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An Investigation into Residents' Willingness to Pay for Vertical Greening in the Renovation of Existing Residential Areas for Greenhouse Gases Reduction- A Case Study of Hangzhou City

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Abstract: There are numerous buildings in existing residential areas in Hangzhou City, which results in much carbon emissions and the formation of greenhouse gases that have exerted significant adverse impacts on the living comfort of citizens in Hangzhou City. It is imperative to conduct a greening renovation of buildings in existing residential areas in Hangzhou City. Vertical greening, as a significant measure of renovation, has received much attention. In this paper we use double-bounded discrete choice format to elicit public's willingness to pay (WTP), and the economic benefits of vertical greening reduces greenhouse gases in Hangzhou City were preliminarily estimated, and the factors that affect residents' payment and participation. A total of 1089 valid samples were obtained via the face-to-face field interview. There were 250 (23.0%) respondents who refused to pay, whose data were subject to processing with Spike model, which had been proved to be more advantageous than traditional models in dealing with zero response problems. Families in Hangzhou City would pay 702.55 Chinese yuan (CNY) each year. The economic benefit of the project is 1.141-1.433 billion CNY. The factors affecting WTP were explored by demographic characteristics, social psychology, knowledge of the environment and theory of planned behavior. The results showed that there were obvious statistical relationships between the age, income, family members, cognition of vertical greening and subjective norms of respondents and their WTP. Meanwhile, the feedback information was collected and analyzed, with the results showing that increasing income, setting up compensation mechanism, promoting the publicity of environmental protection, and disclosing the flow of funds would conduce to residents' participation in the renovation of vertical greening.

Keywords: 1; Residential renovation 2; vertical greening 3; willingness to pay 4; influencing factor 5; Contingent valuation

1. Introduction

Existing residential areas have the disadvantages of high energy consumption and high carbon emissions. Their energy consumption and carbon emissions account for 40% and 36% of the global total respectively (HAT. Can and W. E. Learn 2011). In China, the area of existing buildings has reached about 60 billion square meters, of which residential areas account for 75.3%, public buildings account for 9.9% and production buildings account for 14.8%. As of December 2020, the area of existing buildings that has obtained the green building logo through a renovation is only 2.902 million square meters (Statistics of China 2020), accounting for 0.06% of the total area, which is seriously insufficient. Moreover, with the continuous improvement of urbanization, the carbon emissions in the construction field will get a further increase. Numerous carbon emissions are the

main reasons for the increase in greenhouse gases, climate warming and the exacerbation of greenhouse effects. The increase of greenhouse gases would reduce the environment comfort of residents, increase the energy consumption in the summer, and increases the environmental burden (Xu et al. 2018). And vertical greening can effectively reduce greenhouse gases (Pan et al. 2021)

. During "The Fourteenth Five-Year Plan" of China, there are 11 important cities that have been identified for the renovation of existing buildings. It is urgent to perform the green renovation of existing buildings in Hangzhou City, which is a pilot city for the renovation in southern China.

Existing buildings are proposed relative to newly-built buildings. In China, they generally refer to buildings that have been completed and put into service before January 1, 2000. The renovation of existing buildings aims to save resources (energy saving, land saving, water saving, and material saving), protect the environment, and reduce carbon emissions to the maximum extent in the life cycle after the renovation, and to provide residents with a healthy, applicable and efficient use space and buildings that coexist harmoniously with nature (Ca Mtech.2009).

High building density and insufficient greening have always been the problems perplexed by existing residential areas in Hangzhou City. Vertical greening gets rid of the limitation of traditional plane greening in plant quantity and planting area, through which the smallest occupied area can be employed to create the maximum greening effect, thus alleviating the increasingly fierce contradiction between urban greening land and building land, and providing a breakthrough for increasing the rate of urban greening and a new orientation for the planning of urban land resources (Medl et al. 2017). As per Opinions of the State Council on Strengthening the Construction of Urban Infrastructure, vertical greening is recommended in the renovation of residential areas (C. A. o. China 2018). Besides, Notice of the General Office of Hangzhou Municipal People's Government on Further Promoting the Vertical Greening Work in Hangzhou City from 2015 also suggests that the facades of existing buildings and public facility structures with greening conditions in Hangzhou City shall be fully covered by greening, with the vertical greening area increased by more than 60,000 square meters each year and the city's vertical greening area being more than 500,000 square meters by 2025 (C. H. China 2018).

Driven by the government, the vertical greening have made rapid advancements. Policymakers shall understand the economic benefits of the project and public Influencing factors of the participation, which conduces to making relevant investment decisions. However, the benefits (such as reducing greenhouse gases and purifying air) brought by vertical greening cannot be evaluated by traditional market pricing. The evaluation of WTP by CVM has become a common method to measure its economic value (Laitila et al. 2004). Under the impact of China's national conditions and policies, residents have not yet participated in environmental protection and governance activities. With the implementation of the Environmental Protection Law of the People's Republic of China in 2015, "public participation" has been listed as one of the basic principles of environmental protection in China for the first time, and the urban environmental situation has begun to receive extensive attention, which has presented a significant opportunity that is conducive to public engagement in urban environmental governance. A thorough understanding of residents' acceptance and evaluation of vertical greening contributes to providing a reference for policy formulation.

