frontiers | Frontiers in Ecology and Evolution

TYPE Original Research
PUBLISHED 24 October 2023
DOI 10.3389/fevo.2023.1269584

OPEN ACCESS

EDITED BY
Lewis T.O. Cheung,
York St John University, United Kingdom

REVIEWED BY
Qing Pei,
The Education University of Hong Kong, Hong Kong SAR, China
Benjamin Iaquinto,
The University of Hong Kong, Hong Kong SAR, China

*CORRESPONDENCE
Jichao Geng
gjcjsj@126.com

RECEIVED 30 July 2023
ACCEPTED 10 October 2023
PUBLISHED 24 October 2023

CITATION
Geng J, Yang N, Yang L and Long R (2023) Public willingness to pay for personal carbon trading of green travel: based on survey data from five capital cities in eastern China.
Front. Ecol. Evol. 11:1269584.
doi: 10.3389/fevo.2023.1269584

Public willingness to pay for personal carbon trading of green travel: based on survey data from five capital cities in eastern China

Jichao Geng[1]*, Na Yang[1], Li Yang[1] and Ruyin Long[2]

[1]School of Economics and Management, Anhui University of Science and Technology, Huainan, Anhui, China, [2]School of Business, Jiangnan University, Wuxi, Jiangsu, China

Personal carbon trading is a form of pollution rights trading that is worth exploring as an innovative tool to cut back carbon emissions from travel. This paper proposes a policy scenario in which car users who exceed the average distance traveled quota are required to purchase travel credits from those who do not reach the quota and pay for them on a per hundred kilometer basis. Willingness to pay (WTP) for personal carbon trading is introduced to calculate the travel cost and its influencing factors are analyzed from the perspective of green travel. Using the double-bounded dichotomous choice contingent valuation method (DBDC), 2712 residents' data from five provincial capital cities in eastern China is obtained. Based on this, this study first uses a binary logistic regression model to analyze the characteristics of people who are not willing to pay for green travel carbon trading, and then leverages an interval regression model to explore the willingness and intrinsic motivation of being willing to pay more or less for green travel. The results suggest that perceived usefulness is a key influencing factor of residents' willingness to pay or pay more for green travel; Personal habits have a significant positive effect among those willing to pay; Subjective norms and moral norms can well account for the unwillingness to pay; Attitudes, perceived behavioral control, and environmental awareness fail to predict the willingness to pay among those who are unwilling to pay. In addition, WTP is also affected by demographic variables such as income and educational background. The empirical results as well indicate that the final average level of respondents' WTP is 39.95 yuan per 100 km. The findings of this paper can provide a pricing basis while formulating personal travel carbon trading policies.

KEYWORDS

personal carbon trading, green travel, willingness to pay (WTP), double-bounded dichotomous choice contingent valuation method (DBDC), interval regression model

1 Introduction

With the signing of the United Nations Framework Convention on Climate Change, China has set a strategic decision to achieve carbon peaking by 2030 and carbon neutrality by 2060. China is the world's largest carbon emitter, and its transportation sector has the second highest total carbon emissions in the world (Yang and Zhou, 2020). With the rapid growth in the number of vehicles and travel demand in China's cities, emissions from the transportation sector have continued to grow, averaging 8.4% annually from 2000–2015. Urban residential travel accounts for the majority of these carbon emissions (Sovacool et al., 2022). China is suffering from longer traffic jam, graver carbon emissions and more harmful greenhouse gas emissions owing to its over-reliance on motor vehicles as primary urban transportation (Yang et al., 2018). To handle this, the Chinese government is taking a series of policies and regulations, such as technological upgrades, mandatory restrictions and penalties, and publicity and education tools to inspire residents to adopt a sustainable lifestyle, of which reducing car use and traveling in a green way is a particularly important part (Wang S.Y. et al., 2018; Chen and Yan, 2019; Jie et al., 2020).

In order to guide individual green travel behavior, carbon trading is worth exploring as a new option to achieve individual travel carbon reduction goals. Personal carbon trading scheme is a policy tool to reduce carbon emissions and thus lead a green life; and in the carbon trading market, residents are likely to take the initiative to reduce carbon emissions and then contribute to promoting green travel mode (Fawcett and Parag, 2010). The feasibility of personal carbon trading depends largely on the participants' behavior intentions, and most current studies directly measure whether residents accept and participate in the program (Guo et al., 2021; Lin and Yang, 2023). However, we measure residents' willingness to pay for extra travel carbon emissions which exceeds green travel carbon credits so that the acceptance of carbon trading can be reflected more visually and effectively.

WTP is the extent to which consumers are willing to pay for a product with certain qualities. (Wertenbroch and Skiera, 2002). Hsu et al. (2017) consider WTP as the degree of consumers' willingness to pay a premium for green services and products. Zhang and Feng (2022) consider WTP as a crucial factor in measuring public participation. The contingent valuation method (CVM) can be employed to obtain residents' willingness to pay by constructing a hypothetical market. A hypothetical market can better measure and evaluate WTP because it can provide a conceivable environment in which residents can obtain sufficient information. Not only that, but it can also prevent the policy regime from interfering with their judgment, which can lead to bias in WTP. At present, the most commonly used WTP guidance technique in international academic research is DBDC. Compared with other methods, DBDC gives comparatively more accurate results that are more closely approximate the real WTP of residents (Cai et al., 2007). In addition, Understanding the psychological factors affecting residents' WTP determines whether carbon emissions reduction from travel can succeed (Donald et al., 2014). Some studies indicated that individuals' psychological awareness affects their WTP, which further influences their behavior. Related studies have examined the effects of psychological variables such as responsibilities and environmental attitude, and moral norms on purchase intentions. Environmental behavior models such as the theory of planned behavior (TPB), the Normative Activation Model, and the Technology Acceptance Model (TAM) are frequently utilized (Yang et al., 2023; Hojnik et al., 2021). Therefore, exploring consumers' WTP for green travel from the angle of public psychology, digging into specific psychological variables and their influence on consumers' WTP for green travel carbon trading is of great significance.

