

Doctoral Thesis

**Study on Evaluation of Willingness to Pay for Urban Low-
carbon Strategies in China based on Contingent Valuation
Method and Theory of Planned Behavior**

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Preface

With the signing of the Paris Climate Agreement in 2021, China has set the goal of achieving carbon peaking by 2030 and carbon neutrality by 2060. This has attracted a lot of attention from researchers for the construction of low carbon cities. However, so far, the construction of cities has been more about technical innovation, but there is a lack of research on the environmental value assessment of low-carbon city construction measures. This is not conducive to the improvement of established policies by policy makers and the promotion of various strategies for low-carbon cities. For these reasons, this study selects Hangzhou, Zhejiang Province, Tai an and Qingdao, Shandong Province, China as the target cities for this study. The environmental values of the four low-carbon strategies were assessed by means of the conditional value approach to assess willingness to pay. The factors affecting public payment are also discussed, and the factors that predict each variable of willingness to pay. It contributes to the construction of low-carbon cities in China and the formulation of related policies.

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At last, I would like to give the deepest gratitude to my family for their regretless support and love to me.

Study on Evaluation of Willingness to Pay for Urban Low-carbon Strategies based on Contingent Valuation Method and Theory of Planned Behavior

ABSTRACT

With the acceleration of urbanization and modernization, the consumption of fossil energy in the fields of urban construction, transportation, production, living, and consumption is increasing, resulting in a large amount of urban greenhouse gas emissions, leading to the urban heat island effect, the greenhouse effect, inducing global warming, which in turn causes a series of chain reactions such as extreme weather. It has seriously affected the production life and development security of urban residents. With the signing of the Paris Climate Agreement in 2021, countries around the world are paying more and more attention to a series of problems caused by carbon emissions. China, as the world's largest developing country, has set the goal of achieving carbon peaking by 2030 and carbon neutrality by 2060. China, as the world's largest developing country, has set the goal of achieving carbon peaking by 2030 and carbon neutrality by 2060. Among them, the construction of low-carbon cities is a key project for the Chinese government to focus on. The construction of low carbon cities is of great importance to achieve the set goals of the Chinese government. Unfortunately, however, most of the current research on low carbon cities is focused on the technical field. The research on the environmental value assessment of the established low-carbon city construction and development strategies is still limited.

In response to the lack of environmental value assessment of established low-carbon city strategies, this study uses a more commonly used non-market value assessment method to assess the environmental value of low-carbon city strategies, which include vertical greening, construction of Battery Swapping Station and reduction of urban CO₂ emissions. We compared the willingness to pay for environmental protection with the willingness to pay for reducing urban CO₂ emissions by controlling for variables. This is used to explore the differences in the public's willingness to pay and the different factors influencing willingness to pay under different research subjects.

This study first discusses the theoretical background of the non-market value of low-carbon urban strategies and explains the reasons why low-carbon urban strategies have environmental value. It also explains the reasons why low-carbon urban strategies have economic value through labor value theory as well as subjective economic value theory. It is proposed that its economic value is composed of use value and intrinsic value. And the literature related to the assessment of environmental value of low carbon cities is reviewed in the form of a literature review. It is pointed out that zero response should not be neglected when assessing willingness to pay and that the theory of planned behavior can explain the payment behavior well.

In the questionnaire survey, we mainly used two types of questionnaire collection methods, namely face-to-face interviews, and web questionnaires. Although the web questionnaire has a low

response rate, due to the new crown, the web questionnaire to collect questionnaires effectively from a distance and at low cost. Its validity is also very much worthy of recognition. Since the respondents who refused to pay in our study accounted for about thirty percent of the total respondents, we used the peak model combined with the joint treatment of the two-boundary dichotomous model in the conditional value method to deal with zero responses. We further demonstrate the effectiveness of the peak model for zero response treatment. We also assume that the influencing factors in the theory of planned behavior are variables other than demographics and socioeconomics to discuss the effect on willingness to pay. Finally, we also discuss the effectiveness of the theory of planned behavior in explaining payment behavior using the theory of planned behavior as a predictor.

The results show that residents of Hangzhou, Qingdao are willing to pay CNY 1.743 billion, CNY 1.781 billion and CNY 889 million for the three low-carbon city strategies, respectively. Thus, we demonstrate the feasibility of these programs. Among the factors affecting payment, there is a statistically significant relationship between public income, education level and willingness to pay. In contrast, age has an inverse effect on willingness to pay. Among the variables of the Theory of Planned Behavior, attitudes, subjective norms, and perceptual behavioral control all have an impact on willingness to pay. Therefore, we believe that the theory of planned behavior can well explain the public's payment behavior for low-carbon city strategies.

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Chapter 1

RESEARCH BACKGROUND

CHAPTER ONE: RESEARCH BACKGROUND

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1.1 Background

1.1.1 The impact of increased carbon emissions

Since the industrial revolution, the massive use of fossil fuels has led to the emission of greenhouse gases on a large scale, which are considered to be the main cause of global warming [1]. Among them, carbon dioxide is the most emitted and has the most significant impact on the climate, therefore, it is recognized as the most important greenhouse gas and is also considered as the main cause of warming. By 2020, global carbon emissions reach 38 billion tons, a threefold increase compared to the second half of the 19th century. The International Energy Organization IEA (2019) states that the level of carbon dioxide in the atmosphere is increasing at a rate of 2.0 ppm per year and has exceeded 400 ppm by 2019, much higher than the level of 280 ppm maintained before the industrial revolution [2], and the growth of carbon emissions due to the use of various fossil energy sources over the last three decades is not showing any slowdown (Fig. 1). The large amount of carbon dioxide gas emissions has led to the greenhouse effect, causing global warming is one of the serious challenges facing humanity in the 21st world, and global meteorological observations show that the global average temperature has increased by 0.74°C over the past 100 years or so, and the IPCC states that the period 1983-2012 was the warmest 30 years of the past 1400 years [3].

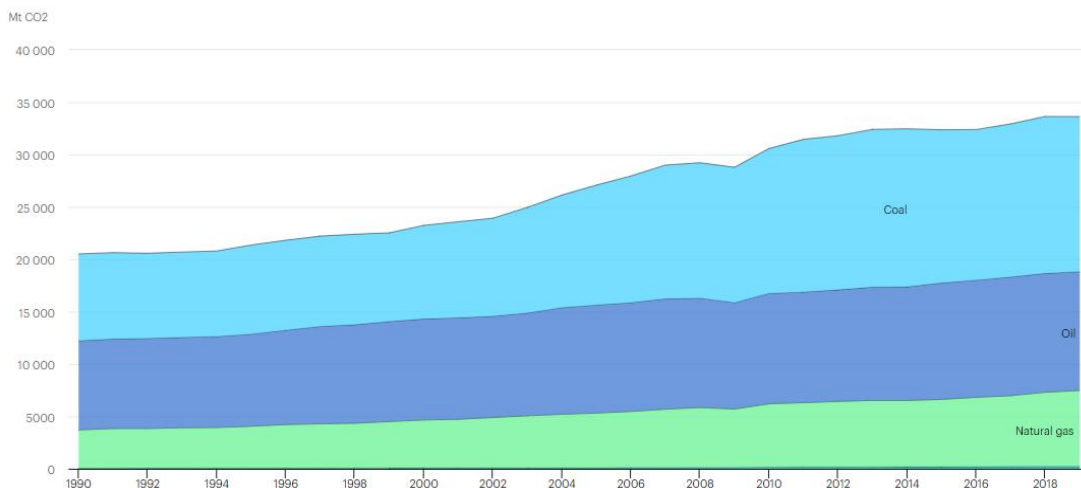


Fig.1-1 CO₂ emissions by energy source, World 1990-2019 (<https://www.iea.org/data-and-statistics/data-browser/?country=WORLD&fuel=CO2%20emissions&indicator=CO2BySource>)

Global warming has also resulted in a few climate abnormalities, such as high temperatures, droughts, and floods, which are currently endangering human production, life, and the environment. For example, during the previous five decades, the frequency of global ocean heat waves has grown by 36%, while the duration of each heat wave has increased by 20%, resulting in a 59 percent increase in the number of days per year when ocean heat waves occur. According to the United Nations Office for Disaster Risk Reduction (UNISDR), worldwide economic losses due to extreme weather have reached \$1.9 trillion in the last 20 years [4]. According to the IPCC's fifth report, if carbon emissions continue at their current rate, global temperatures would rise by 1.1-6.4°C by 2100, and sea levels will rise by 16.5-53.8 cm. This will result in major land flooding as well as natural calamities such as earth subsidence and coastal storm surges. More importantly,

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if global temperatures reach to the red line of 2°C, the ecology on which humans rely would be devastated. Therefore, it is imperative to mitigate carbon emissions to combat climate change [3].

To address global warming, the United Nations Framework Convention on Climate Change (UNFCCC), the first convention to deal with carbon emissions, was founded in the 1990s. With the increased focus on carbon emissions, the Kyoto Protocol and the Paris Climate Agreement were signed one after the other, indicating the world community's attitude and dedication in limiting greenhouse gases and mitigating climate change. As a result, it is obvious that a worldwide formula for reducing carbon emissions has been developed. Combating climate change by lowering carbon emissions has become a critical and time-consuming long-term job for the entire planet.

As the world's largest carbon emitter, China has a very important role to play in reducing carbon emissions, and with the development of China's economy, urbanization is intensifying, which makes the sustainability dilemma faced by China in mitigating urban carbon emissions much higher than the global average [5]. According to the Third National Assessment Report on Climate Change, the rate of climate warming in China since the founding of New China is higher than the global average, with an estimated warming of 0.9-1.5°C per century and a potential warming of 1.3-5°C by the end of the 21st century if corresponding measures to reduce carbon emissions are not developed.