The effectiveness of vertical greening technology has been verified. H.T. Rupasinghe maintains that the maximum indoor temperature in one day can be reduced by 4.89°C by introducing vertical greening into the building facade (Rupasinghe et al. 2020). Li, Zhilei et al. demonstrate that the cooling load can be reduced by 8.8%, and the heat load can be reduced by 1.85% in Zhejiang province, China by increasing horizontal and vertical greening, which can realize the energy conservation, thus reducing the emission of greenhouse gases (Li et al. 2019). In addition, P. Rosasco et al. (2018) demonstrate that the vertical greening system can improve the urban environmental quality, and they also conduct a study on its economic sustainability and verify its reliability (Rosasco and Perini 2018). However, in this series of studies, there is no investigation into the economic benefits of vertical greening in reducing greenhouse gases, the factors affecting WTP, and the factors affecting public participation.

In this paper, the existing research results were expanded from four aspects. Firstly, the effectiveness of Spike model in handling zero response was verified. Secondly, Except for demographic characteristics, The factors affecting WTP were explored by social psychology, knowledge of the environment and theory of planned behavior. Thirdly, the factors affecting residents' participation in vertical greening were explored via the collection and analysis of feedback information.

In the following, the study would be conducted as follows. The research methods in this paper would be discussed in Section 2. The Spike model and WTP estimation model would be discussed in Section 3. The results and discussion would be reported in Section 4. The main conclusions of this paper and the future prospects of related studies would be presented in Section 5.

2. Materials and Methods

2.1 Goods to be appraised

In an attempt to meet the demand of reducing greenhouse gases, Hangzhou Municipal Government aims to supplement 60,000 square meters of vertical greening area each year and achieve the goal of more than 500,000 square meters of vertical greening area in the whole city by 2025 (C. H. China 2018). In this study, the product to be appraised is the value of vertical greening in reducing the emission of greenhouse gases (Regardless of other positive externalities). In the interview, the impact of greenhouse gases was introduced to each respondent in the first place. Subsequently, the benefits of vertical greening in reducing the emission of greenhouse gases were introduced. Besides, the renovation of existing residential areas in Hangzhou City was also presented.

2.2 Inducing approach CVM of WTP

CVM is the most common method to evaluate the non-market economic valuation (Sattout et al. 2007). It has been widely employed in many fields, such as environmental economy, health economy, cultural economy, tourism economy, traffic safety, biodiversity protection, and ecosystem services, with the research area covering almost every country in the world (Sevda et al. 2013) In terms of CVM, a hypothetical market with changes in the quantity or quality of public goods would be established through a survey with the aim of guiding respondents to make choices in these hypothetical markets. The format of the CVM survey asking respondents is to state their WTP for an increase in the supply level or avoiding a decrease in the supply level of public goods (Davis et al. 1963)

2.3 CVM data collection

There are three main data collection methods in CVM: face-to-face interview, telephone inquiry and online mail survey. The limitation of the email survey lies in the low response rate. The telephone interview can only offer respondents some limited information, which has a tendency to increase mutual distrust and affects the quality of interviews. Due to the fact that there is a higher response rate in face-to-face interviews, they have obvious advantages, such as the improvement in the above-mentioned trust between interviewers and respondents, and timely recovery of feedback information from respondents (Szolnoki et al. 2013) National Oceanic and Atmospheric Administration (NOAA) recommends that face-to-face interviews can improve the accuracy of CVM. Therefore, in this paper, face-to-face interviews would be adopted for data collection.

2.4 CVM questionnaire format

CVM questionnaire format mainly includes three types: open-ended, payment-card and closed questionnaires, of which the closed questionnaire includes the single-bounded dichotomous choice format and double-bounded dichotomous choice format. The disadvantage of the open-ended questionnaire is a lack of a reference point on the "maximum payment", which induces a low response rate of the questionnaire (Carson et al. 2006) The payment-card questionnaire has a tendency to cause "rounding consumption", namely that the WTP of respondents will be concentrated on the integer bidding point, but it can achieve excellent effects in determining the scope in the pre-survey (ZHOU et al. 2006) In contrast, the respondents under the closed dichotomous choice format only need to answer "Yes" or "No" for a certain bidding value without giving the specific value of their WTP. Therefore, it has incentive compatibility and is also consistent with people's daily consumption decision-making habits [19] On the ground that the statistical efficiency of double-bounded dichotomous choice format is significantly higher than that of the single-bounded dichotomous choice format, double-bounded dichotomous guidance technology would be adopted to obtain WTP in this paper.

2.5 Payment method

Payment instruments play an important role in CVM research because they provide a payment environment for CVM experiments. In order to avoid respondents from withholding payment due to the distrust caused by their ignorance of payment instruments, they shall be familiar with the payment instruments. It has been revealed in some studies that mandatory payment instruments are more acceptable (Carson 2000) Many researchers select the individual income tax, which is familiar to residents, as a payment instrument (Zhang et al. 2019) However, there are differences in the individual income tax. Individual Income Tax in China (IIT) stipulates that the threshold of income tax is 5000CNY per month, which easily confuses people whose income is less than 5000CNY. Moreover, the living expenses (such as electricity and water charges) that are well known to the public have a more prominently mandatory nature. Therefore, living expenses were selected as the payment instrument in this study. During the pre-survey, the payment instrument was subject to test with good results. As for payment frequency and payment period, the annual fee was selected

with reference to relevant research (Egan et al. 2015) Due to the fact that China would formulate a national economic and social development plan every five years, the payment period was determined as five years.