Although there is an abundance of literature on green travel behavior, most current studies place focus on examining the influencing factors behind travel mode choices (Hamilton and Wichman, 2018; Yang et al., 2023) or cutting back carbon emissions from transportation from a technological perspective (Nazari et al., 2019). Few simulate consumers' acceptability for green travel from the angle of carbon trading, nor do they investigate residents' specific WTP for personal green travel carbon trading. However, leading green travel through travel mode changes is vital to the evolution of low-carbon transportation in China, and understanding consumers' acceptability of and WTP for green travel carbon trading can furnish a theoretical basis for the future development of green travel in China. To fill this gap, this study unfolds from three aspects. First, based on the theory of planned behavior, a comprehensive theoretical framework is established to analyze the internal factors among those unwilling to pay; next, an interval regression model is used to explore the factors that influence residents to pay more or less among the willing-to-pay group. Last, the questionnaire designed using DBDC provides a hypothetical carbon trading background (to achieve carbon neutrality, the Chinese government sets an average travel amount per 100km, those whose amount is exhausted need to purchase from those who do not reach the average green travel amount), and collects residents' travel data from five provincial capital cities in eastern China to calculate the average WTP value. In this context, researches into residents' driving factors and WTP for green travel behavior will help reducing carbon emissions from transportation in China and other developing countries, realizing sustainable development of transportation and addressing concerning energy and environmental challenges. Besides, all these also have theoretical and practical significance for mitigating global climate change and can provide a pricing basis for formulating carbon trading policies of personal travel.

In addition, this paper contributes to existing research in four ways: First, we design a policy scenario and introduce WTP to measure individual acceptance of carbon trading for green travel, which helps to provide some pricing basis for the government to design a carbon trading mechanism for individual travel. Second, we build a comprehensive theoretical model to explain the intrinsic motivation and psychological factors of WTP for green travel carbon trading, and explore the variability of factors influencing whether residents are willing to pay (first question) and willing to pay more or less (second question), which is of great reference significance for studying residents' acceptance of green travel

carbon trading. Third, this study, using DBDC contingent valuation method, can obtain more accurate WTP estimates and thus fill the blank of specific personal carbon trading payment amount in China's green transportation market. Finally, our findings may be of interest to policy makers and transportation authorities, and may help to provide more effective policy support and develop promotion strategies for green mobility; what's more, it can provide references for mitigating increasingly severe urban traffic congestion and the low-carbon transition of China's transportation.

The remainder of the paper is as follows: Section two presents a literature review of willingness to pay, green travel behavior, and carbon trading, as well as the theoretical framework and hypotheses. The third section contains the methodology and data used in the analysis. The analytical results are presented in the fourth part. Section five discusses the research results. The final part summarizes the main findings and provides theoretical policy implications as well as the limitations of this paper.

2 Literature review

2.1 WTP

WTP is the highest price or likelihood that the public pay for environmental products with their willingness, which are an internal activity used to measure consumers' subjective willingness to purchase a specific good (Knetsch and Sinden, 1984; Wertenbroch and Skiera, 2002). It has been applied to various areas of low-carbon behavior (Yang et al., 2023; Belay et al., 2020; Xu et al., 2020). Numerous studies have compared the impact of consumer preferences and WTP on various sustainability labels (Van Loo et al., 2015; Vecchio and Annunziata, 2015). Some scholars have also examined the relationship between willingness to pay and green alternatives to cars in the travel sector. However, there is little literature on residents' WTP preferences for green travel, and the existing literature focuses on green tourism. The literature shows a large range of WTP premiums for green tourism (Lamsal et al., 2016). For example, de Araujo et al. (2022) argue that environmental beliefs have a significant effect on both ecotourism attitudes and sustainable consumption behavior, with the latter two having a significant effect on WTP.

2.2 Green travel behavior and personal carbon trading

Green travel derives from green transportation, which is a manifestation of green consumerism. Green travel refers to the self-commitment people made to engage in traveling in an environmentally friendly manner. That is, to choose travel modes with less impact on the environment such as taking bus, subways, driving environmentally, walking or biking (Yang et al., 2017). Therefore, as an environmental behavior, green travel behavior is part of our efforts to consciously avoid or solve environmental problems (Hines et al., 1986; Hsu and Roth, 1998). Also, being a sustainable, efficient, economical, and environmentally friendly behavior, it has received a lot of attention from scholars (Si et al., 2019). Moreover, several researches have confirmed that green travel behavior does improve traffic flow (Hamilton and Wichman, 2018) and does well to people's health (Ricci, 2015).

The personal carbon trading (PCT) mechanism is considered a market-based mitigation tool that provides residents with guidance on carbon emission reduction with carbon price signals, and has been widely taking into consideration around the world to address climate change and reduce emissions (Li et al., 2018). Meanwhile, some studies suggested that personal carbon trading schemes should be carried out to influence people's choice of transportation so that carbon emissions from personal travel will be reduced. Influences of carbon trading on personal behavior were analyzed in a number of studies, for example, Kuokkanen et al. (2020) found that carbon neutrality knowledge and income have a positive impact on personal carbon trading. Liu (2019) indicated that government policies, residents' environmental awareness and motivation are positively correlated with their willingness to personal carbon trading. Zhang and Feng (2022) uses logit modeling to analyze the effect of attributes on individuals' willingness to participate in personal carbon trading in the context of carbon-neutral policies as well as the effect of public heterogeneity on personal carbon trading. Evidence suggests that residents' behavioral willingness to accept and participate in the program may be influenced by personal factors, such as perceptions of climate change, perceived environmental threats, and environmental awareness (Xie et al., 2014; Liu, 2019). Tan et al. (2019) investigated the driving factors of the public's willingness to participate in individual carbon trading in Guangdong pilot project, and the results showed that the institutional and technical environment, social reference norms, low-carbon cognition, participation feedback and participation risk were the influencing factors of public support for individual carbon trading.

So far, there are few studies related to individuals' participation in green travel carbon trading, and we have not found empirical literature on travel quotas and measures of individuals' willingness to pay for carbon trading.

2.3 Theoretical framework and research hypotheses

The theory of planned behavior is a psychological framework for predicting individual intentions and behaviors and can help us understand how people change their behavior patterns. It has been adopted by a large number of environmental behavioral studies (He et al., 2021; Hu et al., 2021; Gamel et al., 2022). The theory of planned behavior consists of subjective norms, attitudes, and perceived behavioral control. Ajzen (1991) defined subjective norms as the external pressures individuals perceive when considering whether to perform an action. Individuals are usually more willing to comply with expectations of important organizations and individuals, i.e., the stronger the perceived subjective norm from an important person, the more likely an individual is to engage in a behavior (Si et al., 2020). Subjective

norm is composed of two components: injunctive norms and descriptive norms (Blok et al., 2015; Wang et al., 2016). Perceived behavioral control is related to the degree of control others have over performing a particular behavior and the ease of doing so, depending mainly on the perceived costs and benefits of performing it. In other words, the more confidence one has in their skills and abilities, the more they are willing and likely to perform the behavior in question. And it can also be divided into two dimensions: self-efficacy and control beliefs (Cai et al., 2019). As for attitude, it represents an individual's positive or negative evaluation of a particular behavior (Ajzen, 1991), and can be measured from two dimensions: experiential and instrumental attitudes. Experiential attitudes place emphasis on feeling and emotion, while instrumental attitudes give much importance to benefits and functions (Blok et al., 2015). So far, the theory of planned behavior has been successfully applied to many travel behaviors, including bicycle travel (Si et al., 2020; Bai et al., 2022), public transportation travel (Sheng and Zhang, 2022), commuting travel mode choice (Lo et al., 2016), and travel by electric vehicle (Noblet et al., 2014) etc.