Urbanization has energized China's growth by providing cities with adequate workforce and decent infrastructure, so creating a favorable environment for upgrading the economic structure of urban and rural areas and widening the space for economic development. During the urbanization process, a huge number of people migrate from rural regions to towns and cities, creating spaces for large-scale economic activity and stimulating the fast expansion of urban home construction, industry, transportation, tourism, and other businesses. According to China: Promoting Efficient, Inclusive, and Sustainable Urbanization (General Report), issued by the State Council Development Research Center, the nation has witnessed unprecedented economic development over the last 35 years and has effectively pulled 500 million people out of poverty. According to International Monetary Fund data, China's GDP share of the global economy increased from 2.25 percent in 1978 to 14.81 percent in 2016, placing it second in the world. In order to construct a moderately wealthy society, China released the National Development Plan for New Urbanization (2014-2020) in March 2014, proposing that the resident population's urbanization rate reach 60% by 2020. According to research conducted by the State Council's Development Research Center and the World Bank, China's urbanization rate is predicted to exceed 70% by 2030. On the other hand, as cities get more urbanized, their carbon emissions rise, and China's urbanization rate has climbed by 20% in the last 20 years of the twenty-first century [6]. Quick urbanization has resulted in a rapid growth in building area, a big increase in different fossil energy vehicles, and a worsening of the urban environment, all of which have resulted in an increase in urban energy consumption and carbon emissions. According to the China Statistical Yearbook, China's urban energy consumption has climbed from 60,000 tons of coal to 430,000 tons of coal during the last 30 years, representing a 7.1 percent yearly growth. According to the World Bank, China has surpassed the United States as the world's top carbon emitter since 2005, and by 2021, China's carbon emissions will be nearly twice that of the United States, putting China under enormous pressure to cut global carbon emissions [7].

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As mentioned above, rapid urbanization has brought about rapid economic growth in China and also led to a sharp increase in carbon emissions. Under the dual pressure of domestic economic development needs and international carbon emission reduction situation, how to control carbon emissions while promoting urbanization is a key issue that the Chinese government needs to solve. To effectively address this issue, the Chinese government has made urban low-carbon economic development an important strategy and has developed a series of measures.

1.1.2 Related measures to reduce carbon emissions

In order to reduce urban carbon emissions, the National Development and Reform Commission of the People's Republic of China launched pilot low-carbon provinces, regions and cities in 2010, and each pilot city has issued a low-carbon city development plan based on its own industrial structure, resource endowment and technological advantages. A low-carbon city means promoting a comprehensive low-carbon urban development through energy efficiency improvement, energy structure adjustment, transformation of high-carbon industries to low-carbon industries, and more environmentally friendly resource allocation. Local governments have already proposed some corresponding technologies and measures, and these measures to mitigate carbon emissions can be divided into the following categories

The first is to reduce carbon emissions by increasing the area of urban greenery. Urban greening system plays an important role in reducing urban carbon emissions because it is the only way to reduce carbon emissions without consuming energy. Through the reasonable arrangement and management of urban greening, carbon emissions and the overall energy consumption of the city can be indirectly reduced to achieve the effect of reducing carbon emissions. It is mainly through the photosynthesis of plants to absorb CO₂, according to the relevant data, every 10,000m² of green space can absorb about 900kg of CO₂ and produce about 750kg of O₂ per day. However, with the intensification of urbanization, the reduction of carbon emission by increasing urban green space will also face some problems. With the increasing urbanization, the area of urban green space is decreasing, so how to effectively increase the green area per unit area has become a key concern for policy makers, and with the continuous technological advancement, new technologies such as vertical greening and rooftop greening have been greatly promoted. The advantage of these measures is that they achieve diversified use of space without consuming urban land.

The second is to reduce carbon emissions by optimizing and upgrading urban energy sources. The first is energy upgrades for households, such as using solar energy to replace traditional energy sources to achieve carbon emission reductions. China has the world's largest photovoltaic (PV) market, with a cumulative installed PV capacity of over 200GW in 2019. This is almost double the national solar PV target set in 2016 (105GW by 2020). Cumulative solar capacity is expected to reach 1,500 GW by 2060, a six-fold increase compared to 2020. By that time, a quarter of China's energy consumption will come from solar energy, and solar energy has enormous potential to contribute to low-carbon cities and to the sustainability of society [8]. The most direct way to replace traditional energy sources is through solar power generation, and the Chinese government has established a series of distributed PV construction measures to promote the construction of urban solar distributed PV, with the share of DSPV systems in the total cumulative capacity increasing from 13% in 2016 to 31% in 2019 (Fig. 2.). There has been widespread interest in

changing the energy mix and thus urban carbon emissions through PV.

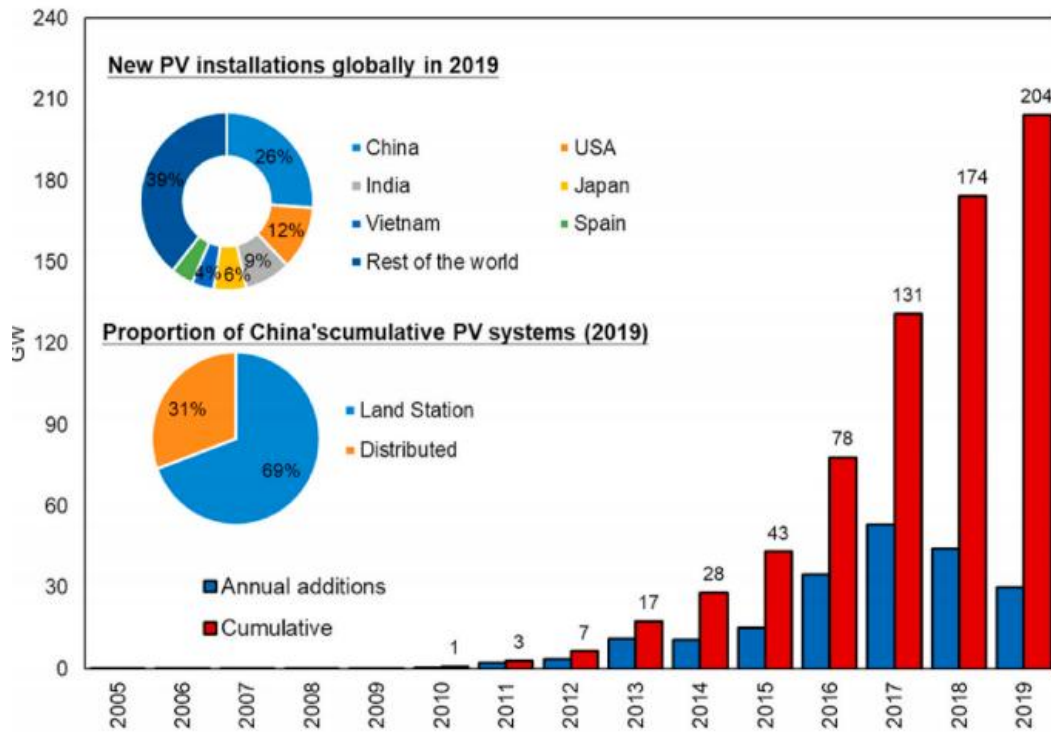


Fig.1-2. Solar PV capacity and annual additions in China (2005–2019) [8]

The third way to mitigate urban carbon emissions is through changes in driving tools and the associated energy mix, most notably by replacing fuel vehicles with new energy vehicles, according to a study published by the International Council on Clean Transportation, which found that medium-sized electric vehicles have lifetime carbon emissions that are 60-68 percent lower than equivalent-sized fuel vehicles. -68%. This gap will continue to grow as we use more electricity from renewable sources. In Europe, EV lifetime carbon emissions are 66-69% lower than equivalent sized gasoline vehicles, 60-68% in the US, 37-45% in China, and 19-34% in India. Following improvements in engine technology and fuel production efficiency, this will increase to 74-77% in Europe, 62-76% in the US, 48-64% in China, and 30-56% in India by 2030, proving that new energy vehicles have a huge advantage in reducing urban carbon emissions. Although the construction of charging piles and fast charging piles has achieved satisfactory results, the slow charging speed and long charging time are the main factors restricting the development of electric vehicles. Therefore, the government has increased the promotion and construction of electric vehicle exchange stations. The exchange stations have similar attributes to gas stations and can be recharged with energy in just 1-2 minutes. It has a strong promotion effect on accelerating the development of electric vehicles.

Fourthly, through the development of circular economy, waste utilization, etc. to reduce municipal waste as well as sewage emissions, the aim of reducing carbon emissions while protecting the environment is achieved. In the circular economy (CE), resources and products are divided, leased, reused, repaired, refurbished, and recycled to extend product life cycles, reduce waste, and generate added value [9]. For example, the promotion of the resourceful use of municipal

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wastewater and the construction of corresponding supporting facilities. In order to promote the development of circular economy the state has promulgated a series of measures. In December 2021, the National Development and Reform Commission of China issued the "Pilot Program for the Configuration of Recycled Water Utilization in Typical Areas", which requires each local government to strengthen the construction of sewage recycling infrastructure, ensure the profit space of relevant market players, and play the role of government guidance for the market. It also requires the development of reasonable and effective policy measures. The purpose of reducing carbon emissions is achieved through the resource utilization of sewage and the upgrading of existing sewage treatment plants.

1.1.3 Evaluation of the environmental and economic value of measures related to low-carbon measures in cities

Much of the research has addressed the link between low-carbon cities, urban design, and policymaking. Oke [10] defines eight modes of investigation of urban climate practice: conceptualization, theorizing, field observation, modeling (numerical, statistical, and scale), model validation, use in urban low-carbon plans, post-implementation effect assessment, policy creation, and modification. While the first four programs have made tremendous progress in recent decades, translating research findings into design and urban policy has been slow. One of the most significant obstacles in this discipline is the transition from knowledge to practice. This study concludes that more available knowledge and suitable instruments, as well as more proactive environmental regulations, are required to overcome this barrier. According to Eliasson [11], while urban designers and producers of urban low carbon strategies are interested in urban low carbon, there is very little study on the impact of urban low carbon measures and policy creation and its research. This phenomenon is caused by five factors: Technical reasons (e.g., a lack of tools and procedures to gather and evaluate climatic data), policy reasons (e.g., the need for economic priority among different activities), organizational reasons (e.g., challenges based on the decision-making process), and market reasons (budget constraints). Although the Chinese government has carried out several successive batches of low-carbon city pilots and directed many relative measures, such as increasing urban vegetation, promoting renewable energy, environmental protection, and resourceful waste utilization, Liu [12] pointed out that since 2010, the Chinese government has carried out several successive batches of low-carbon city pilots and directed many relative measures, such as increasing urban vegetation, promoting renewable energy, environmental protection, and resourceful waste utilization. However, improvements in associated regulations and practices are still needed, particularly in built-up metropolitan regions.

The environmental benefits of low-carbon city-building techniques are frequently underestimated. One key explanation for this outcome is that policymakers or specialists in charge of public resources (local governments) are more interested in the economic repercussions (actual value) of a specific urban development. Because green cities are a non-priced commodity, estimating their environmental worth is challenging. Given the limited public resources available for low-carbon cities, failing to quantify the environmental benefit associated with these initiatives will leave policymakers with a lack of reliable investment evidence. Floater G [13] emphasized the need of price devices in balancing urban economic expansion while addressing the problem of urban climate deterioration. The consequences include low-carbon urban pricing, sprawl, and contamination. Incentives that are not favorable to sustainable growth can be decreased by altering

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subsidy structures and the pricing of negative externalities in urban sprawl.