2.6 Factors affecting WTP

There are many factors affecting WTP. In the traditional scope test, only socio-economic factors would be included, without the consideration of the excess part, which would ignore emotional, cognitive, attitudinal, and behavioral variables (Heberlein et al. 2004) Researchers have drawn two important conclusions through research: when respondents know more, like more and experience more about the public goods to be appraised, they are likely to give higher value to them; when respondents have relevant knowledge, experience and good attitudes towards the public goods to be appraised, the valuation of WTP is more likely to be effective. When people want to reveal their WTP, they would trust their intuition, feelings and basic values. Considering that the payment behavior of respondents must be the result of a well-thought-out plan, more and more researchers begin to pay attention to social psychological factors, such as attitudes, beliefs and values, which make people more successful in predicting their payment behavior (Heberlein et al. 2005) Personality and social development is a traditional field of social psychology, including the impacts of family members on individual thinking. (Heberlein et al. 2005) believe that possessing relevant environmental knowledge can make the valuation of results more effective. As per the theory of planned behavior, belief, perceived resources and behavior can be combined to explore the influencing factors of WTP. Therefore, in this study, except for the traditional variables of demography, such covariates as social psychology, environmental knowledge and theory of planned behavior have been supplemented to explore the influencing factors of WTP.

2.7 Questionnaire design

Before the interview, 24 interviewers were determined, with 3 in each group to obtain 8 groups in total. There was a manager and two interviewers in each group, which could avoid the interviewers' personal emotions affecting the statistical results (Franceschi et al. 2011) . In this study, guidance was provided to respondents, including the research background, research significance and answers to the questions for respondents. In order to avoid the data deviation caused by age, only those residents aged 18-65 were subject to the interview.

In WTP inquiry, the selection of the number and limit of bidding points is very important. The minimum value of the endpoint value should be accepted by 90% of respondents, while the maximum value should be rejected by 90% of respondents (Turner R K. 1993) Combined with the data obtained from the pre-survey, 10 bidding points, such as 10, 25, 50, 100, 200, 400, 800, 1500, 3000 and 6000, were selected. In order to avoid the lowest (high) bidding point missing the lower (high) bidding value in the second round of inquiry, both points of 10 and 6000 were avoided in the first round of inquiry. Subsequently, it could be obtained for 8 bid combinations (10/25/50), (25/50/100), (50/100/200), (100/200/400), (200/400/800), (400/800/1500), (800/1500/3000), (1500/3000/6000) CNY. The middle amount in the data group was firstly selected for inquiry. If it is rejected, the lower amount in the data group would be selected for inquiry; if it is allowed, the higher amount in the data group would be selected for inquiry.

The interview process is shown in (Figure 1.) As for respondents whose WTP is greater than zero, the core valuation question of WTP is: Hangzhou Municipal Government has carried out vertical greening renovation of existing residential areas to reduce the emission of greenhouse gases. Would you like to submit a certain amount of money by raising living expenses during the next 5 years? If the respondent answers "Yes", a higher bidding value would be selected in the next round of inquiry; if the answer is "No", the lower bidding value would be selected in the next round of inquiry. For those who withhold payment, the zero response would be employed for a judgment according to their choice. The collected data would be processed by Spss25 and RStudio for obtaining WTP and relevant influencing factors.

