.

The findings confirm that the moderating effect of risk perception on the relationship between purchase intention and purchase behavior is significant ($\beta = -0.092$, p < 0.000), and **H13** is supported. This implies that the unfavorable link between PI and PB is strengthened by RP. In other words, customers are kept from turning their CAP purchasing intentions into actual purchase activity when there is a high perceived risk. It seems logical that when a customer realizes a danger is involved, he or she gets nervous and looks for ways to lower the risk. The riskier the purchase of a CAP for the consumer, the harder it will be for them to carry through on it.

4.3.2. Mediation analysis

The bias-corrected nonparametric percentile Bootstrap approach was used to examine the model's mediating effects using AMOS 26.0. Compared with the traditional causal regression test, the bootstrap method has the advantage of being efficient and suitable for smaller sample sizes. The test results of the direct, indirect, and total impacts between the variables in the model, as well as the mediating paths, are obtained. The sampling number was set to 2000. According to bias correction and percentile, the indirect relationship is significant (P < 0.01) when the upper and lower interval values don't contain 0 and $Z \ge 1.96$. According to Table 7, AC's direct, indirect, and total effects on the influence of PN are all significant, indicating a significant and partial mediation between the two. This shows that raising residents' AC and AR can support residents' PN, with AR having a major mediating influence. In other words, there is a path of "AC \rightarrow AR \rightarrow PN." Finally, the direct, indirect, and total effects of PBC on PB are significant, and the point estimate of its mediating path "PBC \rightarrow WTP \rightarrow PB" is -0.076 with a confidence interval that does not contain zero, indicating that WTP partially mediates the effect of PBC on PB. These findings support the growth and promotion of carbon labeling and have important implications for policymakers and businesses.

5. Discussion

The results of the study indicate that consumers' willingness to pay a premium for five carbon-labeled agricultural products, such as carbon-labeled milk, corn, bananas, tomatoes, and eggs, is 27.50 %, 29.73 %,

Table 7

Results of indirect effects	s between	variables i	in the	structural	equation	model.
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Paths	Estimate	Coefficient	phase product	Bootstrapping			Supported	
				Bias-correcte	d	Percentile		
		SE	Z-Value	Lower	Upper	Lower	Upper	
$AC \rightarrow AR \rightarrow PN$ $PBC \rightarrow WTP \rightarrow PB$	0.252^{***} -0.076^***	0.044 0.029	5.727 -2.621	0.174 -0.145	0.346 -0.031	$0.171 \\ -0.14$	$0.343 \\ -0.03$	Yes Yes

Note: * presents *p*<0.05, ** presents *p*<0.01, *** presents *p*<0.001.

26.86 %, 26.51 %, and 24.26 %, respectively. This aligns with worldwide study patterns revealing a growing consumer concern regarding the ecological consequences of their dietary decisions [88]. Like the findings of Polimeni et al. [89] and Zare Mehrjerdi and Woods [90], there is a significant impact of respondents' occupation, region of residence, and degree of education on their willingness to pay premiums for CAP. The study focuses on integrating NAM into TPB, which finds that consumers' ATT, PN, SN, PBC, AR, and AC have a positive effect on their PI, with PBC and SN having the greatest direct effect. The remarkable effect of PBC on PI suggests that the accessibility of information and resources provided to consumers is a key factor in facilitating low-carbon consumption decisions. This finding aligns with the existing literature, which indicates that enhancing consumer self-efficacy and providing social support are essential strategies for promoting sustainable consumption behaviors [10]. Awareness of consequences and attribution of responsibility are also significantly correlated, highlighting the importance of recognizing environmental impacts and personal responsibility in promoting low-carbon behaviors.

The study finds that respondents' willingness to buy CAP has a negative influence on purchasing behavior, which is less consistent with earlier findings [36]. This could be because CAP is not easily accessible on the market, and the limited number of respondents who have seen CAP and purchased it may have influenced the results of the study. Another explanation for this could be that the intention-behavior gap widens because of the forgetting effect, which occurs when respondents can no longer reliably recall behaviors at the time of the survey. This could be captured by the time lag. This finding suggests that the intention-behavior gap might be wider than expected, especially when considering the differences between self-reported and observed behaviors. The intention-behavior gap, which emphasizes the discrepancy between someone's intentions and actual behavior, is a topic of much discussion in various scientific areas. Evidence from green consumer psychology research suggests that there is a gap between most people's intentions and subsequent behavior [91]. Kormos and Gifford [92] conducted a meta-analysis of 15 studies, revealing that psychological constructs could only explain 21 % of variances in objective behavior. Furthermore, conscious variables that predict intention are not always predictive of actual behavior, nor can they be used to estimate the environmental impact of that behavior [93]. The negative moderating effect of RP on the link between PI and PB has been substantiated by research, exposing the psychological obstacles that buyers face to convert their desire to pay into real purchasing behavior. For this paper, even if the consumers' intention to purchase exists and RP is an essential moderator, the final purchase of CAP may be subject to change due to personal psychology, marketing price, and other issues. In contrast, it is also possible to have consumers who do not report intent but have actual behavior. We also explore the role of information on consumer WTP of CAP. Consumers who are hesitant to pay the premium would be more willing to pay by almost half after receiving favorable information about carbon labeling. This supports the point made by earlier research regarding the significance of information in consumers' perceptions of new products [94,95,96,97]. The study's final mediation effect test result, "AC \rightarrow AR \rightarrow PN," emphasizes the key role of AC in shaping PN, and the path "PBC \rightarrow WTP \rightarrow PB" implies that people's willingness to buy environmentally friendly products may be influenced by their PBC, which may then have an impact on their PB. In summary, the current model emphasizes the multi-faceted nature of consumers' low-carbon behaviors, in which awareness, attitudes, perceived control, and social norms interact to influence intentions and behaviors.