Several studies have tried to reveal the value of low-carbon cities in terms of urban greening, urban environmental waste recycling, and urban energy upgrading. Rupasinghe and Halwatura [14] argued that the maximum indoor temperature of a day can be reduced by 4.89°C after introducing vertical greening on building facades, which can effectively reduce energy consumption in summer. Li [15] argued that in Zhejiang Province, China, by increasing horizontal greening and vertical greening, the cooling load can be reduced by 8.8% and the heat load can be reduced by 1.85%, which can achieve energy saving, thus reducing greenhouse gas emissions, and achieving low carbon construction in cities. Pervez [16] demonstrated the environmental protection of beaches and the impact of garbage recycling on low carbon in cities, and he studied the beaches in Qingdao City, and he concluded that if the environment of beaches is not protected, due to The increased carbon emissions due to garbage pollution, etc. would increase the annual greenhouse gas emissions per square kilometer of beach by 54.546 to 72.684 t-ha⁻¹ and 2.615 to 2.988 kg-ha⁻¹ of CO₂ and N₂O emission fluxes. about 2080 ~ 3888 CNY. Charles [17] studied the low carbon upgrading of urban office buildings. The results showed that low carbon retrofitted buildings can save more than 70 tons of CO₂-eq per year per year from reduced natural gas consumption. The return on investment for upgrading the building envelope was 7.7 years. Net-zero energy building performance can be achieved by adding photovoltaic solar panels and solar heating to meet the total energy demand of the building with a return on investment of 11.6 years.

However, the value of the numerous positive environmental externalities generated by low-carbon policies in cities is difficult to quantify using market-based instruments. The value of reducing carbon emissions should be characterized as non-market value. The worth that cannot be reflected by market pricing is referred to as non-market value. Most environmental services and initiatives, for example the clean drinking water, fresh air, and biodiversity is not a marketable commodity. According to our research, this is the advantage of lowering carbon emissions. Because environmental products and services are not exchanged on the market, market pricing cannot demonstrate how much people are prepared to pay for these commodities. These environmental objects can only be priced using a non-market value evaluation.

Several researchers have started to investigate the non-market worth of the positive environmental externalities associated with low-carbon cities, or the factors that influence payments. dang et al, [18] studied the factors that influence the public's influence on the WTP of sustainable consumption patterns. The results showed that materialism and health consciousness reduced and positively influenced consumers' willingness to pay extra to offset carbon emissions, respectively. Tan and Lin,[19] assessed the Chinese public's WTP for the construction of charging facilities to achieve low carbon in cities and found that at a price point of 0.836 RMB/KW, men with higher income or specific knowledge of new energy vehicles were more likely to purchase pure electric vehicles. Ardeshiri and Rashidi [21] assessed the public's WTP for reducing travel anxiety and quantified preferences for existing policies in Australia. The results showed that the public WTP was \$31.9/year. However, there are some limitations in the methodology of the discussed studies. To the best of our knowledge, the range of subjects studied in this series of studies is generally large, for example, for charging facilities. There is no precision as to which specific measure of social acceptance and WTP.

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1.1.4 Problem formulation

The above analysis shows that taking a low-carbon development path and building low-carbon cities are crucial to the successful transformation and sustainable development of China's economy. The government has developed many measures for encouraging the development of low-carbon cities. It has provided policy guidance and decision support for the successful implementation of low-carbon city construction. However, there are some limitations in the research on measures related to low carbon cities. So far, policy makers have placed more emphasis on the economic benefits of low carbon cities and other related measures, while the environmental values are often ignored. In terms of research methods, many researchers tend to have a larger scope when studying a particular low-carbon measure, while research on specific implementation methods is still lacking. Also when assessing the value of a measure, they tend to analyze the reduced carbon emissions by technical means, which is then translated into a response amount. However, the assessment of the environmental value of measures to reduce urban carbon emissions is rarely calculated. This will have an impact on investors' investments, as well as on the assessment of the economic value of low-carbon measures.

In addition, the construction of low-carbon cities in China is still in the exploration stage and lacks a mature development model and construction path. Although the low-carbon construction actions of many foreign cities have provided experience for the construction of low-carbon cities in China, most of the cities in China have huge differences in the development stage, urban industry and energy consumption structure, historical and cultural background and economic development level compared with the cities in western developed countries, which make the construction of low-carbon cities in China cannot copy the development models of foreign countries. For example, the \$22 billion Masdar City in Abu Dhabi, UAE, has been described as a "zero-carbon city that focuses on technological advancement regardless of cost". The city's construction reflects the UAE's emphasis on new energy technologies and will be the world's first green city that does not use a drop of oil. Obviously, no city in our country has yet been able to fully borrow and realize this vision. Not only that, the large number of cities in China and the huge differences in urban characteristics make it impossible to have a uniform model or path for building low-carbon cities in China, but it should be closely focused on the city's own characteristics. Therefore, it is important to assess the factors influencing the willingness to pay for the relevant measures formulated by local governments in order to provide policy recommendations for the relevant policies. It is also important to provide policy recommendations to local governments by assessing the factors that influence their willingness to pay. This is because public participation has far-reaching implications for the construction of low-carbon cities. And providing constructive suggestions for policies through the study of public participation behavior requires less capital and time investment than other methods [22].

1.2 Purpose of this study

1.2.1 Research Objectives

The main research objectives of this paper are to investigate the environmental value of low-carbon measures in cities and the public's willingness to pay, to explore the key influencing factors of the level of low-carbon city construction, and to propose relevant policy recommendations for low-carbon city construction in order to promote the comprehensive and

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smooth development of low-carbon city construction. To achieve these goals, this paper will focus on theoretically answering the following scientific questions

1. The theoretical basis of the economic evaluation of measures related to low-carbon cities is explored, and the reasons for the economic value of the positive environmental externalities of low-carbon cities are explained, the implication of their monetary worth is defined, as well as the theoretical meaning of their monetary worth evaluation methods is discussed.
2. This study provides a relevant literature review of studies related to the use of the conditional value approach to assess the non-market value of low-carbon city-related measures, compares the main trends in the design of CVM studies of the environmental value of urban low-carbon measures, summarizes possible biases and their solutions, as well as explores the primary factors influencing people's willingness to pay.
3. This study assesses willingness to pay for low-carbon measures (vertical greening, battery exchange stations) in Hangzhou, China, and low-carbon measures (mitigation of urban CO₂ emissions) in Qingdao, China, through face-to-face interviews and online questionnaires, respectively, and explores the factors that influence willingness to pay. We also compared Qingdao's low-carbon strategy with its environmental strategy by using a control variable approach to explore the differences in public attitudes toward different public environmental products with the same respondents.
4. This study is based on the theory of planned behavior and proposes a predictive model of expanded behavior based on the traditional theory of planned behavior and tests the model to predict better incentives to promote residents' pro-environmental behavior.

1.2.2 Research significance

China's low-carbon city construction is still in the exploration stage and needs both theory and practice to catch up with the developed countries' level as soon as possible. The study of the environmental value of low-carbon city strategy has important theoretical and practical values, which are as follows.

1. It enriches the theories related to the construction of low-carbon cities. This paper reviews the existing literature on the understanding and analysis of low-carbon cities and finds that low-carbon city-related studies generally ignore the environmental value of low-carbon city measures, i.e., they focus too much on the actual economic benefits brought by low-carbon cities and ignore the specific environmental value (WTP) of low-carbon city-related measures. In fact, the construction of a low-carbon city is a dynamic process, and only by accurately estimating all aspects of the process can effective measures be taken, and reasonable policies be formulated to guide the construction of a low-carbon city. Therefore, this paper discusses the environmental value of low-carbon city construction measures from the perspective of the environmental value of low-carbon city construction measures, and enriches the theory related to low-carbon city construction. It provides a new perspective for the study of low-

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carbon city measures and strategies. This paper systematically compares the current policy documents on low-carbon construction, explores the factors influencing the construction level of low-carbon cities, ensures the operability and scientific of the factors, and explores the hierarchical structure and importance of the factors based on the background of the times. It provides a new research perspective for the development of low-carbon city measures and strategy research in China.

2. Adding theoretical support to promote the construction of low-carbon cities. China's low-carbon city construction is in its initial stage and lacks a large amount of theoretical support to guide the construction of low-carbon cities. This paper composes the experience of low-carbon city construction at home and abroad through literature review, and distills and summarizes the advantages, disadvantages, opportunities, and challenges of low-carbon city construction practice in China, which provides practical support for promoting low-carbon city construction in China.

1.3 Research Content and Research Methodology

The study's purpose is the measures to develop a low-carbon metropolis, and the study's focus is on its economic worth. Except for the introductory section in the first chapter and the closing section in the last chapter, the major section is separated divided into three sections that follow theoretical study (Chapter 2), methodological study (Chapter 3), and experimental study (Chapter 4) and (Chapters 4-7). (Fig 1-3)

The first section is theoretical, and it includes Chapter 2. This section focuses on composes and reviews the economic evaluation of measures related to low carbon city construction, contingent evaluation methods and the theory of planned behavior. For the economic evaluation of carbon emission reduction measures, this study mainly discusses the content of the economic value of carbon emission reduction measures and externalities, public goods, and willingness to pay are all connected economic notions. For the conditional value approach, we mainly explain its economic basis, its development history, and possible deviations in its remedies. For the theory of planned behavior, we describe its theoretical development procedure, as well as connotations, and discuss the theory's use in related domains

The second section is the methodology part. According to the research on the conditional value approach regarding existing valuation methods, the research design of the conditional value approach is further investigated and debated. First, this study analyzes the experimental participants and experimental procedure designs preceding studies on the conditional value method. Second, this study analyzes the major academic controversies regarding the conditional value method research and summarizes and discusses the possible errors and their solutions. Third, this study summarizes the major influencing factors affect willingness to pay of responses This section will give evidence for Section 3's experimental research design.

The third part is a literature review, which focuses on the environmental value assessment of previous low carbon city strategies to identify the shortcomings and extract the valuable parts.

The fourth section focuses on estimation methods. The way in which the questionnaire was asked

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and the basis for its preparation are described. As well as details of the face-to-face interviews and web-based questionnaires and data processing methods. The two-boundary dichotomous conditional value method was used to elicit the WTP, and SPSS24 and R language were used to process the data. A spike model was utilized in this work to accommodate the significant amount of zero response data. The study also explored the influencing factors that affect residents' participation in supporting low-carbon city construction.