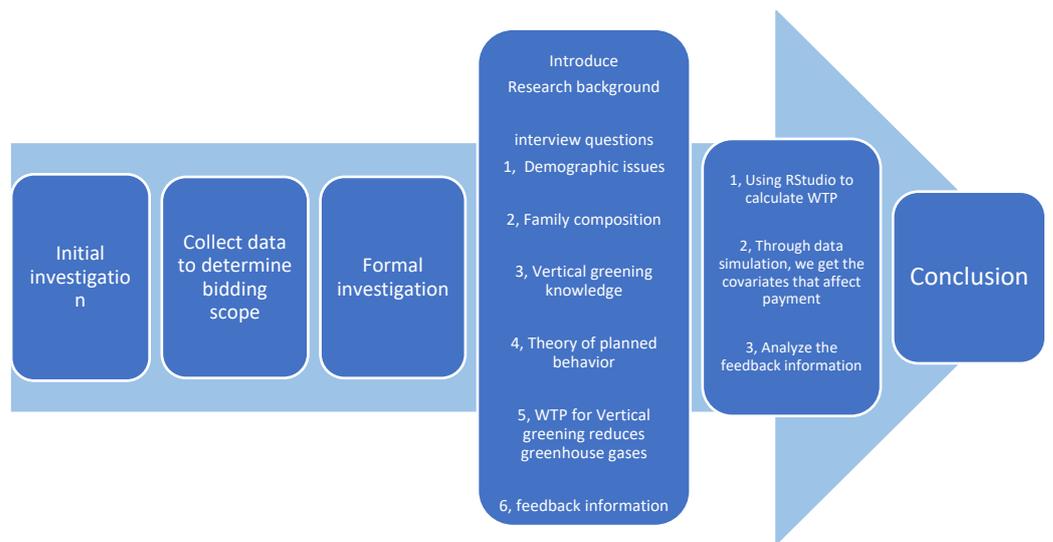


Figure 1. Interview process

The pre-survey was carried out on February 17, 2021, and an open-ended questionnaire survey was conducted among 200 residents in Hangzhou City at random, with a view to obtaining a more accurate bidding scope. A formal survey was conducted from February 20 to March 1, 2021. A total of 1500 interviews were conducted. In the survey, there were 369 respondents who refused to pay the expenses. It is necessary to further analyze the reasons why interviewees were unwilling to join the market. A total of 5 question options were designed accordingly (Figure 2.). According to the protest response judgment standard (Strazzer et al. 2003), C, D and E can be considered as protest responses, and A and B can be considered as true zero responses. The statistical results showed that there were 250 true zero responses and 119 protest responses. Since the interview was random, it could be assumed that the distribution of protesters in the sample was random. Therefore, those protesters were eliminated directly. There were 838 respondents whose WTP was greater than zero, with the response rate of the questionnaire being 77.0%. The number of valid samples, efficiency and response rate of the questionnaire all reached the standards recommended by the NOAA Review Committee (Meyerhoff et al. 2006).

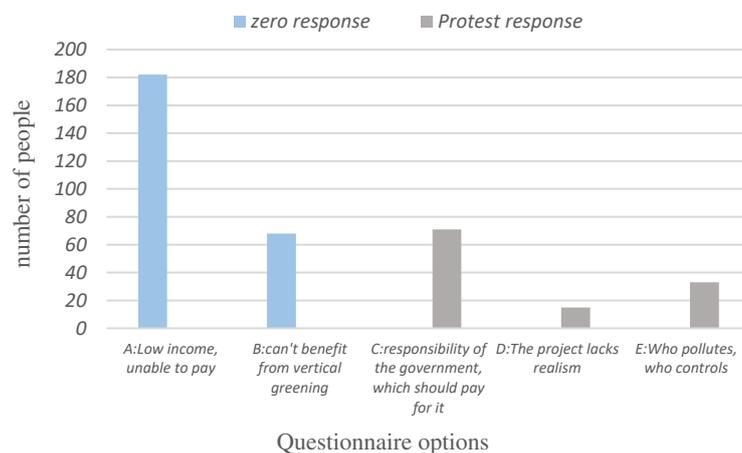


Figure 2. Reasons for not willing to join the market

On account of the differences in social conditions and economic characteristics of the respondents between different districts in Hangzhou City, in an attempt to ensure the accuracy of the questionnaire, the sampling was performed based on the population distribution in the valid questionnaire to avoid representative deviation. As shown in (Figure 3.), the proportion of the sampled population is equivalent to the proportion of the actual population in each district, which indicates that the sample is more representative.

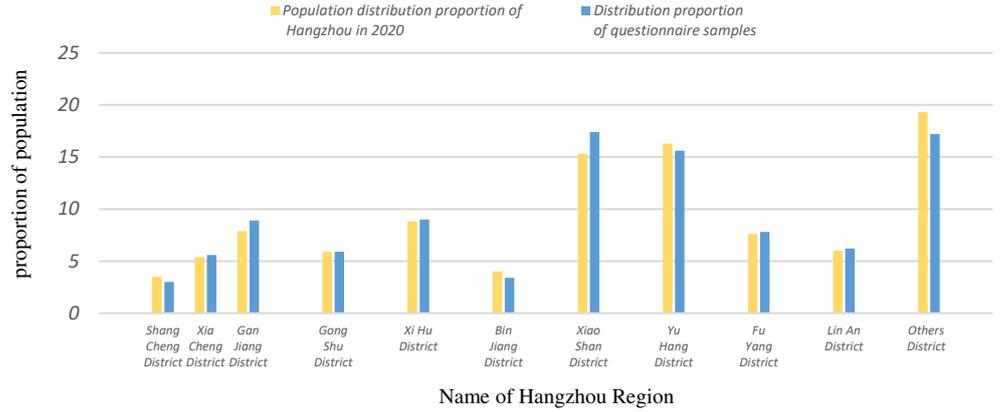


Figure 3. Distribution and population comparison

3. Spike model optimization DBDC

3.1. Traditional DBDC-CVM model

In the traditional DBDC format, respondents would be asked whether they are willing to pay or accept the bidding value of a specific amount M_i ($i=1 \dots n$). The first answer of "Yes" or "No" would be regarded as a reference basis for the second inquiry to adjust the bidding amount. As for WTP, when the answer of respondents is "Yes" for the first time, another higher bidding amount M_i^H would be asked for the second time; otherwise, they would be provided with another lower bidding amount M_i^L , namely $M_i^L < M_i < M_i^H$. If the indicator T is employed to express the response to a given amount M_i , it can be assumed that $T = Y$ represents showing WTP and $T = N$ represents showing unwillingness to pay. As a result, there would be four possibilities of answers from respondents: willing-willing, willing-unwilling, unwilling-willing, and unwilling-unwilling. The binary-indicator variables would be H_i^{YY} , H_i^{YN} , H_i^{NY} , and H_i^{NN} respectively. $G_c(M; X)$ is the cumulative distribution function (CDF) of WTP, X is an unknown parameter that needs to be valued, M is the value of the bid, and the logarithmic likelihood function is

$$\ln L = \sum_{i=1}^N \{H_i^{YY} \ln[1 - G_c(M_i^H; X)] + H_i^{YN} \ln[G_c(M_i^H; X) - G_c(M_i; X)] + H_i^{NY} \ln[G_c(M_i; X) - G_c(M_i^L; X)] + H_i^{NN} \ln G_c(M_i^L; X)\}$$

Formulating $1 - G_c(\cdot)$ as logistic Cumulative distribution function and combining this with $X = (\alpha, \beta)$ yields:

$$G_c(M_i; X) = [1 + \exp(\alpha - \beta A)]^{-1}$$

The mean value of WTP is $\bar{C} = \alpha/\beta$, where \bar{C} is the mean value of WTP, and the result can be positive or negative.