As research on the theory of planned behavior deepens, the predictive power of the traditional TPB model can no longer meet the needs; thus, some of researchers made attempts to add new variables, hoping to enhance its predictive power (Bagheri et al., 2019; Zhang et al., 2021). Individuals' behavior is also influenced by moral factors (Thøgersen, 1996). In the norm activation model, moral norms are defined as moral obligations towards specific environmental behaviors, and people with higher personal moral norms are more responsible and liable for replacing their old travel modes with more environmentally friendly ones (Si et al., 2020). Moral norms play a key role in environmental protection, green consumption behaviors as well as public transportation and electric vehicle's intention to use (Chen, 2016; Arkorful, 2022). Mostly used in researches on the driving factors behind some kind of behavior, the technology acceptance model is frequently adopted to predict in combination with the theory of planned behavior (Yang et al., 2023). Perceived usefulness is generally defined as the extent to which an individual believe the application of some particular technology will help improve job performance and achieve a worthwhile goal (Davis, 1989), and it has implications for consumer acceptance of new and innovative products (Schuitema et al., 2013). Other researchers argue that personal habits also influence behavioral intentions and that if consumers travel in a sustainable way for a long time, their travel habits will be stored and formed in their mind automatically (Gomes and Lopes, 2023). Green travel is considered as a specific pro-environmental behavior, personal concern for the environment may influence the perception and acceptance of green travel among residents, and those who are more concerned about the environment will consider more about the impact on environment their consumption brings. Knowledge about environmentally friendly products has a prominent effect on consumers' attitude and purchasing intention (Liu et al., 2018). Wang C. et al. (2018) argue that rich environmental knowledge can significantly encourage residents' green travel behavior. Therefore, some scholars have added subjective knowledge (Qian and Yin, 2017), and environmental awareness (Liu et al., 2017) to the travel behavior model.

Green travel behavior, as an environmental behavior, is also evidently influenced by socio-demographic characteristics. Many studies have investigated the socio-demographic characteristics of consumers willing to pay for low-carbon products, and it turns out that groups with higher income and higher educational background are more willing to consider low-carbon consumption in comparison with those less educated and paid (Yue et al., 2013; Shuai et al., 2014); and men show a greater sense of responsibility for low-carbon consumption than women (He et al., 2011). Besides, socio-demographic characteristics also have a direct impact on residents' travel mode choices, which may involve their gender, age, income, and education level. For example, high-income residents may prefer traveling by private cars because they may care more about time costs and have higher demand for comfort and convenience (Yang et al., 2018). In addition, millennials are more inclined to engage in green travel behaviors compared to others (Circella et al., 2017).

According to previous findings, a comprehensive model (Figure 1) is built to predict the influencing factors of residents' WTP for green travel carbon trading. In this new model, the TPB model is taken as the basis, perceived usefulness from TAM, moral norms, environmental awareness, personal habits, subjective knowledge as well as socio-demographic characteristics all are incorporated in it. Here, we propose the following eight hypotheses:

H1. Subjective norm has positive effects on WTP;
H2. Perceived behavioral control has positive effects on WTP;
H3. Attitude has positive effects on WTP;
H4. Perceived usefulness has positive effects on WTP;
H5. Environmental awareness has positive effects on WTP;
H6. Moral norm has positive effects on WTP;
H7. Personal habit has positive effects on WTP;
H8. Subjective knowledge has positive effects on WTP.

3 Methods

3.1 Methodology

3.1.1 Contingent valuation method

Green travel has positive externalities to the public environment (reducing greenhouse gas emissions, etc.) and is a public environmental good. Since there is no market price for the positive externality, the economic value is hard to measure. CVM is a method to estimate the non-market value. It is combined with a questionnaire to determine respondents' willingness to pay for a non-market good (green travel) (Venkatachalam, 2004; Wang and Zhang, 2009). CVM provides a hypothetical scenario that helps respondents get a more common context in which they can answer elusive questions such as green travel, this helps improve the predictive validity of the measurement of WTP; Moreover, it is widely adopted when measuring WTP in ecological field, such as electricity assistance (Kim and Yoo, 2020), waste incineration (Xu and Lin, 2020), and electric vehicle charging station construction

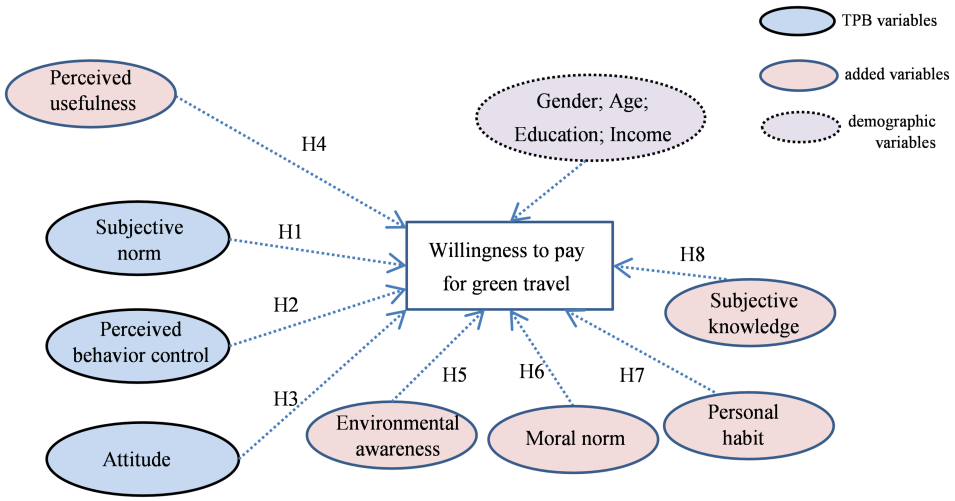

FIGURE 1
Theoretical model.

(Tan et al., 2022). DBDC, by far the most popular and accurate method, can obtain more information about respondents' WTP (Cai et al., 2007); It first gives an initial bid amount denoted as T, respondents who answer "yes" will be asked a question about a higher bid with a bid value of T^H, and respondents who answer "no" will be asked a question about a lower bid with a bid value of T^L; In the end, four bid intervals will be obtained: interval data ([t_0, t_1], [t_2,t_0]), left-censored data ([0, t_2]) and right censored data([t_1,+∞]) (t_0 represents the initial bid value, t_1 and t_2 are second bid values, representing upper bid values and lower bid values respectively). Numerous empirical studies on green energy, climate change, low-carbon consumption, and waste utilization have used DBDC to estimate willingness to pay for environmental goods. (Tyack and Ščasný, 2018; Soliño et al., 2019; Elahi et al., 2022).