The fifth part is the experimental part, in which several measures for low-carbon urban construction are studied. The focus is on the willingness to pay for five strategies, namely the construction of a switching station, a vertical green wall, beach protection, upgrading of a sewage treatment plant, and a solar PV roof.

The sixth part proposes an extended TPB model to explain its incentive mechanism. to capture the variables that motivate the public to better participate in the construction of low carbon cities. Amos25 is used for structural equation modeling.

The seventh part summarizes the findings of the previous study and suggests how to effectively promote the pro-environmental development of residents based on the results of the study.

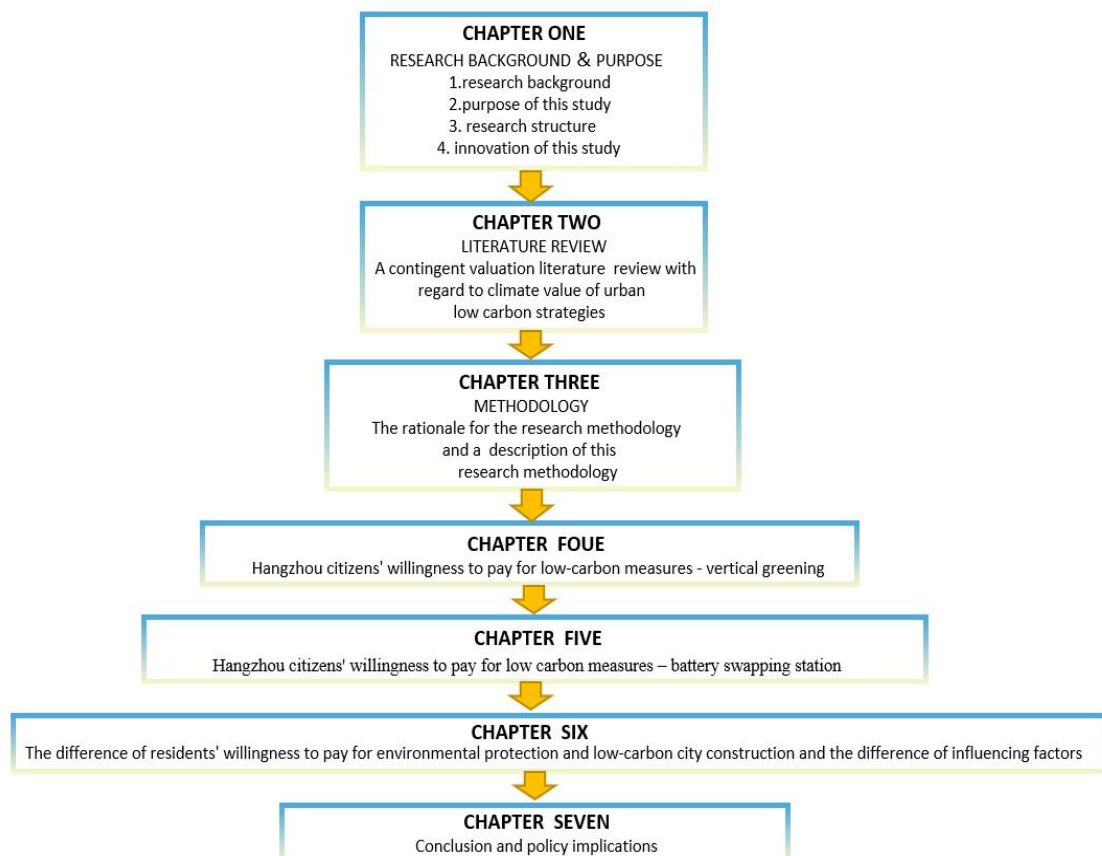


Fig1-3 Research Process

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1.4 Innovation of this study

1. This paper evaluates the environmental value of measures related to low-carbon cities, while for the first time, the above measures are evaluated. In addition, the factors that influence the notion of planned behavior is used to investigate inhabitants' willingness to pay in depth. as well as extension theory.
2. This study presents for the first time the theoretical basis of economic evaluation of urban low-carbon measures from a theoretical perspective and defines its content and connotation.
3. This study summarizes the research design of relevant CVM studies at the methodological level and through a literature review, as well as the factors influencing respondents' WTP, and possible biases and their remedies. This data might be useful for future conditional value method measures of low-carbon cities and the development of related strategies.
4. At the experimental level, compared to previous studies, this study introduced and tested a two-boundary dichotomous conditional value method combined with a spike model for dealing with zero replies in conditional value method investigations. In terms of factors influencing respondents' willingness to pay, this study extended the traditional theory of planned behavior by means of introducing variables such as policy concerns, perceived personal interests, and perceived morality to improve the predictive power of the traditional TPB model.

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Chapter 2

A LITERATURE REVIEW OF WILLINGNESS TO PAY FOR LOW CARBON STRATEGIES IN CITIES

**CHAPTER TWO: A LITERATURE REVIEW OF WILLINGNESS TO PAY
FOR LOW CARBON STRATEGIES IN CITIES**

**CHAPTER 2: A LITERATURE REVIEW OF WILLINGNESS TO PAY FOR
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CHAPTER TWO: A LITERATURE REVIEW OF WILLINGNESS TO PAY FOR LOW CARBON STRATEGIES IN CITIES

2.1 Introduction

After three centuries of high-speed industrial civilization, the globe is under enormous strain from climate change, resources, and the environment. The epitaxial growth model of urban development cannot adapt to the current environment, and the urban development model must shift [1]. Up to 78 percent of the world population may reside in cities by 2050 [2]. It has put a significant strain on city environments. Low-carbon cities are now a widespread endeavor across the world, and metropolitan cities in many countries have made the creation of low-carbon cities an urban development aim, focusing on cost minimization in the process of economic growth and the harmonious cohabitation of people and environment. Low-carbon city development has become a fundamental method for coordinating economic and social development, ensuring resource and energy security, and coping with global climate change, gradually evolving into the mainstream model of future economic and social development, and becoming an important strategic choice to promote energy conservation and emission reduction, as well as sustainable economic and social development.

Cities, as the primary unit of regional economic and social growth, have inexorably become the focal point of China's low-carbon development. China is now undergoing fast urbanization, with the National Bureau of Statistics of China estimating that the country's urbanization level may approach 70% by 2050. How to maintain sustained economic growth while addressing numerous urbanization-related issues and attaining sustainable urban development has been a focus of academic and government concern. Low-carbon cities are a necessary step in China's urbanization, and they play a significant role in determining the efficacy of medium- and long-term economic and social growth. Low-carbon city practice and idea expansion have emerged as an emerging field of low-carbon development in recent years. Low-carbon cities have not only overcome the bottlenecks that have stifled Chinese city growth but have also created new development prospects. Cities have undertaken several worthwhile efforts to promote renewable energy sectors, green buildings, and sustainable transportation, as well as a variety of associated methods.

Low-carbon cities have been a key focus of the Chinese government by reducing the number of fuel-fired vehicles and promoting the development of electric vehicles. Fuel motor vehicle emissions in China are one of the major causes of urban traffic pollution in various countries. Some developed countries account for 30% to 60% of their air pollutant emissions from automobiles. New energy vehicles, represented by electric vehicles, are becoming one of the important initiatives to solve urban traffic pollution and low-carbon transition in developed countries such as the United States, Japan and the European Union. China is now vigorously promoting the development of electric vehicles, according to the National Bureau of Statistics of China, as of December 2020, China's new energy vehicle fleet has exceeded 6.5 million units, accounting for about 2 percent of China's total vehicle fleet, including 4.93 million electric vehicles, accounting for about 1.8 percent of the total vehicle fleet, which is the absolute mainstay of new energy vehicles. The Ministry of Industry and Information Technology has proposed that by 2025 BEVs sales will exceed 25 percent, and as old fuel cars are phased out one by one the number of electric vehicles will increase significantly, significantly increasing the public demand for their energy supply. However, it also faces some problems, and so far, there are no studies on

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the willingness to pay for the construction of electric vehicle exchange stations and the assessment of their environmental value in this regard [3].

Mitigating carbon emissions in cities through vertical greening is also an important strategy to achieve green and low-carbon cities. By 2020, buildings will account for 40% and 36% of global energy consumption and carbon emissions, respectively. However, as of December 2020, only 2.902 million square meters of existing buildings have been retrofitted to obtain the green building label, accounting for 0.06% of the total area, a serious shortfall. In addition, along with the increasing urbanization, carbon emissions from the building sector will continue to rise. The large amount of carbon emissions is the main reason for the increase of greenhouse gases, triggering climate warming and aggravating the greenhouse effect. Vertical greening gets rid of the limitation of traditional flat greening in terms of the number of plants and planting area, realizes the use of the smallest area to create the largest greening effect, alleviates the increasingly sharp contradiction between urban greening land and construction land, and finds a breakthrough for increasing urban greening rate, as well as a new direction for urban land resource planning [4]. The Opinions of the State Council on Strengthening Urban Infrastructure Construction states that the use of vertical greening is recommended. However, public research on the assessment of vertical greening and its environmental positive externality value is likewise very limited.

There are also many low-carbon urban strategies developed by governments in china, including rooftop solar, beach litter removal, and sewage treatment plant renovation and so on. Unfortunately, most of these policies have been implemented with a benefit assessment and lack of environmental and non-use value assessment. This is detrimental to the implementation of the strategy and to investors' investment in environmental products. Therefore, it is necessary to assess the environmental value of urban low-carbon strategies (public environmental products). Before the next step, we tried to study the literature review on the past use of conditional value method to evaluate low-carbon city construction measures, especially for China, but unfortunately, no relevant research was found. Therefore, we reviewed and studied relevant literature on low-carbon city construction strategies in the past decade in order to select a more stable evaluation method and data collection method from the conditional value method. For the next step in our research.