3.2. Spike model

In developing countries, due to the low income level of residents and weak awareness of environmental protection, coupled with the public's unfamiliar situation of CVM, there will be many respondents who would choose to withhold payment in the questionnaire survey, which is the frequent zero response in CVM research. Ignoring this point will cause deviation of WTP. On the ground that Spike model has the advantage of handling zero response (Yoo et al. 2002), it would be adopted in this study to handle zero response (Kristrom B. 1997). In this study, there were 250 (23.0%) respondents who choose to withhold payment.

Spike model is a supplement to DBDC-CVM. In DBDC-CVM model, when the respondent is asked to answer subsequent questions when the answer is unwilling-unwilling (H_i^{NN}), Spike model allows the probability of 0WTP to be a certain positive decimal (Kristrom B. 1997). In Spike model, the closed double-bounded WTP inquiry question includes two steps: first, respondents would be asked whether they are willing to join the market again, and if the answer is "Yes",

the traditional double-bounded dichotomous inquiry would be conducted; if the answer is "No", the reason why they are unwilling to join the market would be asked to judge whether the respondent belongs to a protest group. The formula can be expressed as rejection H_i^{NNN} and consent H_i^{NNY} , as follows:

$$\ln L = \sum_{i=1}^N \{H_i^{YY} \ln[1 - G_c(M_i^H; X)] + H_i^{YN} \ln[G_c(M_i^H; X) - G_c(M_i; X)] + H_i^{NY} \ln[G_c(M_i; X) - G_c(M_i^L; X)] + H_i^{NNY} [\ln G_c(M_i^L; X) - G_c(0; X)] + H_i^{NNN} [G_c(0; X)]\}$$

In which

$$G_c(M_i; X) = \begin{cases} 0 & \text{if } < 0 \\ [1 + \exp(\alpha)]^{-1} & \text{if } = 0 \\ [1 + \exp(\alpha - \beta A)]^{-1} & \text{if } > 0 \end{cases}$$

The spike is defined by $[1 + \exp(\alpha)]^{-1}$. The average value of WTP can be presented as follows:

$$\bar{C} = (1/b) \ln[1 + \exp(\alpha)]$$

4. Results

4.1 Data

The data of the 8 bidding groups mentioned above are summarized in (Table 1). In the interview, 91% of the respondents would choose to pay a minimum of 10 CNY, while 90% of the respondents refused to pay 6000CNY, which is equivalent to the results of the pre-survey. Since the sample size is increased, it can be believed that the endpoint value has high accuracy. As shown in (Figure 4), with the increase of bidding value, the proportion of people choosing YY and YN is decreasing, while the number of people choosing NNY and NNN is increasing.

Table 1 Response distribution

Bid Amount	YY	YN	NY	NNY	NNN	SUM
(50/25/10)	71 (52%)	43 (32%)	10 (7%)	4 (3%)	8 (6%)	136 (100%)
(100/50/25)	53 (39%)	39 (29%)	14 (10%)	8 (6%)	22 (16%)	136 (100%)
(200/100/50)	48 (35%)	41 (30%)	13 (10%)	11 (8%)	23 (17%)	136 (100%)
(400/200/100)	40 (29%)	37 (27%)	16 (12%)	15 (11%)	28 (21%)	136 (100%)
(800/400/200)	36 (26%)	36 (26%)	12 (9%)	14 (10%)	38 (29%)	136 (100%)
(1500/800/400)	29 (21%)	27 (20%)	13 (10%)	23 (17%)	44 (32%)	136 (100%)
(3000/1500/800)	19 (14%)	24 (18%)	17 (13%)	32 (23%)	44 (32%)	136 (100%)
(6000/3000/1500)	13 (10%)	22 (16%)	21 (15%)	37 (27%)	43 (32%)	136 (100%)
sum	309 (28%)	269 (25%)	116 (11%)	144 (13%)	250 (23%)	1088 (100%)