3.1.2 Logistic regression

To explore the characteristics of people who are not willing to pay for green travel carbon trading, estimation is conducted here by using the binary logistic regression model (LRM) which is a special form of log-linear model widely used in the analysis of public intentions (Harper et al., 2020; Shin et al., 2022). It utilizes maximum likelihood estimation and can guarantee the best fit at each point. In the model, P is the probability of a positive outcome and $1 - P$ is the probability of a negative outcome, then $\ln(P/(1-P))$ is P as Logit change, which is denoted as $Logit(P)$. In addition, α is a constant and β_m is the logistic regression coefficient. That is, it represents the relative contribution of the factors that affect willingness to pay. If the coefficient is positive, $e^{\beta_m} > 1$, indicating a direct correlation between the factor and willingness to pay. If the coefficient is negative, $0 < e^{\beta_m} < 1$, indicating that the factor and willingness to pay are negatively correlated. In the modeling analysis of this paper, odds ratio (OR) is used to reflect the difference between the willingness to pay of those who are not willing to pay and those who are willing to pay in terms of the influencing factors, thus establishing a link between those who are not willing to pay and the influencing factors. If OR = 1, it indicates that there is no correlation between the influencing factors and the willingness to pay; If OR > 1, it indicates that the influencing factor is the factor that affects the willingness of the person who is unwilling to pay, and it is considered that the influencing factor is "positive" correlation with the person who is unwilling to pay; if OR< 1, the opposite is true.

$$\boldsymbol{Logit(P) = \ln (P/(1-P)=\alpha+\beta_1 X_1+\cdots+\beta_m X_m} \quad (1)$$

$$\boldsymbol{Z=\alpha+\beta_1 X_1+\cdots\beta_m X_m} \quad (2)$$

With P as the dependent variable, a linear regression equation is established:

$$\boldsymbol{P=e^z/(1+e^z)} \quad (3)$$

$$\text{The decision function is: } \boldsymbol{y} = \begin{cases} \boldsymbol{0, P(y=1|X)\leq 0.5} \\ \boldsymbol{1, P(y=1|X)>0.5} \end{cases} \quad (4)$$

In this paper, y represents the two possibilities that those who are willing to pay are 0 and those who are not willing to pay are 1. x is the independent variable representing each influencing factor, including gender, age, education, income, city, subjective norm, perceived behavior control, perceived usefulness, attitude, environmental awareness, moral norm, personal habit and subjective knowledge.

3.1.3 Interval regression

To more accurately estimate the factors that influence respondents' willingness to pay more or less for green travel carbon trading, an interval regression model is used here for estimation. Interval regression analysis is a data analysis method with interval number as the research object, which reflects the range

of changes in the data and can more accurately estimate the additional amount that respondents are willing to pay for green travel carbon trading. Moreover, in the double-bounded binary problem, respondents are asked to choose the upper and lower limits of the willingness to pay, so the results obtained by using the interval regression model are more authentic and credible. The interval regression model is mostly used to assess the net value of various environmental products. (Choi et al., 2016; Amoah, 2017). The interval regression model is specified in the following form that y_i is the continuous, unobserved latent variable of willingness to pay, x_i is explanatory variables (gender, age, education, income, and city, subjective norm, perceived behavior control, perceived usefulness, attitude, environmental awareness, moral norm, personal habit and subjective knowledge), β is parameter vector, and ϵ_i ($\epsilon \sim N(0, \sigma^2)$) is the error term of the regression.

$$y_i = x_i\beta + \epsilon_i \tag{5}$$

For the estimation of β, the maximum likelihood estimation method is used, and the log-likelihood functions are: B_i^L and B_i^U are used to denote the upper and lower bounds of respondents' WTP choices, respectively, and $\phi(\cdot)$ is the cumulative distribution function of the standard normal distribution.

$$L = \sum_{i=1}^{n} log\left[\phi\left(\frac{B_i^L - x_{i\beta}}{\sigma}\right) - \phi\left(\frac{B_i^U - x_{i\beta}}{\sigma}\right)\right] \tag{6}$$

3.2 Data

To achieve all goals of this study, a questionnaire survey is conducted to collect data. Every measured variable in this study is selected or adapted from relevant studies. Prior to the formal survey, a pre-survey with a size of 100 is conducted to define the range of bid values for WTP so that the accuracy of measurement will be improved. In addition, an interview with three professors and four doctoral students in organizational behavior is done to enhance the reliability and validity of the measurement scale. Taking their suggestions into account, we optimized the scale by adding and removing some details and improving the wording of questions, as a result, it becomes much simple and comprehensible. Finally, Table 1 identifies the measurement scales used to collect data in the official questionnaire.

The demographic characteristics of the respondents were presented in the first section (age, gender, educational background, and monthly household income). The second section adopts a five-point Likert scale to assess eight psychological variables (attitude, perceived behavioral control, subjective norm, perceived usefulness, environmental awareness, personal habit, moral norm and subjective knowledge). The higher the score, the higher the level of agreement, e.g., a score of 1 indicates "strongly disagree" a score of 5 indicates "strongly agree". The third part investigates the budget per 100 km one plans to spend on carbon trading for green travel. Respondents are provided with a scenario, in which we assume that the Chinese government sets an average distance traveled quota to achieve its carbon neutrality goal, and exceeding this quota would result in additional environmental

TABLE 1 Measurement scales in the formal questionnaire.

Dependent variables	Item(s)
WTP	To achieve carbon neutrality by 2060, the government has set an average amount of travel per 100 km, beyond which there is additional environmental damage and therefore an additional payment to those who do not reach the average amount of green travel (i.e., a certain amount of compensation for going below this amount). Are you willing to pay "xx", (RMB 5, 15, 30, 50, 75, 100, 150) followed by an increase or decrease in the value of the initial bid immediately after answering the first dichotomy question (Yes/No).
Independent variables	**Item(s)**
Attitude (Blok et al., 2015)	Instrumental attitude: I think implementing green travel behavior can achieve energy saving and emission reduction.*
	Experiential attitude: I think green travel behavior is wise.*
Subjective norm (Blok et al., 2015; Wang et al., 2016)	Injunctive norm: My friends and family expect me to implement green travel behavior.*
	Descriptive norm: My family, friends and people around me are implementing green travel behavior.*
Perceived behavior control (Cai et al., 2019)	Self-efficacy: I have many opportunities to implement green travel behavior.*
	Control beliefs: It's entirely up to me to implement green travel behavior.*
Perceived usefulness (Schuitema et al., 2013)	I think implementing green travel behavior can improve my quality of life.*
Environmental awareness (Liu et al., 2017)	I always care about environmental protection.*
Moral norms (Chen, 2016; Arkorful, 2022)	I have a responsibility to take action to reduce carbon emissions.*
Personal habits (Gomes and Lopes, 2023)	I've gotten used to saving energy and reducing emissions.*
Subjective knowledge (Qian and Yin, 2017)	I am well aware of how to reduce carbon emissions in my daily life.*
Control variables	**Item(s)**
Gender	1=male; 2=female
Age	1=Less than 18; 2=18–25; 3=26–30; 4=31–40; 5=41–50; 6=51–60; 7=More than 60
Monthly household income	1=Less than RMB 2000; 2=RMB 2001–5000; 3=RMB 5001–10 000; 4=RMB 10 001–20 000; 5=More than RMB 20 000
Education	1=Incomplete secondary school; 2=Secondary school; 3=Junior College; 4=Bachelor degree; 5=Master degree or above