2.2 Method

The conditional valuation approach is a common method for assessing the value of environmental resources for low-carbon urban measures. In environmental economics, the conditional value approach is commonly used to assess the use and non-use values of public environmental products, and in recent years countries have seen an increase in carbon emissions from cities due to urbanization, as well as an increase in the value of assessing low carbon urban strategies through the conditional value approach. However, there is a lack of studies that summarize this willingness to pay and review the literature. We summarize the studies related to the conditional value approach and low-carbon city strategies. We provide information on the countries studied, the data collection methods, the specific low-carbon strategies, the willingness-to-pay elicitation methods, and the willingness-to-pay valuation results to contribute to future research and valuation of low-carbon city strategies. In addition, we discuss the factors influencing willingness to pay and

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explore the behavioral impact on willingness to pay through various theoretical frameworks on behavioral impacts. We also discuss the validity of different payment instruments and data elicitation techniques and highlight the relative reliability and validity tests to be conducted in future studies. This chapter focuses on the evaluation of conditional valuation studies of low carbon city strategies. The focus is on the assessment of willingness to pay for vertical greening as well as the construction of switching stations, and their environmental value. Factors affecting payments are also evaluated.

We conducted a relevant literature search using the Scopus database in April 2022 specifically as follows: the primary search willingness to pay obtained a total of 24,187 articles, the secondary search willingness to pay as well as the conditional value method obtained a total of 6052 articles, the tertiary search searched low carbon on the basis of the first two levels of search and obtained a total of 179 articles, and the search low carbon cities on the basis of low carbon retrieved a total of 70 relevant articles, the specific search process is as follows (Fig 3-1).

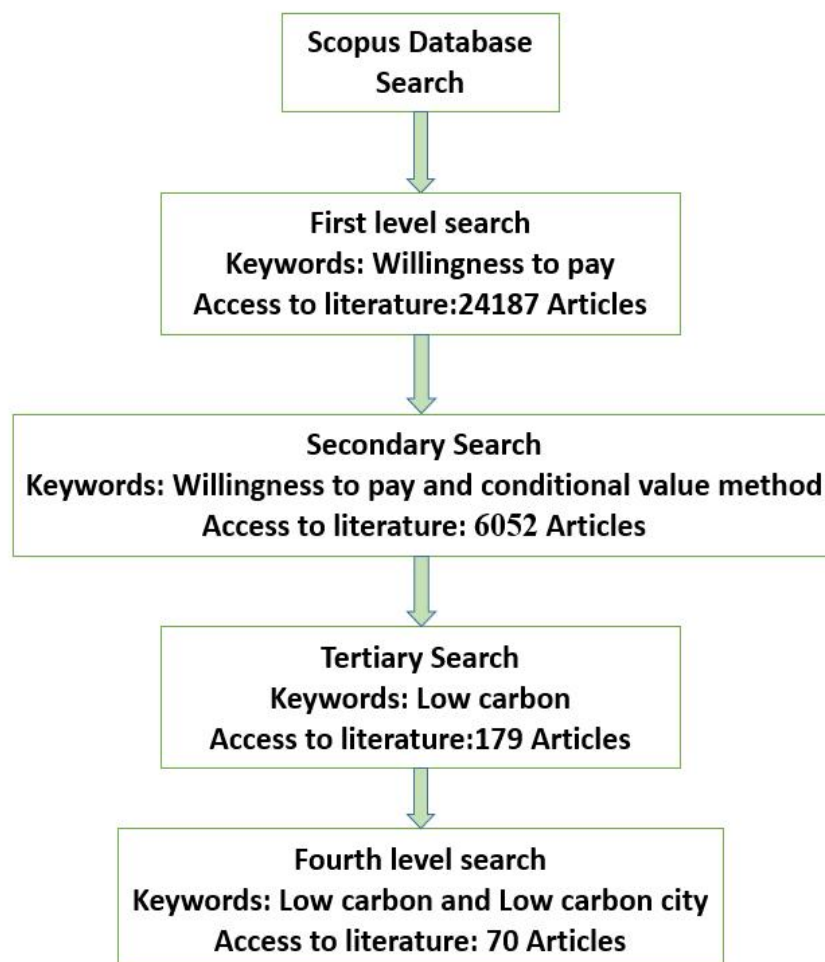


Fig 2-1 Specific search process

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Of the 70 articles, there were 64 research articles, 3 conference papers, 3 review articles, and 1 book chapter (Fig 3-2). We focused on 63 of these research articles to summarize them. Among these articles, 18 are from China, 12 from the United States, 8 from Korea, 6 from the United Kingdom, 4 from Australia, 4 from the Netherlands, 3 from Germany, 3 from Italy, 3 from Mexico, 2 from South Africa, and 1 from Nigeria Fig shows that, except for China, Mexico, and South Africa, most of the research on the valuation of willingness-to-pay for low-carbon city strategies is concentrated in developed countries. Among developing countries, China is far ahead of the studies on low carbon strategies. Thus, China is the world's largest carbon emitter, and with the 2030 carbon peaking and 2060 carbon neutral targets being set. China is increasingly focusing on urban carbon mitigation, but it is not enough.

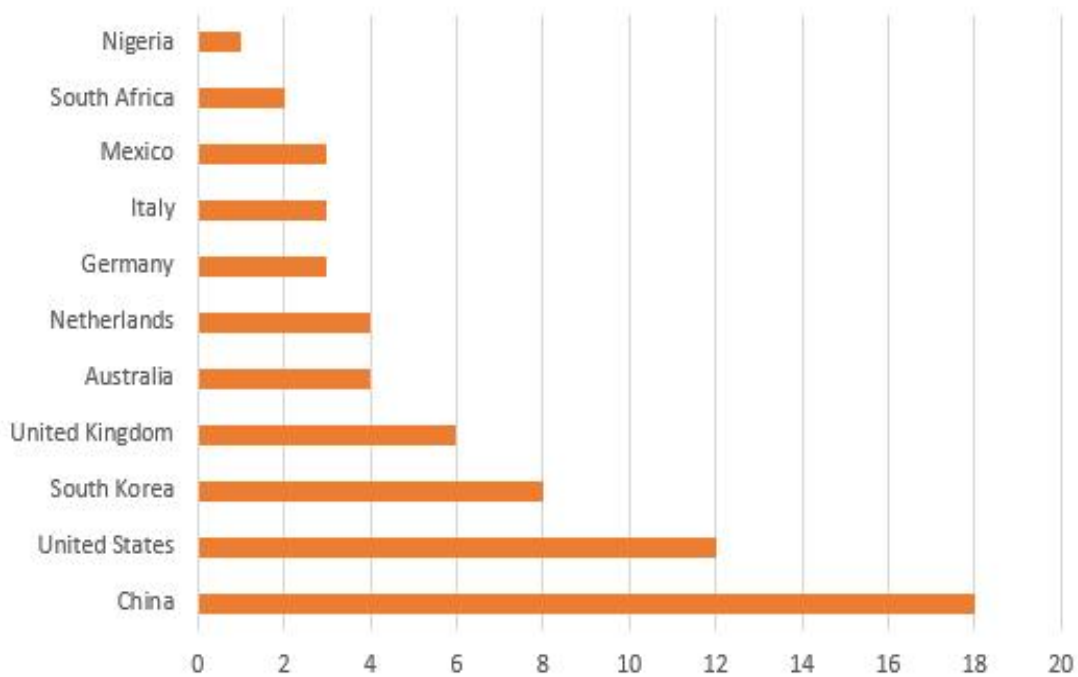


Fig 2-2 Literature Study Area

For each type of literature, we need to examine the following aspects of what each researcher has studied.

1. In studies related to low-carbon cities, the impact on the willingness to pay caused by different countries and different incomes, developed countries have better incomes and theoretically the nationals of developed countries should have a higher willingness to pay. When the ability to pay is different, what are the respective percentages of payments to support the construction of low carbon cities as a percentage of income? Do developed countries have a higher percentage share.
2. What is the focus of each researcher's study on urban low-carbon strategies and what information they try to obtain from the study? In the assessment of willingness to pay, was only the numerical value of willingness to pay assessed or were the factors influencing willingness to pay assessed. Or were both assessed.

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3. What are the specific data collection methods and the methods for estimating willingness to pay? This helps to provide implications for our study.
4. What are the types of low carbon city strategies in countries around the world? This will help various countries to learn from each other about low carbon city strategy research.
5. Which method is used as a means of payment when assessing willingness to pay? Thus, in previous studies, different payment methods can have an impact on the public's willingness to pay. Therefore, understanding the reasonable payment method is more likely to make the public pay. Thus promote the construction and promotion of low carbon cities.
6. What are the factors that influence willingness to pay in different low carbon city strategies? This helps to advance the green low carbon city at a smaller cost.

Among the 63 articles we summarize, there are two main methods of estimating willingness to pay, with the conditional value method accounting for the majority and the choice experiment method. Like the conditional value approach, the choice experiment approach uses a questionnaire to collect information and estimate willingness to pay to estimate the environmental value of public environmental products. In the conditional value approach, the characteristics of the selected product are fixed, while in the choice experiment approach, these characteristics are flexible. In the conditional value method, the researcher collects information from the selected products, while in the choice experiment method, the researcher generates information from the unselected products. The discrete choice conditional value method can be considered, to some extent, as a simplified version of the choice experiment method.

2.3 Research result

2.3.1 Literature characteristics

We have summarized the literature on urban green and low-carbon strategies, and the detailed results are shown below Table 3-1

Table 2-1 Summary of literature on green low carbon strategies (illustrate)

Author	Research object	State	Mean
Ji et al., 2022 [5]	Green roofing	Korean	3.77 USD
Ayodele et al., 2021 [6]	Green Electricity	Nigeria	10% of the electricity bill
Eom et al., 2021 [7]	Eco-toilet	Korean	12 USD
Tan et al., 2022 [3]	Electric Vehicle Swapping Station	China	61USD/Family year
He et al., 2022 [8]	Garbage collection	China	49.93 USD

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Huh et al., 2021 [9]	Wastewater Treatment Plant Upgrade	Korean	27-39 USD
Tan et al., 2021[10]	Vertical Greening	China	110 USD/Family year

We can find that most articles are closely related to green, such as green energy, green electricity, green roof and so on. Among them, Chinese families have a higher willingness to pay for environmental protection, and we guess that Chinese families are more willing to pay for environmental protection.

2.3.2 Factors affecting willingness to pay

The research of willingness to pay is critical for the study of payment affecting. We focused on the elements (antecedents and consequences) that impact willingness to pay in our literature review study on low carbon methods in order to better uncover the antecedents and consequences to give a theoretical framework for our investigation. We only summarized factors that were statistically significant at levels greater than 5%. Following a summary of the finding's Personal characteristics of respondents (age, gender), education level (elementary, middle school, high school, bachelor, master, PhD), family size (number, composition of members, presence of children), attitude towards green low carbon strategies, attitude towards environmental products, knowledge of urban low carbon strategies (knowledge, experience), motivation to participate in low carbon city construction are the main factors influencing payment. Norms of pro-environmental behavior (Table 3-2).