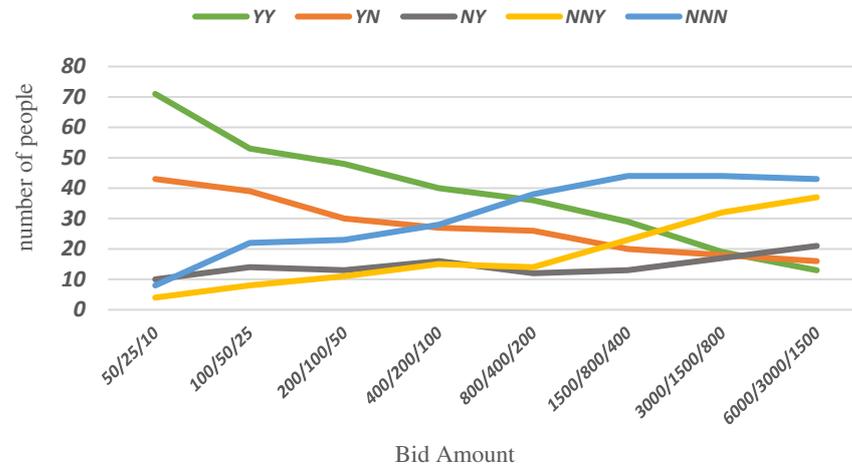


Figure 4. Response distribution

The interview content has been subject to statistics summarized in (Table 2) and a comparison with the census data of the National Bureau of Statistics of China, with the results showing that there are some similarities in gender, job and census results, and there is a large gap in the final educational background and age distribution. Firstly, with the consideration of the limited sample size, and that Hangzhou, as an emerging city in China, would attract numerous college graduates each year, there would be a deviation between age and census data. Due to the fact that there is no big gap in social factors and other aspects, it can be considered that this sample is suitable for estimating the whole population of Hangzhou City.

Table 2 Definition and parameters of covariates

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Gender	Male =1	551	50.6	0.50	0.50	0.50
	Female=0	537	50.4			
Age	18 ≤ Age < 44 =1	648	60.0	1.46	0.70	1.63
	44 ≤ Age ≤ 59=2	390	35.8			
	59 < Age ≤ 65=3	50	4.2			
Final education	University degree or above=1	713	65.5	0.66	0.48	0.41
	others=0	375	34.5			
Job	Have stable job=1	848	77.9	0.78	0.42	0.71
	others=0	240	22.1			
Housing conditions	Housing after 2000 years=1	772	71.0	0.71	0.45	
	Housing before 2000 years=0	316	29.0			
Physical condition	Health=1	918	84.4	0.84	0.63	
	others=0	170	15.6			
Income	More than 5500=1	758	70.0	0.70	0.46	
	others=0	330	30.0			
Living conditions	Not live alone =1	783	72.0	0.72	0.45	
	Living alone =0	305	28.0			
Raising children or elder	Raising children or elder=1	539	49.5	0.50	0.50	
	others=0	549	50.5			

Greenhouse effect knowledge	Have the knowledge =1	457	42.0	0.42	0.49
	others=0	631	58.0		
Vertical greening knowledge	Have the knowledge =1	497	45.7	0.46	0.50
	others=0	591	54.3		
Attitude	Believe Vertical greening can alleviate the greenhouse effect =1	923	84.8	0.85	0.36
	others=0	165	15.2		
Subjective norm	Pro environmental behavior will be supported=1	888	81.6	0.82	0.39
	others=0	200	18.4		
Perceived behavioral control	Ability to participate in activities to improve greenhouse effect=1	765	70.3	0.70	0.46
	others=0	323	29.7		

4.2 Analysis of feedback information

During the interview, the protest responders have been excluded and feedback information has been collected from all the respondents (Figure 5). There are 209 respondents who choose to withhold payment, and they believe that increasing their income and formulating corresponding compensation mechanisms would improve their participation in vertical greening. Besides, there are 41 respondents suggesting that they do not know the relevant information about vertical greening and believe that the government shall increase the publicity of environmental knowledge. Among those respondents who have the WTP, 771 respondents believe that the government should disclose the flow of payment funds, increase information transparency and ensure the rational use of expenditures; 205 respondents think that representatives should be selected to supervise the government's behavior; 112 respondents think that the binding force of relevant laws should be appropriately enhanced. Besides, the respondents are also subject to questions about their participating patterns in vertical greening (Figure 6). There are 713 respondents who would choose to provide financial support, 115 respondents who would protect the vegetation of vertical greening, 203 respondents who would actively publicize knowledge about vertical greening, and 57 respondents who have no spare time for related activities.