*5-point Likert scale: 1, strongly disagree; 3, neither agree nor disagree; 5, strongly agree.

damage; Therefore, if you have to pay an extra fees for those who travel green (It means that they haven't reached the average travel amount), then how much RMB are you willing to pay for green travel? Respondents is first introduced to the initial bid level for green travel, and if they answer yes, they are asked the high value of the bid; if they answer no, they are asked the low value of the bid. Based on the pre-survey data, we set a total of 7 bidding groups: (1/5/10), (10/15/20), (20/30/40), (40/50/60), (60/75/90), (90/100/120) and (120/150/180). The process of respondent selection of bidding is shown in Figure 2.

In the final phase of the DBDC, a question will be provided to respondents who say "no" to both the initial bid value and the second reduced value. This will allow to obtain the maximum WTP amount, i.e. whether they are willing to provide a maximum amount they are willing to pay. When respondents are unwilling to pay (zero bids), they are asked to explain the reason for their unwillingness to pay. The specific reasons are shown in Figure 3.

There are three reasons we choose these five capital cities in East China (Hefei, Hangzhou, Jinan, Nanjing and Shanghai) for our survey. First, these cities are highly populated, economically developed, large in urban area, relatively mature in public transportation system and have a huge demand for transportation; Second, most studies on WTP for green travel carbon trading in China focus on fast-growing cities in China, and this paper seeks to understand the representative average level of WTP for green travel carbon trading among Chinese residents; Finally, compared to studies in other countries, study on Chinese residents' average WTP for green travel carbon trading is more likely to provide a reference for the implementation of green travel incentive policies and individual carbon trading in China. Because of the gaps in economic development and infrastructure development among these five cities, by investigating the per capita incomes of these five cities, we have categorized them into two levels, with Shanghai, Hangzhou, and Nanjing as one level, and Hefei and Jinan as the other level.

From March 2022 to mid-May 2022, we distributed the questionnaire online in an anonymous manner on the Questionnaire Star website (a popular online survey platform in China). The online questionnaire was distributed to the residents through social media channels (WeChat). Using a snowball sampling method, the questionnaire was first sent to residents and then they were invited to hand out it to friends and family, which was able to guarantee the quantity and quality of the questionnaire. A total of 4,656 residents participated in this questionnaire survey. The final number of completed responses was 3198 (response rate of 69%). Data were then screened to ensure the validity of the responses. Questionnaires that were blank, incompletely completed, and had contradictory responses to

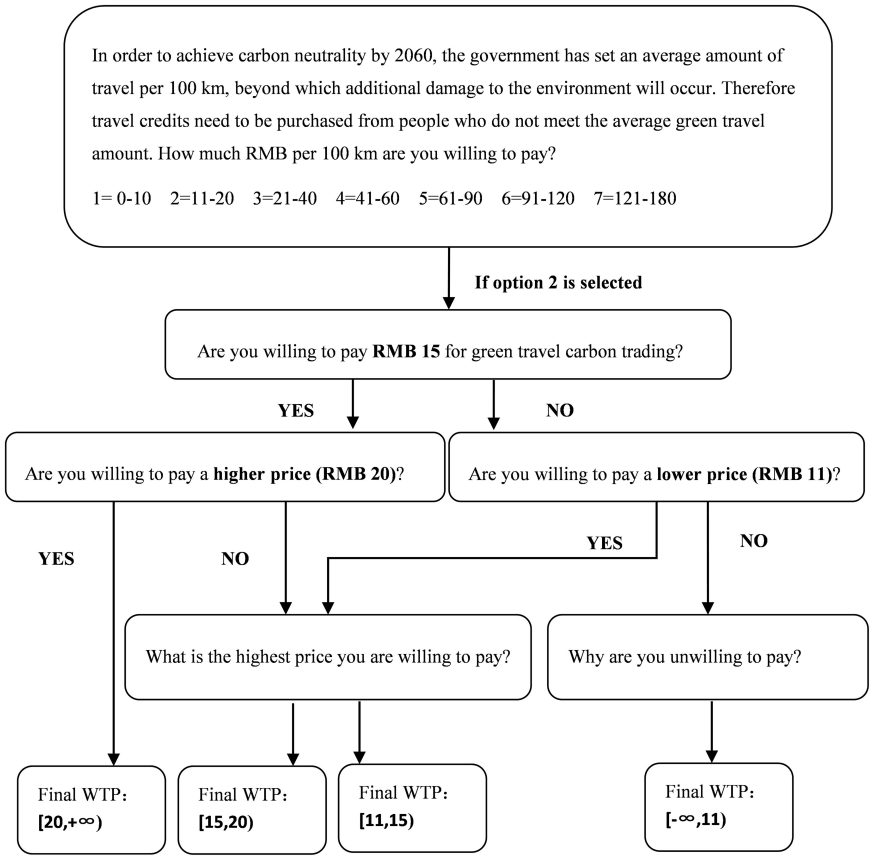

FIGURE 2
The bidding process of DBDC.

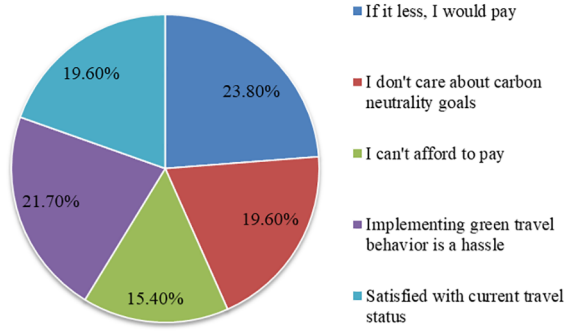

FIGURE 3
Reasons for rejecting the offered.

questions were eliminated, and 2712 questionnaires were retained for analysis. Of these, 1854 questionnaires were willing to pay and 858 questionnaires were unwilling to pay.