Table 2-2 Factors affecting willingness to pay

Influencing Factors	Numbers	Positive correlation	Negative correlation	Statistical level is not significant
Gender	55	28	20	7
Age	50	15	25	10
Household size	12	4	0	8
Education level	44	31	0	13
Employment	6	3	1	2
Kids (have or not)	4	4	0	0
Environmental Attitude	43	28	0	15

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Perception of personal interest	14	14	0	0
Knowledge	6	5	0	1
Experience	6	6	0	0
Moral Code	2	2	0	0
Policy Perception	2	2	0	0

In the literature review, most of them will include the demographic characteristics of the respondents, where the significance of gender on payment is controversial, as the proportion of positive and negative effects is closer, so further research is necessary. The effect of age on payment tends to be negative, meaning that the older the person is, the lower the willingness to pay, which most researchers believe is due to older people being less receptive to new things. Educational attainment has a significant positive effect on willingness to pay, with the higher the educational attainment the stronger the willingness to pay. Since we focus on the strategy of low carbon cities, it indicates that respondents with higher education level they are more willing to support low carbon cities. The study of the effect of having a stable job on willingness to pay is still more somewhat in the limited available literature and there is no clear conclusion on whether there is an effect on payment. Respondents are more likely to pay for low-carbon urban strategies if they have young children in the household. Respondents' attitudes toward environmental products have a more significant positive effect on willingness to pay. Of course, in some studies, attitudes toward environmental products do not influence willingness to pay. But there is no negative effect. The perception of personal interest has a strong positive effect on willingness to pay. This means that respondents are more willing to pay when they feel that the low carbon city strategy will bring them benefits. This is reflected in two main areas, health status and financial benefits. People with environmental knowledge tend to have a higher willingness to pay.

2.4 Discussion

The conditional value approach is a common way to evaluate the use of public environmental products and has been developed over a long period of time, and researchers have discussed and studied the various advantages and disadvantages of the conditional value approach. By studying the willingness to pay for low carbon city strategies. We found significant differences in valuation methods, questionnaire approaches, and subjects and respondents in different studies. The differences lead to very different estimation results.

The perceived value of green low-carbon strategies is influenced by willingness-to-pay inducing factors. There are three main types of elicitation methods in the conditional value approach regarding green low-carbon strategies, namely open-ended, payment card and dichotomous. Each of these three elicitation methods has different advantages in previous studies, with open-ended questions being easier to answer, but leading to higher zero and protest responses. The two-

CHAPTER TWO: A LITERATURE REVIEW OF WILLINGNESS TO PAY FOR LOW CARBON STRATEGIES IN CITIES

boundary dichotomous elicitation is more complete but has the disadvantage that it requires a large number of questions, and the results estimated by the model are often higher than the actual willingness to pay, and the choice of bidding points needs to be determined by a pre-survey, which increases the cost of work and time. The payment card style is often influenced by visitors in the valuation.

By comparing the valuation results, the dichotomous form tends to have higher valuation results than the payment card form with open-ended. In contrast, the valuation results of the two-boundary dichotomous form of the dichotomous formula are relatively more conservative [11]. Several researchers have also confirmed the conclusion of the higher reliability of the two-boundary dichotomy through a literature review, providing four possible reasons for this [12]. The first reason is related to strategic behavior, which is not impossible in DBDC, implying that people tend to disclose their actual willingness-to-pay in DBDC exams. The second reason is that answering DBDC questions is straightforward, yet it may be difficult for anyone to determine an appropriate valuation for a hypothetical market. A third explanation is the ambiguity of people's preferences; depending on the format, individuals tend to answer "yes" or provide a bid, which would be consistent with a bias to say "yes" and a starting point bias. Alternatively, individuals respond to willingness-to-pay questions with two goals in mind: they want to accurately answer the willingness-to-pay question while communicating their support for the cause at hand. Although some studies have consistently shown more and less findings using different elicitation methods, it remains unclear whether elicitation methods provide a more accurate assessment.

In the literature we summarize, 31 explicitly state the willingness-to-pay estimation method, while the remaining do not explicitly state the estimation method. They put more emphasis on the importance of the results and ignore the impact of the valuation methods. In other words, they assume that the results are consistent across all valuation methods. This is not consistent with the results of the actual studies. Therefore, there is a need to discuss the valuation methods in the study of conditional value method. In 31 papers, three main induction methods were used, open-ended, payment card, and dichotomous. As well as the choice experiment method and the survival analysis method. Of these, the survival analysis method was used less frequently in only 1 article, which was valued by building a survival regression model, open-ended in 8 articles, payment card type in 5 articles, dichotomous in 13 articles, and choice experiments in 4 articles.

The payment instrument is an important factor in experiments with the conditional value approach because it provides the necessary payment environment [14]. The study of the conditional value approach depends heavily on one's understanding of the intrinsic characteristics of the commodity to be paid for. Payment instruments are a medium through which the public pays for goods or services, either through pre-subscription or at the point of consumption, and people evaluate products differently according to different payment instruments.

In the above study, we also found that mandatory payment instruments are more likely to make respondents make reasonable choices about the value of their willingness to pay, which not only helps to ensure incentive compatibility but also helps to reduce respondents' behavior of exaggerating their willingness to pay. Therefore, in our study, we chose the mandatory payment instrument as the payment instrument.

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In the study of low-carbon strategies, many researchers have addressed the factors influencing willingness to pay. One of the most frequent discussions has been about behaviorology. A large proportion of researchers have discussed payment behavior using the theory of planned behavior. And good estimation results have been obtained. In the early studies, many researchers focused mainly on demographics his characteristics, and related characteristics of demographic economics. Then this approach was criticized. The reason was that these demographic variables could only assess moderate differences in behavior. The introduction of the theory of planned behavior, on the other hand, led to a greater interest in the influence of psychological dimensions on behavior. According to the original theory of planned behavior model, the best predictors of behavior are behavioral intentions, which are influenced in part by attitudes that reflect positive or negative evaluations of individuals' behavioral choices; second, subjective norms that refer to the social pressure on group members to perform the behavior; and third, perceived behavioral control, which refers to the perceived ease or difficulty of the behavior [15]. In our study on low-carbon strategies, attitudes did have a statistically significant effect on respondents' willingness to pay at the 1 percent level. Moreover, control beliefs indirectly measured through prior willingness-to-pay experience and knowledge were positively correlated with willingness-to-pay. the TPB model may be useful in exploring the theoretical framework for understanding its influences.

2.5 Conclusion

In the above literature analysis, the following conclusions are mainly drawn: among the current estimation methods of willingness to pay, the treatment and solution of zero response are relatively single, and further solutions are necessary. The peak model proposed by Kristrom (1997) is an effective way to deal with zero response, and its effectiveness has been proved, but the application of the peak model is very limited. In our literature review study, there is no case of using the peak model to conduct research on low-carbon city strategies. Therefore, we use the peak model to evaluate the willingness to pay to fill in the research gap.

2.6 Outlook

Through literature review, we found many variables affecting the willingness to pay for low-carbon city construction measures, but unfortunately, no researchers have discussed the influence of the theory of planned behavior on the willingness to pay. The theory of planned behavior is a common method to explore individual behavior, which mainly includes three variables: attitude, subjective norms and perceptual behavioral control [16]. So far, the theory of planned behavior has become a common way to discuss individual behavior [17]. China's top-down management model has lasted for many years, so public perception of policy is very important. This is how much the public supports a policy when it is made. However, the use of policy perception in literature review is also very limited. Therefore, we will join the discussion of planned behavior theory and policy perception in our next research. To explore the influence of variables on individuals' willingness to pay for low-carbon city strategies.

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Chapter 3

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3.1 Economic value of measures for low-carbon cities

3.1.1 The economic value of reduce urban carbon emissions

First, two approaches describe the economic worth of lowering urban carbon emissions. The actual reduction in energy consumption because of using cleaner energy sources and the value generated from using cleaner energy sources. This sort of value is frequently calculated using a combination of algorithms and energy costs. On the other hand, their theory of environmental and economic value is mainly according to marginal utility theory of value and labor theory of value and has gotten less attention. This study will demonstrate why lowering urban carbon emissions has an environmental and economic value from these two perspectives.

The focus of economic theory study and practice switched from the sphere of circulation to the field of production with the birth of the school of political economics, and the classical school proposed the labor theory of value. The system of the labor theory of value was briefly formed by English traditional economists: William Petty, Adam Smith, and others. William Petty initially put up the essential premises of the labor theory of value, then Adam Smith studied the idea in detail, and David Ricardo completed the classical labor theory of value. Karl Marx incorporated Hegel's philosophical concepts, created a comprehensive analysis of the quality and quantity of value, and constructed the Marxist labor theory of value based on the classical school's economic theory of value in the 1860s.

According to the labor theory of value, labor is the only source of value. Abstract human work in a unified condition is the essence of value. The quantity of value is determined by amount of socially required work time. The value of low-carbon city development is first elaborated in this paper using Marx's labor value theory.

The population and demand for human people are fast increasing in the contemporary economy and society based on commodities, the scale of production is rapidly rising, and science and technology are rapidly improving. Human activities have left a global footprint, environmental resource exploitation has expanded to practically all areas, and the environmental impact of human activities has beyond the ecosystem's carrying capacity. Natural resources have been depleted, and the natural environment has degraded in economic development [2]. Economic development's long-term viability and basis have been shattered, the conflict between resources and economic growth has worsened, and the worth of environmental resources become increasingly important. To attain long-term development, a significant natural resource creation and reproduction need a significant amount of work. to create a balance between natural and social reproduction. The modern natural resource reproduction process integrates natural and social reproduction processes.

Understanding, use, conservation, renewal, progress, and scientific research are all social reproduction processes that comprise "socially essential labor that may be exchanged and concentrated in products without selection." When human work is concentrated on developing low-carbon urban measures, the mitigation of urban carbon emissions, and so on, according to Marx's theory of the value of labor, the labor performed should have value. This is the value of the most fundamental low-carbon urban initiatives and strategies [3].

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On the other hand, the utility theory of value is an economic theory that explains value and its production process in terms of products' capacity to satisfy human wishes or human beings' subjective psychological appraisal of the utility of things. It's the opposite of the labor theory of value. It was mostly represented as the general utility theory before the 1860s, and it has been primarily expressed as the marginal utility theory since the 1870s. In the first half of the 17th and 18th century, economic writings clearly articulated and thoroughly developed the utility-value hypothesis [4]. Baben, an early English economist, was one of the first to state the utility-value viewpoint openly. He stated that the utility of all items determines their worth; what is useless has no value; the usefulness of objects is determined by meeting requirements; all objects become useful and hence valuable only when they can fulfill human beings' fundamental physical and mental demands.