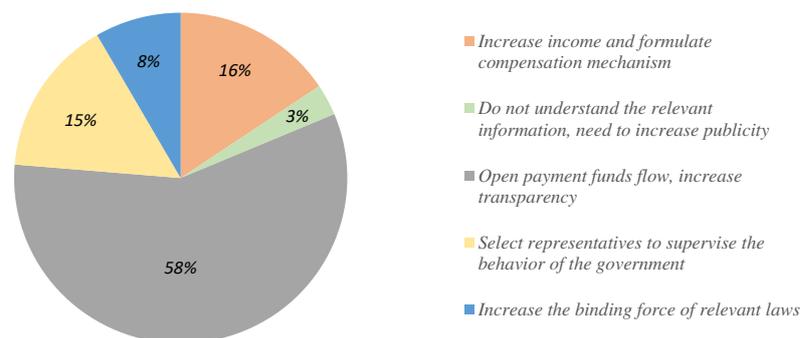


Figure 5. Feedback information for residents to participate in vertical greening

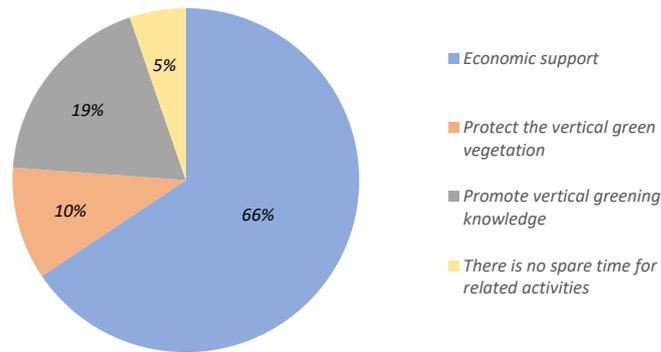


Figure 6. Feedback information for residents to participate in vertical greening

4.3 Assessment of covariation and detection

There are 15 variables in total in the interview question, in which the independent variables could be divided into 4 models according to their different types. The demographic characteristics are included in Model 1; the variable of family members is supplemented in Model 2; the variable of environmental knowledge is supplemented in Model 3; three variables in the theory of planned behavior are supplemented in Model 4. Via the comparison of models, it can be found that Age < 44 in Models 2, 3 and 4 is statistically significant at the level of 1%, which indicates that young people are more willing to pay for vertical greening. However, people over 59 years old are not as enthusiastic about environmental payment as young people. In Model 2, the final education is statistically significant at the level of 5%. In Models 3 and 4, there is a strong correlation between educational background and payment. In models 1, 2 and 3, there is a strong correlation between personal health status and WTP. In all models, income is statistically significant at the level of 1%. The above analysis shows that the level of income significantly affects the payment behavior of residents. The variables of family members indicate that the presence or absence of old people or children in the family is statistically significant at the level of 1%, which demonstrates that the composition of family members can exert a significant impact on the payment of respondents. The two variables of environmental knowledge are statistically significant at the level of 1%, which indicates that people with relevant environmental knowledge are more inclined to generate payment behavior. In Model 3, the subjective norm is statistically significant at the level of 1%, and attitude and cognitive behavior control are statistically significant at the level of 10%, which indicates that the subjective norm can provide guidance for people's WTP more.

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In order to ensure the accuracy of the results, the interval range of MTP has been subject to the verification with Monte Carlo simulation method; Meanwhile, partial correlation coefficient

and single factor have been employed to test the covariates in the model (Podsakoff et al. 2003), with the results showing that there is no abnormal value.

Table 3 Estimation Result with Covariance

Variable	Model 1		Model 2		Model 3		Model 4	
	Coef	p values						
Constant	0.549	0.015	0.758	0.0018**	1.087	0.000***	1.823	0.000***
<i>Demographic attributes</i>								
Gender	0.173	0.123	0.106	0.345	0.042	0.717	0.089	0.443
Age<44	0.220	0.075*	0.476	0.001***	0.017	0.000***	0.530	0.000***
59 < Age	0.440	0.128	0.494	0.086*	0.445	0.001***	0.623	0.036**
Final education	0.128	0.279	0.141	0.229	0.235	0.048**	0.190	0.116
Job	0.078	0.628	0.163	0.318	-0.023	0.885	0.036	0.827
Housing conditions	0.119	0.335	0.116	0.349	0.129	0.302	0.145	0.254
Physical condition	0.847	0.000***	0.291	0.049**	0.288	0.061*	0.159	0.319
Income	0.732	0.000***	0.652	0.000***	0.775	0.000***	0.675	0.000***
<i>Family members (social psychology)</i>								
Living conditions			0.210	0.119	0.101	0.460	0.192	0.172
Raising children or elder			0.552	0.000***	0.429	0.003***	0.386	0.009***
<i>Environmental knowledge</i>								
Greenhouse effect knowledge					0.481	0.000***	0.370	0.006***
Vertical greening knowledge					0.543	0.000***	0.332	0.011***
<i>Belief and perceived resources</i>								
Attitude							0.286	0.093*
Subjective norm							0.821	0.000***
Perceived behavioral control							0.282	0.088*
Bid	0.001	0.000***	0.001	0.000***	0.001	0.000***	0.001	0.000***
spike	0.233	0.000***	0.234	0.000***	0.238	0.000***	0.324	0.000***
MTP	712.528	0.000***	720.341	0.000***	737.188	0.000***	746.718	0.000***
95% confidence interval	665.439~		665.439~		688.652~		698.145~	
	758.767		758.767		784.849		794.413	
99% confidence interval	651.383~		672.264~		674.164~		683.647~	
	774.277		767.551		800.835		810.412	
Wald statistic	265450.399		249780.897		269374.166		286690.607	
Log-likelihood	-2109.693	0.000***	-2098.279	0.000***	-2072.845	0.000***	-2044.115	0.000***

Annotation: The unit of MTP is CNY, *p<0.1, **p<0.05, ***p<0.01

4.4 Non-covariance estimation results

The purpose of setting covariance is to determine the variables that could exert a greater impact on the WTP, which, however, would affect the valuation results, so the non-covariance would be employed for calculation. The results are shown in (Table 4). The maximum likelihood function would be employed to estimate the parameters, with the spike's parameter being 0.238. The statistics results show that the zero response accounts for 23%, and the fitting degree can reach 96.6%.

Wald statistics rejects the zero hypothesis with the estimated parameters being zero. The 95% confidence interval of WTP is 657.946 - 746.187, the 99% confidence interval is 643.571 - 761.468, and the value of MTP is 702.551CNY, which is near the mean of those two intervals. It is statistically significant at the level of 1%, which proves that the fitting effect is good.