3.3 Reliability and validity

Cronbach alpha coefficient is introduced to test the reliability of the scales. We used SPSS 24.0 for each of the psychological variables completed. The Cronbach alpha value was 0.940, almost all of which are well above the minimum of 0.7, indicates good reliability of the overall measure (Fornell and Larcker, 1981). Meanwhile, we tested the validity of the questionnaire, and validity is usually tested using the KMO test as well as the Bartlett test. Ultimately, we calculated a KMO statistic of 0.960, which is higher than 0.7, and a Bartlett sphericity test value of 0.00, which is lower than 0.1. This indicates that the results are concordant with the structure of the questionnaire design.

4 Results

4.1 Descriptive statistics

The basic information of the respondents is as follows. Among the respondents, 1134 (41.8%) are male and 1578 (58.2%) are female. the 18–25 age group (29.9%) has the highest percentage of respondents, followed by the 26–30 and 41–50 age groups (23.2%). Nearly 50.2% of respondents has a bachelor's degree and 16.2% has a master's degree or higher. The monthly household income of the respondents is reported as follows: 36.5% of the respondents' income lies between 10,001 and 20,000, 4.6% earn less than 2,000, and 19.2% earn more than 20,000. The respondents were distributed in five cities as follows: Shanghai accounted for 21.2%, Nanjing for 19.6%, Hangzhou for % percent, Hefei for 24.1% and Jinan for 16.4%. Among the psychological variables, "In my daily life, it is my responsibility to implement green travel behavior." This item has a mean value of 3.82, while the item "I believe that implementing green travel behavior will improve my quality of life" has a mean value close to 3.88.

4.2 Distribution of WTP responses

The distribution of residents' answers on WTP for green travel is shown in Table 2. In the first question, i.e., whether they are willing to pay for green travel, 68.36% gives positive answers. Regarding the second question, i.e., the distribution of positive WTP, the sample is relatively even, specifically, about 10% of the sample is distributed in the categories of [0, 10], [61, 90], and [91, 120]. [11, 20], [21, 40], and [121, 180] all accounts for about 15%, and the largest number of residents is distributed in [41, 60], accounting for about 20%.

The results of the two bids obtained based on the questionnaire data are clearly shown in Table 3. The percentage of valid questionnaires agreeing to the initial bid value in the first bid was mostly distributed among 10, 20 and 40 yuan. 52% of the respondents answered "yes" to the initial question. Based on the results of the second bid, an average of 31.6% of respondents answer "No/No". The remaining 37.9% of respondents express that the WTP price is between the low and initial bidding price (13.5%) or between the initial and high bidding price (16.2%). About 38.6% are willing to pay a higher price.

4.3 Results of WTP modeling

4.3.1 Logistic regression

In the binary logistic regression model, we assume that the number of people who are not willing to pay extra for green travel carbon trading is 1 and the number of people who are willing to pay extra is 0. We analyze the questionnaire data using Stata 16.0 software so as to understand the effect of psychological and demographic variables on those who are not willing to pay. The final results are presented in Table 4.

As the empirical analysis shows, in terms of subjective norms, the odds of those who are not willing to pay extra for green travel carbon transactions are 75.7% of those who are willing to pay,

TABLE 2 Distribution of WTP response.

Questions	Options	Observations	Percent (%)
Whether to pay for green travel?	Yes	1854	68.36
	No	858	31.64
	Total	2712	100
If yes, how much more money are you willingness to pay?	0–10	222	11.97
	11–20	294	15.86
	21–40	348	18.77
	41–60	372	20.06
	61–90	162	8.74
	91–120	162	8.74
	121–180	294	15.86
	Total	1854	100

TABLE 3 Bidding results.

Bidding cards	Yes (Answer to first bid)	No (Answer to first bid)	NY	YY
			NN	YN
5/1/10	174 (46)	204 (54)	72 (2.6)	170 (6.3)
			82 (3.0)	54 (2.0)
15/11/20	234 (51)	228 (49)	100 (3.7)	114 (4.2)
			128 (4.7)	120 (4.4)
30/21/40	234 (39)	360 (61)	72 (2.7)	246 (9.1)
			222 (8.2)	54 (2.0)
50/41/60	294 (57)	222 (43)	44 (1.6)	164 (6.0)
			258 (9.5)	50 (1.8)
75/61/90	144 (60)	96 (40)	42 (1.5)	84 (3.1)
			54 (2.0)	60 (2.2)
100/91/120	216 (56)	168 (44)	24 (0.9)	180 (6.6)
			102 (3.7)	78 (2.9)
150/121/180	63 (91)	12 (9)	12 (0.4)	90 (3.3)
			12 (0.4)	24 (0.9)
Total	1422 (52)	1290 (48)	/	/

Values in parentheses are percentages; frequencies are outside the parentheses.

indicating that those who are not willing to pay have lower expectations of green travel and are less likely to follow the opinions of those around them compared to those willing to pay. Similarly, those unwilling to pay think that the probability of them shouldering the moral responsibility for the environmental benefits of green travel is 67.5% of those willing to pay. Perceived usefulness could also affect two different groups. If one believes that green travel benefits him/her and the environment less, then the probability of him/her unwilling to pay is 81.3% of those willing to pay. However, there shows opposite effects on perceived behavioral control, attitudes, and environmental awareness. In addition, when monthly household income is more than 10000, the percentage of those unwilling to pay is lower than that of those willing to pay. Personal habits, subjective knowledge, gender, age, and education factors were not significant in influencing whether residents were willing to pay.

4.3.2 Interval regression

In the interval regression model, we assume that the WTP of consumers who do not choose green travel is 0, while the WTP of consumers who choose green travel is 1. According to DBDC, there are four outcomes, Yes-Yes (1-1), Yes-No (1-0), No-Yes (0-1), and No-No (0-0). In this study, the interval regression model is employed to analyze the influencing factors of paying more or less among the willing-to-pay group.

The test results of interval regression model of respondents' WTP for green travel are displayed in Table 5. Unlike the logistic regression results, the psychological factors that influenced the willing-to-pay group to pay more or less are just perceived usefulness and personal habits. The more deeply one perceives that green travel will benefit him/her and the environment, the more he is willing to pay more. Likewise, the more respondents are accustomed to implementing energy-saving and environmentally friendly behaviors in their daily life, the more willing they are to pay more extra money for personal carbon trading of green travel. In addition, for demographic variables, the higher the education level, the more people are willing to pay.

4.3.3 WTP results

Based on the questionnaire data collected by DBDC contingent valuation method, this study calculated Chinese residents' average willingness to pay for green travel using an econometric model and the Stata software ("Doubleb" command). The final results show that residents of five provincial capitals in East China are willing to pay RMB 39.95 more per 100 kilometers for the act of green travel carbon trading.