The study provides a useful theoretical basis for the development of appropriate policies that can help further carbon labeling policies; however, it does have limitations. This paper only explores consumers' responses to behavioral intentions to a single label, and there is no research on multiple labels and their interaction effects. Additionally, willingness to pay in this study is based on hypothetical scenarios where participants imagine consuming the products. Estimating latent variables is somewhat uncertain because of this reliance on hypothetical situations. To investigate and evaluate findings in a more practical setting, performing non-hypothetical experiments would be a valuable direction for future research. To gather more thorough survey data and research findings, efforts might be undertaken in to increase the sample size and the study's scope.

6. Conclusion

This study investigates residents' willingness to pay a premium amount for carbon-labeled agricultural products using micro-survey data from 580 residents in various regions of China, integrates and extends the Theory of Planned Behavior and the Norm Activation Model, and examines the effects of factors on residents' willingness to pay and premium amount for CAP from both theoretical and empirical aspects.

The following policy implications and related suggestions can be drawn based on the above findings. At the government level, the government should formulate effective guidelines and norms for low-carbon consumption, continuously improve them, and promote them to strengthen residents' sense of identity and responsibility for CAP consumption. Through official media and slogans, the government should also promote concepts of low-carbon agricultural product consumption and consumption patterns and increase public knowledge of the drawbacks of consuming agricultural products with high emissions. Using the advantages of the Internet to spread the word about the harmful effects of increased carbon emissions through pictures, videos, and other media to raise public awareness of the critical environmental situation we are currently in as well as the risks associated with not implementing carbon reduction as a motivation to support low-carbon behavior. Through multi-channel publicity, we will raise environmental protection awareness, promote the public's understanding of CAP, enhance consumers' recognition and identification with CAP, and stimulate the public's sense of responsibility and obligation to protect the environment and health through CAP. Policymakers may need to think of alternative strategies to encourage low-carbon food choices, such as incorporating low-carbon requirements into programs for certifying restaurants or offering incentives to restaurants prioritizing low-carbon environmental protection.

At the enterprise level, agricultural enterprises ought to introduce more styles and types of CAP, establish technical standards and CAP certification systems, and ensure that consumers can easily recognize and purchase CAP that meets their needs to increase the market share of CAP. They should also work to foster consumers' favorable attitudes toward green brands and products through appropriate promotions, publicity, and other marketing activities. Finally, businesses ought to focus on the design and promotion of CAP to dispel any preconceived notions that consumers may have about CAP and to lessen the possibility that they will refrain from buying CAP because of risk factors. Retailers should focus more on spreading information about these products' positive environmental and human health effects to increase buyer interest and WTP. Simultaneously, consumers should be guided to moderately reduce their sensitivity to the price of carbon-labeled products, which is conducive to promoting enterprises to increase the production of carbon-labeled products and optimize the reduction of carbon emissions, and has a positive effect on the promotion of carbonlabeled products. In conclusion, this research can potentially make a practical contribution to the body of knowledge by giving other fields opportunities to address the escalating environmental problems and advance the adoption of carbon labeling.

CRediT authorship contribution statement

Yalin Xu: Writing – original draft, Software, Methodology, Formal analysis. Zhiwen Zhang: Investigation, Data curation. Yanjun Ren: Visualization, Validation, Supervision. Rong Yuan: Supervision, Project administration. Yanan Wang: Writing – review & editing, Supervision, Project administration, Funding acquisition. Rui Li: Investigation. Shunan Zhao: Investigation. Lu Qiu: Visualization, Validation.

Declaration of competing interest

We declare that we have no conflicts of interest in this work.

We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sftr.2024.100363.

Acknowledgments

Appendix A

Fig. A1, Table A1.



Fig. A1. Examples of carbon labels. A. Carbon Neutral Label: Does not disclose explicit carbon emissions data and indicates that carbon neutrality has fully offset the product's carbon footprint. B. Carbon Footprint Label: Indicate the carbon emissions over the entire product's life cycle or at each stage of the product's life cycle. C. Carbon Rating Label: the total value of carbon dioxide emissions generated throughout the product's life cycle and the level of carbon reduction. D. Carbon Reduction Label (which simply indicates that the product's whole-life carbon dioxide emissions are below a set standard). E. Carbon labels with additional elements (such as the traffic light elements and carbon emission data above combined for product comparison).

Table A1

Symbols and interpretations used in SEM analysis.

Symbol	Interpretation
ξ	Independent variable
η	Dependent variable
X	Observed variables influenced by ξ
Y	Observed variables influenced by η
$\Lambda_{\mathbf{x}}$	Factor loading coefficient matrix between X and ξ
Λ_y	Factor loading coefficient matrix between Y and η
δ	Measuring error of X
ε	Measuring error of Y
В	The matrix of the correlation coefficient of the dependent variable
Γ	The matrix of the correlation coefficient between ξ and η
ζ	The error of the dependent variable

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Data availability

Data will be made available on request.

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