Galliano, an Italian economist, was among the first to develop the concept of utility value. He explained that value is the ratio of an object's supply to its demand and the parties decide that value to an exchange's estimate of a good's usefulness or, more precisely, by the utility and the object's scarcity. The utility value theory [5] describes the value and the process of value generation by looking at an object's capacity to satisfy one's wishes or the subjective psychological judgment of one's usefulness.

Nicholas Baben, an early English economist, felt that the worth of all things is derived from utility; the usefulness of commodities is to fulfill human aspirations and requirements, and anything that meets human physical and mental desires is helpful and valuable. According to Italian economist Fernando Galliano, value is the ratio of a commodity's demand to a human being, which is based on the exchange's evaluation of the commodity's utility [6]. The idea of utility-value was elaborated and written in the first part of the 17th and 18th century, well entrenched in bourgeois economics [7] with the emergence of commodity-exchange relations and commodity-exchange interactions.

The utilitarian theory of value made no significant development from the second part of the 18th century to the present to the beginning of the 19th century. Classical political economics established the labor theory of value with the culmination of industrialization and the emergence of socialism production. Adam Smith and David Ricardo heavily attacked the utility theory of value while developing the labor theory of value. Jean Say, a French economist, emphasized the value theory's utility but did not contribute to its future development [8].

In response to the labor theory of value, the notion of marginal utility value evolved after the 1930s. William Lloyd, a British economist, was a pioneer of the marginal utility value theory. He argued that a commodity's value reflects only a person's psychological feelings and does not reflect the commodity's intrinsic nature; that value is determined by human desires and human valuation; and those human desires and valuation vary with the quantity of the item and the difference between fulfilled and dissatisfied wants [9]. William Lloyd made a distinction between total and marginal utility, implying that the item's worth is determined by marginal utility. The market price of an item is always governed by the minimal intensity of demand, which may lead to real purchases, according to Irish economist Samuel Longfield [10].

Hermann Heinrich Gerson, a German economist, was a crucial figure in developing the marginal

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utility theory. In his article "The Development of the Laws of Human Exchange and the Norms of Human Behavior," he reaffirmed the theory of utility value. He proposed the famous Gerson theorem, which includes the theorems of diminishing either desire or utility and equality of marginal utility and the theoretical foundation of the value of marginal utility theory [10]. The Austrian economist Killinger introduced the "principle of national economics" after H. Gerson, which asserts that the least gratified want determines the value of a product among the different desires offered by the commodity to satisfy the welfare of the people. In the same year, British economist William Jevons released Theory of Political Economy, proposing the "ultimate utility level" theory of value; in 1874, French economist Leon Valas published Pure Political Economy, proposing the "theory of sparse value." At about the same time, these three economists suggested the idea to determine the value of marginal utility [11]. Carl Menger, Wilhelm Jevons, and Leon Vallas worked together to create the marginal utility theory. The notion of the value of marginal utility became a comprehensive theoretical system after Friedrich Wessel and Eugen Bumbavik developed it.

Subjective utility theory, which has superseded the mainstream of economic value theory is objective value theory., has been revitalized by marginal utility theory. The utility theory of value has benefited considerably from research on the link difference between utility, total utility, and marginal utility. According to the marginal utility theory of value, an item's worth is determined by two factors: usefulness and scarcity. The subjective delight or usefulness received from consuming a commodity or service is referred to as utility. There would be no value if there were no usefulness. As a result, the source of an item's worth is utility. Measures to minimize carbon emissions in cities can enhance people's comfort, reduce air pollution caused by emissions, moderate summer urban heat produced by the greenhouse effect and the heat island effect, and increase labor productivity, particularly for outdoor workers. The indirect economic impact of lowering carbon emissions in cities has acquired a firm foundation.

It is worth mentioning that utility is split into two categories: total and marginal. Total utility is the total amount of pleasure derived from consuming a specific amount of a particular product. Total utility is proportional to an individual's level of consumption, i.e., the more products and labor consumed, the higher the total utility and marginal utility is the extra impact of each additional unit of consumption. The marginal value of such reductions determines the Willingness to payfor steps to reduce urban carbon emissions

3.1.2 Environmental value classification

Environmental resources have significance as a material base for human existence and development, in addition to geographical difference, wholeness, scarcity, and multifunctional [12]. The value of environmental resources may be divided into two categories: use value and non-use value, which is also known as intrinsic value or conservation value in environmental economics. The function of meeting user requirements or preferences in the use of environmental resources is known as use value, and it may be divided into two types: direct use value and indirect use value. Non-use value is the inherent worth of environmental resources that is not tied to human use. It includes the environmental resources have choice value, existence value, and legacy value. Consumers' propensity to save excess resources to avert future resource shortages is known as

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choice value. Without any purpose or plan to exploit it, existence value provides a natural human value. Motives or intents for future usage may be included in heritage value [13]. (Figure 2-1).

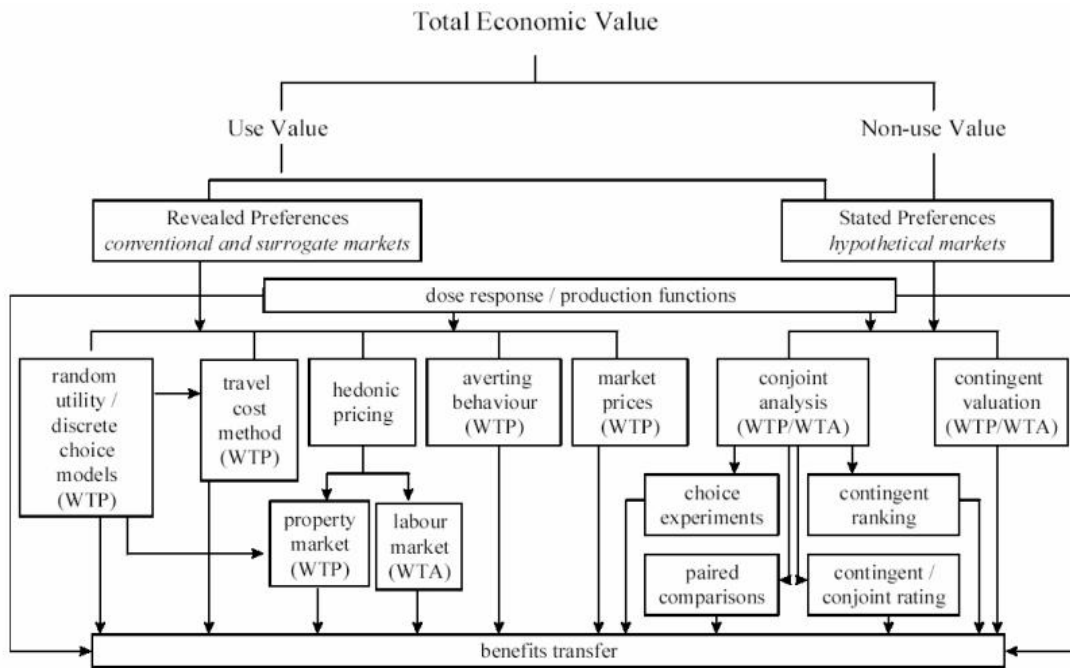


Figure 3-1. The several types of valuation methodologies and the overall economic worth

Note: Pearce and Howart (2000); we are grateful to Stanislav Kutáček of the Czech Transport Research Center for providing the chart; the chart also cited in Bateman et al. (2002)

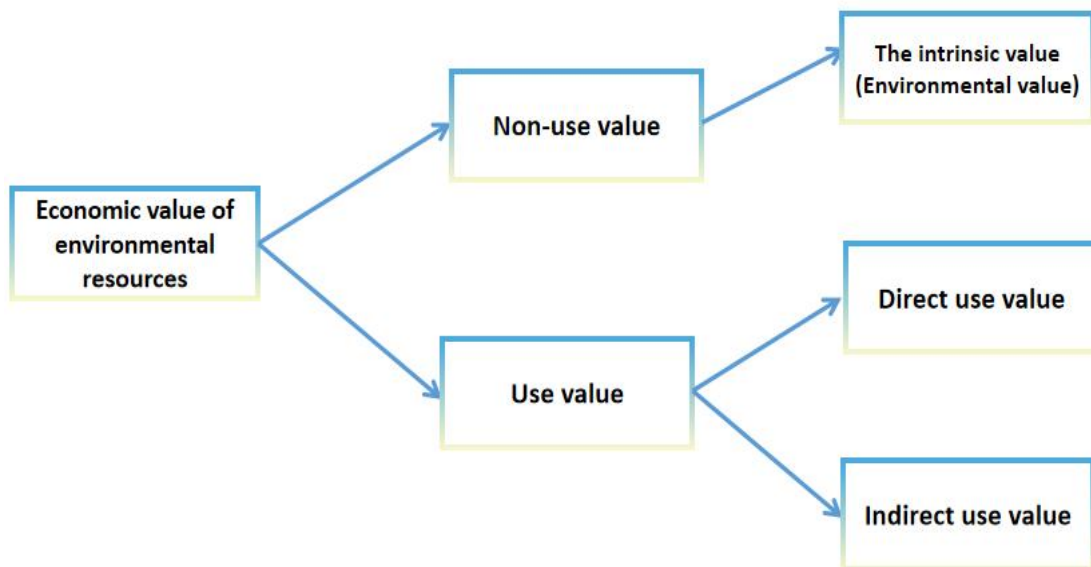


Figure 3-2. Environmental resources have a monetary worth

While there is a uniform framework for identifying environmental resource values in the subject of environmental economics, there are some slight variances in specific views, as follows. Choice

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value, legacy value, and existence value all cross and overlap in ways that are difficult to describe and categorize. Scholars disagree on how to classify selection value, with some classifying it as use value rather than non-use value.

According to Carson [14], non-use values often account for a large share of the economic worth of environmental resources. A cost-benefit analysis that ignores the worth of environmental resources while they are not in use is flawed and potentially deceptive. Non-use values, like use values, have the potential to influence human welfare. Zeng [15] investigated the origins of non-use values in academia and stated that the non-use value of natural resources is a nebulous and difficult-to-define date. In terms of economic theory, including non-use values in the purview of economic value evaluation is incorrect and impossible.

Low-carbon cities are strongly linked to the environment, and they incorporate both use and non-use values, such as carbon emission reduction and energy savings. As a result, research on low-carbon city solutions should be performed within the context of environmental economics' "use-value-non-use value" of environmental value.