5 Discussion

In this study, from the perspectives of carbon trading, a questionnaire is designed using DBDC; and based on the TPB model, adding new variables such as moral norm, perceived usefulness, environmental awareness, personal habit and subjective knowledge into it, a comprehensive theoretical model is ultimately constructed. As a result, residents' WTP for green travel carbon trading and its key driving factors are revealed. The key findings are discussed below.

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TABLE 4 The empirical results of binary logistic regression model.

Variables	Odds Ratio	Std.Err	z	P>|z|	[95% Conf. Interval]	
Subjective norm	0.753	0.083	−2.57	0.010	0.606	0.935
Perceived behavior control	1.295	0.141	2.37	0.018	1.045	1.603
perceived usefulness	0.811	0.059	−4.48	0.000	0.572	0.804
Attitude	1.280	0.109	2.89	0.004	1.083	1.513
Environmental awareness	1.214	0.105	2.23	0.026	1.024	1.439
Moral norm	0.678	0.059	−4.48	0.000	0.572	0.804
Personal habit	1.000	0.084	0.00	0.997	0.848	1.180
Subjective knowledge	0.958	0.076	−0.54	0.592	0.820	1.120
Gender (Female)	0.809	0.105	−1.63	0.081	0.627	1.044
Age (Less than 18)	/	/	/	/	/	/
Age (18–25)	0.708	0.332	−0.74	0.461	0.282	1.776
Age (26–30)	1.321	0.610	0.60	0.547	0.534	3.266
Age (31–40)	0.974	0.448	−0.06	0.955	0.395	2.401
Age (41–50)	1.058	0.483	0.12	0.902	0.433	2.587
Age (51–60)	1.023	0.689	0.03	0.973	0.273	3.827
Education (Incomplete secondary school)	/	/	/	/	/	/
Education (Secondary school)	2.957	1.560	2.06	0.051	1.051	8.314
Education (Junior College)	1.234	0.531	0.49	0.625	0.531	2.867
Education (Bachelor)	1.896	0.797	1.52	0.128	0.832	4.321
Education (Master or above)	0.626	0.296	−0.99	0.322	0.248	1.581
Household income (Less than 2000 monthly)	/	/	/	/	/	/
Household income (2001–5000 monthly)	0.276	0.110	−3.23	0.162	0.126	0.603
Household income (5001–10000 monthly)	0.711	0.235	−1.03	0.301	0.372	1.359
Household income (10001–20000 monthly)	0.613	0.204	−1.47	0.001	0.319	1.175
Household income (More than 20000 monthly)	0.478	0.166	−2.12	0.034	0.242	0.945
City	0.832	0.116	−1.32	0.186	0.633	1.093
_cons	1.592	1.218	0.61	0.543	0.356	7.12

Assume that the person who is willing to pay is 0. The person who is not willing to pay is 1.

First, out of 2712 valid questionnaires, 858 (31.64%) of users indicated that they are unwilling to pay for green travel carbon trading. This finding suggests that it is particularly important to understand the influencing mechanism behind the reluctant payers. Therefore, we use a binary logistic regression model to analyze it and find that moral norms and subjective norms can effectively reduce the level of reluctance to pay, that is, people with higher moral level and stronger subjective norms are less likely to be reluctant to pay and more likely to be willing to implement green travel behavior. In this case, more attention should be paid to promoting the leading role of important people and organizations as a result of residents' dependence on their expectations and actual behavior. Similar results can be found in the study of Blok et al. (2015). Donald et al. (2014) also confirm the positive role of moral norms in the study of commuters' transportation mode choice. A possible explanation is that pro-environmental behavior is always featured with altruism which leads to high moral norms among people. Apart from this, our findings provide evidence that close to 60% of people are willing to pay more for green travel carbon trading, suggesting that there is a promising market for green travel in China and that most people seemed willing to adjust their travel behavior to reduce CO2 emissions. Therefore, among the willing-to-pay group, interval regression models are applied to test the hypothesis, and the results demonstrate that personal habits are the strongest predictor of WTP for green travel carbon trading, i.e., the stronger people's previously formed green travel habits are, the more they are willing to pay more. This has been confirmed in previous studies on WTP for carbon trading (Liu, 2019). These results generally suggest that green travel is

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TABLE 5 The empirical results of Interval regression model.

Variables	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Subjective norms	−2.004	3.945	−0.51	0.611	−9.735	5.727
Perceived behavior control	4.623	3.797	1.22	0.223	−2.819	12.066
perceived usefulness	7.337	3.426	2.14	0.032	0.623	14.052
Attitude	2.159	2.753	0.78	0.433	−3.236	7.555
Environmental awareness	1.441	3.060	0.47	0.638	−4.557	7.439
Moral norms	−0.777	2.949	−0.26	0.792	−6.557	5.003
Personal habits	6.698	2.707	2.47	0.013	1.392	12.004
Subjective knowledge	−3.316	2.864	−1.10	0.273	−8.749	2.477
Gender (Female)	−1.810	4.368	−0.41	0.679	−10.370	6.751
Age (Less than18)	/	/	/	/	/	/
Age (18–25)	0.663	22.744	0.03	0.977	−43.913	45.240
Age (26–30)	−19.496	22.646	−0.86	0.389	−63.881	24.888
Age (31–40)	−42.938	22.534	−1.91	0.057	−87.104	1.228
Age (41–50)	−39.511	22.493	−1.76	0.079	−83.598	4.575
Age (51–60)	−49.443	27.816	−1.78	0.075	−103.962	5.076
Education (Incomplete secondary school)	/	/	/	/	/	/
Education (Secondary school)	52.899	19.163	2.76	0.006	−15.340	90.458
Education (Junior College)	54.046	14.558	3.71	0.000	−25.514	82.579
Education (Bachelor)	45.727	14.546	3.14	0.002	−17.217	74.327
Education (Master or above)	51.082	15.545	3.29	0.001	−20.615	81.548
Monthly income (Less than 2000)	/	/	/	/	/	/
Monthly income (2001–5000)	14.317	12.402	1.15	0.248	−9.992	38.625
Monthly income (5001–10000)	−3.924	10.925	−0.36	0.719	−25.336	17.488
Monthly income (10001–20000)	−11.624	11.000	−1.06	0.291	−33.184	9.935
Monthly income (More than 20000)	−1.238	11.295	−0.11	0.913	−23.376	20.901
City	1.218	4.425	0.28	0.783	−7.455	9.891
_cons	102.061	31.416	3.25	0.001	40.487	163.635
/lnsigma	3.936	0.035	112.44	0. 000	3.868	4.005
sigma	51.238	1.794			47.840	54.877

a sustainable consumption in the context of sharing economy, and that personal travel carbon trading behavior is consistent with the theoretical model's explanation of individual behavior.