Table 4 Covariance free estimation

Variables	Coefficient	T values	P values
constant	0.763	13.784	0 ***
beta	0.002	510.421	0 ***
spike	0.238	19.101	0 ***
MTP	702.551	30.337	0 ***
interval_95	657.946~746.187		
interval_99	643.571~761.468		
Wald statics	260550.388	13.784	0 ***
Like hood	-2146.195	510.421	0 ***

Annotation: The unit of MTP is CNY, *p<0.1, **p<0.05, ***p<0.01

4.5 Discussion of the results

Vertical greening can generate many benefits for the environmental improvement, energy conservation and emission reduction. Most researchers have conducted a study on the passive energy saving of vertical greening (Othman and Sahidin. 2016), or conducted an investigation on the economic value of reducing energy consumption (Ottel  and Perini. 2017). There is no relevant study to analyze the economic benefits brought by reducing greenhouse gases, and policies are often "profit-oriented" on the ground that economic benefits are contributive to promoting the implementation of policies (D. City. 2017). It may become a research orientation in the future to study the economic benefits brought by various measures of environmental protection so as to promote the formulation and implementation of environmental protection policies.

The average income of Hangzhou citizens in 2020 is 9,510 USD, and the number of registered households is 2,481,400 units (Zhejiang Bureau of Statistics). With the consideration that covariance may affect the results, the non-covariance has been employed for the calculation, with the results showing that Hangzhou citizens would pay 107.77 USD per year, accounting for 0.65% of the total household income, and the total payment is 267 million USD. This is similar to the proportion of expenditure in other related cases (Zhang et al. 2019), which indicates that Chinese families would like to pay a considerable proportion of the cost for improving the environment. As per the calculation of 99% confidence interval, the total amount of annual WTP of Hangzhou citizens is between 245 million USD and 290 million USD. Hangzhou Municipal People's Government requires an additional 300,000 square meters of vertical greening area each year, with a construction cost of about 230 USD per square meter and a construction cost of 69 million USD in total. Therefore, the economic benefit of the project is between 176 million USD and 221 million USD. These numerical results conduce to providing a reference for policymakers to formulate policies.

With the "public participation" has been stipulated in the *Environmental Protection Law of the People's Republic of China* as one of the basic principles of environmental protection, more attention would be paid to public participation and environmental assessment (Sim es et al. 2016). The renovation of existing residential areas is the core content of significant research and development projects in China during the "13th Five-Year Plan", vertical greening is an important link in the renovation, and public participation is especially important for policymakers to formulate the next plan. Heberlein et al. criticize that in the traditional model, attention would only be paid to the results of the WTP, and the impacts from human emotions, subjective experience, and social psychology have been ignored. Therefore, the covariance of the composition of family members, environmental knowledge and theory of planned behavior has been supplemented on a demographic basis, with the results showing that whether there are elderly and children in family members, relevant environmental knowledge and subjective norms in theory of planned behavior have statistical significance at the level of 1%, which demonstrates that people's emotional and psychological activities would exert an impact on WTP and participation. It may become the orientation for researchers to make a further exploration on payment by supplementing variables in the framework of social psychology and theory of planned behavior.

5. Conclusions and Outlook

5.1. Conclusions

There are plentiful existing residential buildings in China, and numerous emissions of greenhouse gases caused by high energy consumption and high carbon emissions have brought huge burdens to the environment. With the implementation of the renovation plan for existing residential areas, vertical greening, as one of the key technologies, has attracted extensive attention from the Chinese government for its economic benefits in reducing the emission of greenhouse gases. In this paper, the following research results have been achieved:

1. The Spike model and double-bounded dichotomous CVM are employed to deal with the zero response, and the obtained WTP is statistically significant at the level of 1%, which verifies that the Spike model can deal with the zero response with a better performance.

2. Due to the fact that there are differences in the tax, it is easy to confuse respondents by regarding it as a payment method. In this study, it is believed that living expenses are more effective as a payment method.

3. The annual WTP of each household in Hangzhou is 702,551 CNY (108,263 USD), which accounts for 0.65% of total household income, and the total annual payment is 1.743 billion CNY (268 million USD).

4. The income level, the presence or absence of the elderly and children in the family, environmental knowledge and subjective norms exert significant impacts on residents' WTP.

5. The participation of residents in environmental activities can be improved via increasing income, formulating compensation mechanisms and increasing the transparency of the government.

5.2. Outlook

1. The renovation of existing residential areas is the core content of significant research and development projects in China during the "13th Five-Year Plan", and it includes numerous residential environment renovation projects. However, there are few studies on the application of WTP in the renovation of existing residential areas. Researchers can conduct a thorough study from the perspective of the WTP and influencing factors in an attempt to provide a reference for the formulation and implementation of policies.

2. In most research objects, there are only two variables, namely payment or withholding payment. However, in actual situations, there will be cases of requesting compensation among those who withhold payment. It remains to be verified whether the double-bounded dichotomous CVM and peak value model can deal with some complex multivariate research objects.

3. The protest rate is also a significant indicator to measure the effectiveness and reliability of CVM, and it is also an important indicator to measure the fitting degree of peak model. However, there is still a lack of agreement on the definition of protest response and true zero response, which needs to be verified through a more comprehensive study by researchers.

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Yang Tan: Conceptualization, analysis, investigation, writing—original draft preparation.
Hiroatsu Fukuda: writing— review and editing.

Zhang Li: supervision

Shuai Wang: analysis

Weijun Gao: methodology

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