Perceived usefulness is a positive predictor of green travel carbon trading behavior for both those unwilling to pay and those willing to pay. This may be because perceived usefulness is a positive predictor of attitudes and intentions towards green travel behavior, implying that when consumers perceive that personal carbon trading systems are more useful to promote green travel across the society, they tend to pay for this reasonable policy; on the contrary, if consumers lack trust in personal carbon trading systems, they will pay less or be reluctant to pay. This result also coincides with the findings of previous studies on green behavior (Shi and Wang, 2017). Studies showed that consumers are more inclined to technologies or behaviors with higher perceived usefulness. (Wang and Dong, 2016; Li et al., 2018; Liu et al., 2018).

Psychological variables such as attitude, perceived behavioral control and environmental awareness were invalid in predicting the behavioral characteristics of the reluctant group compared to the willing-to-pay group; Even though they are valid predictors in the theoretical model, that is because they are used to predict general behavior, and there is a gap between these variables and behavior in predicting WTP for green travel carbon trading in this paper. Relevant conclusions have not been found in previous studies, which may be due to the fact that some residents do not yet have a good perception of personal carbon trading and lack trust in paying for green travel carbon trading and are unsure of

its validity. However, once the value of carbon trading is perceived, residents might still be willing to pay. Owing to the uncertainty, further validation of this finding is needed in the future.

Regarding the demographic characteristics, monthly household income (especially above 10,000 RMB) is an important characteristic that predicts whether residents are willing to pay for green travel carbon trading behavior. Namely, the lower the income, the less likely they are willing to pay. This is consistent with previous findings that the higher the monthly income is, the more likely they are willing to behave in a low-carbon way (Yue et al., 2013). In addition, education is also an important demographic variable influencing people's willingness to pay more or less, i.e., the higher the education level, the more they are willing to pay for green travel carbon trading behavior. Previous studies have also demonstrated that people with lower education level are less willing to implement low-carbon behaviors (Yang et al., 2018). The findings also found that the effect of the city level variable on willingness to pay is insignificant, probably because the sample encompasses residents with different demographic characteristics in each city.

Lastly, we figure out that the average amount residents are ultimately willing to pay for green travel carbon trading is RMB 39.95 per 100 km, demonstrating that Chinese residents have a relatively high willingness to pay for green travel. This provides an aid for the government to improve environmental and economic performance by using and marketing green transportation, and might also offer a reasonable basis for future pricing of green travel carbon trading. At the same time, it also manifests that our respondents can meaningfully process the rather abstract concepts of green travel credits and carbon trading, and that the degree to which they value the environment can had an impact on their behavior to some extent.

6 Conclusions

The world is under unceasing threat from climate change. In order to address these problems, many countries have set emission reduction targets; and the Chinese government and companies are making constant efforts towards the goal of carbon neutrality by 2060 such as pushing for a cleaner, more sustainable way to travel, which relies not only on innovative transportation solutions but also on individuals' conscious green travel behavior. Through a questionnaire survey of residents from five provincial capital cities in eastern China, this study analyze the key drivers of Chinese residents' WTP for green travel carbon trading, ultimately yielding interesting empirical results. First, respondents show a high willingness to participate in personal carbon trading for green travel; Second, the binary logistic regression results verifies the positive effects of perceived usefulness, subjective norm and moral norm on willingness to pay for green travel carbon trading. In contrast, perceived behavioral control, attitudes, and environmental awareness are invalid to predict the WTP of unwilling groups. For those willing to pay with monthly incomes below 2000, those with monthly incomes more than 10,000 are less likely to be unwilling to pay. Interval regression analysis shows that perceived usefulness and personal habits are strongly associated with the magnitude of willingness to pay in this group of willing payers, and that the higher the education level, the stronger the willingness to pay. In addition, we make an attempt to calculate the average willingness to pay for green travel credits among Chinese residents, and the results shows that Chinese residents are willing to pay an extra 39.95 RMB per 100 km on average for green travel.

The findings of this study will lay a foundation for making individual travel carbon trading policies in other similar regions. The government is supposed to formulating policies related to travel carbon trading. Although the Chinese government has implemented many policies to encourage green travel, there are few related to green travel carbon trading. Firstly, in order to increase residents' acceptance of green travel carbon trading, policy makers should broadcast the usefulness of green travel and personal carbon trading through various media channels, encouraging the public to form a habit, and such publicity can focus on the effectiveness of green travel carbon trading; Secondly, urban residents think highly of subjective norms and moral norms, in which case the government should pay more attention to promoting the leading role of important people and organizations, and it is necessary to set an example of good public figure. In addition, policymakers should also focus on give implications to those with lower sense of responsibility, encouraging them to learn what others do, increasing public's psychological commitment by further enhancing the belief that environmental issues are inextricably linked to all people and let them aware that they are able to and responsible for environment protection by themselves rather than solely relying on government. Finally, the fairness and stability of the policy also play a very important role. The government should highlight that residents will be rewarded for their efforts to reduce their carbon emissions and footprint, and that the policy is fair to each. They should also make clear their determination to launch a personal carbon trading policy, which will increase residents' willingness to participate.

Although the study demonstrates some valuable findings, there are still some limitations. First, the survey only included urban residents in eastern China, so the findings may not be representative of the whole country. Future studies should target a broader region and a more representative sample; Second, all variables in this study are based on respondents' self-reports, so the findings may be subject to social desirability bias; Future research could consider more social factors that may affect travel intentions, such as policy environment, travel time and travel distance; Third, considering the difficulty of obtaining data on subsequent behavior, the dependent variable in the theoretical model is the public's willingness to pay for green travel carbon trading, rather than the actual behavior. Therefore, future research may incorporate actual behavior into the model with the hope of measuring subsequent behavior for in-depth study. Finally, our empirical results do not support all of our research hypotheses, and future research may continue to test insignificant results with more generalized data.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study is carried out in line with Code of Ethics in Counseling and Clinical Psychology and Code of Ethics for Psychological Counseling and Clinical Psychology of Chinese Psychological Society; and the protocol is authorized by the China Occupational Safety and Health Association – Occupational Mental Health Professional Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

JG: Conceptualization, Investigation, Software, Supervision, Writing – review & editing. NY: Formal Analysis, Methodology, Writing – original draft. LY: Project administration, Validation, Investigation, Writing – review & editing. RL: Funding acquisition, Validation, Conceptualization, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by the National Natural Science Foundation of China (Grant number 72104001), the Outstanding Youth Scientific Research Project of Anhui Universities (Grant number 2022AH030082), and the Major Project of National Social Sciences Foundation of China (Grant number 22ZDA112).

Acknowledgments

The authors are grateful to several professors and PhDs who provided valuable comments in the preparation of the questionnaire.

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.

Publisher's note

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