The economic benefit of reducing urban carbon emissions, on the other hand, is primarily represented in the supply of non-material direct use values (increasing air quality, lowering health risks, enhancing the comfort of the urban thermal environment, and so on) as well as indirect use values. indirect use values (comfort, greater productivity, and decreased risk of connected diseases), and direct use values Urban low-carbon measures is important aspect of urban ecosystem services. Regardless of its non-use values, a component of the service (heritage value, option value, and existence value).

This study further separates their economic and non-economic values based on the value categorization of low carbon city-related metrics in the context of "use value and non-use value." Economic value has a precise meaning in the context of value theory conceptualization. According to Pierce and Kerry Turner, value is determined by human desires and measured by consumer surpluses. Economic value may be thought of as the total of users' and non-users' values [16]. Because its direct use value may have a direct influence on people, the economic worth of lowering carbon emissions not debatable.

The economic worth of its non-use value should be additional investigation. Environmental values is interpretable in a variety of ways. The first is the ecological product regarding commodity value, which is the worth of the resource entity as a market exchange; the second is the worth of ecosystem's presence of more important species or creatures; and third is ecosystem's functional worth, which is value of ecological studies like biodiversity research.

Ecological value should be represented more in information connected to resource valuation and t functional worth of the topic of resource usage, representing the "expert value" of the ecosystem, from a commercial viewpoint. Expert judgment in a relevant subject is merely a specific piece of information to be included in the evaluation of urban carbon emission reductions, not a measure of wellbeing, according to welfare economics. It is appropriate for impact evaluation but not for economic analysis [17].

The following is the basic concept behind developing an evaluation system for low-carbon city

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measures: 1 There are two types of value in strategies to reduce urban carbon emissions: The value of direct and indirect usage. The direct use value is represented in reduced carbon emissions, which can give non-physical non-consumption values (enhancing thermal comfort, boosting productivity, and lowering the incidence of linked diseases); the indirect use value is mostly comprised of ecological values (reducing air pollution, mitigating the heat island effect, and regulating climate change). Ecological value is a "professional value" that explains the specific knowledge in GHG emission reduction, but it is not a measure of wellbeing and hence is not included in the economic value. The direct use value of the favorable environmental externalities associated with low-carbon urban strategies is the subject of this article.

3.1.3 Theoretical foundations for evaluating the economic benefit of carbon emission reductions from urban carbon emission reductions

When the sources of reducing urban carbon emissions are identified, a theoretical foundation for future discussion of economic value evaluation methodologies is established. The contingent valuation approach is theoretically supported by the public goods theory. The requirement to assess the economic worth of reducing urban carbon emissions is expressed by externality theory; Willingness to pay and accept are two direct measurements of reducing urban carbon emissions. The economic evaluation of reducing urban carbon emissions is based on willingness to pay, public externality theory, willingness to accept and goods theory.

Lindahl proposed the notion of public goods, which Samuelson expanded on in two excellent articles published in 1953 and 1954. He said that a public good is a communal consumer good that is shared by all members of society and that all members of society may enjoy the product at the same time: one person's use of the product does not decrease the consumption of the product by other members of society. "Public goods," on the other hand, are things whose advantages are distributed inequitably throughout society, regardless of whether any person wishes to acquire them. The public goods theory is one of the foundational theories of the new political economy, and it serves as the foundation for the proper handling of the government-market relationship, the transformation of government functions, the construction of public finance and revenue, and the marketization of public services. The indivisibility of utility, the non-competitiveness of consumption, and the non-exclusivity of benefits are three qualities that distinguish public products or services from private goods or services. The most frequently recognized definition is that presented by Samuelson and offered by the following economists, which evaluates and defines public goods in terms of two fundamental qualities. To begin with, non-exclusivity is the opposite of exclusivity in terms of consumption. Second, consumption's non-competitiveness is proportional to its competitiveness [17]. Non-exclusivity states that the product's utility cannot be split among various users, implying that anybody can free to use and that those who do not pay for the public good cannot be ruled out due to technological reasons. This indicates that the public good benefits the whole population, regardless of whether they pay for it.

When a public benefit is supplied, nonrivalry means that any consumer's use of the public good has no effect on the utility of other consumers or society. The pure theory of government spending. There are two sides to the specific implications.

First, the marginal cost of production is zero, i.e., the marginal cost of production increases as the

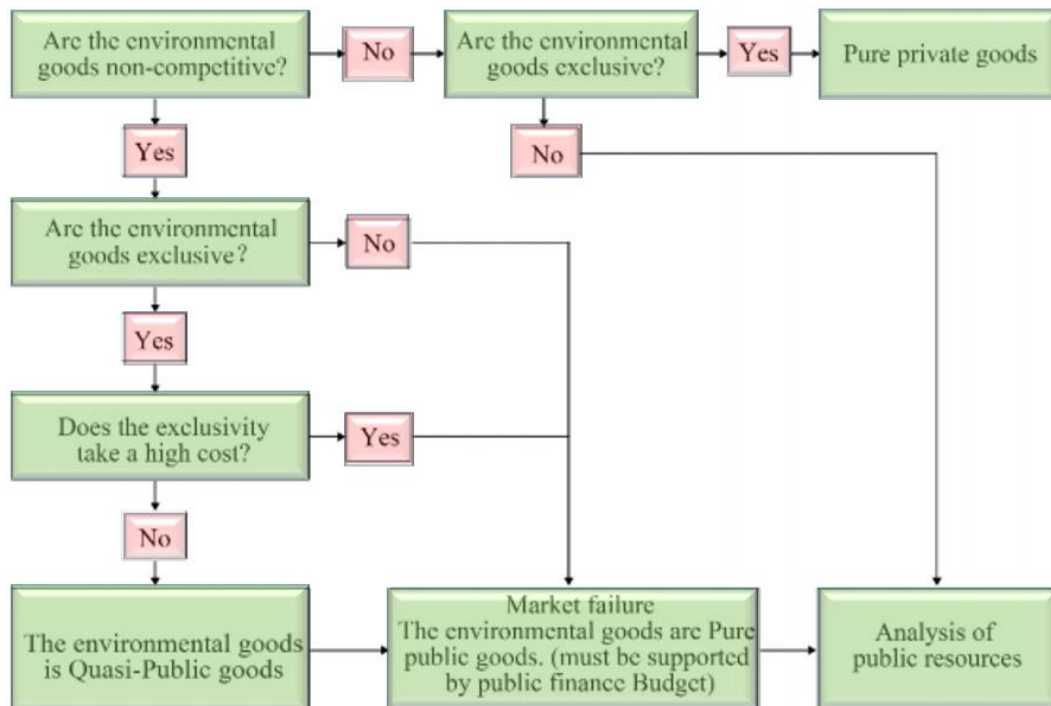
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number of customers increases. A difference in marginal cost derives from an increase in output. The marginal cost of production owing to an increase in output and an increase in customers is inconsistent for public goods; however, the marginal cost of congestion is zero, i.e., one consumer's consumption has no effect on the amount or quality of other consumers' consumption. Not only are these things eaten at the same time, but there is no congestion impact. The indivisibility of the commodity also contributes to non-competitiveness. consumption's When a product does not achieve full consumption, the increase in customers has no effect on the variable manufacturing costs and has no impact on other consumers' consumption [17] [18]. The public good may be distinguished using the process depicted in the picture, which is based on the non-competitive and non-excludable properties of consumption. The first stage in defining a public good is to determine whether the product's use is competitive. Competitiveness should not be allowed in a pure public good. If the competing product is also exclusive, it is a totally exclusive item; if it is not also exclusive, it is a publicly managed resource.

Second, if the environmental product is non-competitive, its exclusivity must be examined. The product is a pure public benefit if it is technically non-exclusive, or the cost of exclusivity is prohibitively high.

Third, if the product is not competitive and the cost is not large, it is a quasi-public good that is exclusive and uncompetitive.

Four categories of environmental goods may be drawn from the foregoing discussion: 1. pure public goods, non-competitive and non-exclusive; 2. pure private goods, competitive and exclusive; 3. quasi-public goods, non-competitive and exclusive; and 4. public resources, competitive and non-exclusive [19].



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Figure 3-3. Public goods identification (Source: M, Hua. 2017. Public economic. Shanghai: Fudan University Press)

Mitigation of urban carbon emissions might be deemed a pure public benefit with non-competitive and non-exclusive qualities, according to the definition and identification procedure of public goods. The utility of one person does not affect the utility of other residents, which is a non-competitive feature of reducing urban carbon emissions. Even if an extra city resident is added, the utility of the inhabitants who benefit from carbon emission reduction is unaffected, and the cost of congestion for city residents is close to zero.

3.1.4 Externalities

Economic externality, also known as economic activity externality, is a key concept in economics that refers to externalities that occur when one economic agent's behavior (state, enterprise, or individual) has a direct impact on another economic agent without a corresponding payment or compensation. Externality is also known as external cost, external impact, or spillover effect in economics. Externalities can be beneficial or harmful. A positive externality occurs when an individual economic actor's activity benefits others or society at no cost to the beneficiary, whereas a negative externality occurs when an individual economic actor's activity harms others or society at no cost to the person who causes the external diseconomies. Externalities were originally discussed by British economist George Marshall in his famous work "Principles of Economics," which has been in print for over 110 years. Externality, also known as external effect or spillover effect, is the external influence of a person's or a firm's action on other persons or companies that does not occur in a price-based exchange between the parties involved, and hence has an external impact. An external economic effect, more specifically, is an effect of one economic agent's conduct on the welfare of another economic agent that is difficult to capture in monetary or market transactions. The utility function of the consumer can be used to reflect economic externalities. The occurrence of externalities is often believed to be one of the flaws in the market system for resource allocation. In other words, when externalities exist, the market mechanism alone is frequently insufficient to promote efficient resource allocation and enhance societal welfare, and the government should gently interfere. Externalities, particularly external diseconomies, are still a more important socioeconomic concern, such as pollution or harm to the environment [20].

In his book *Welfare Economics*, published in 1924, Arthur Pigou, a student of Marshall, expanded on and developed the topic of externalities. From the standpoint of optimal social resource allocation, Arthur Pigou used marginal analysis to identify marginal net social output and marginal net private output, as well as the important concept that externalities may be negative or positive, as well as developed the theory of static technological externalities [18]. The externalities of urban sprawl are linked to the deterioration of the UHI effect. According to Samuelson, one individual may impose additional costs or advantages on others during the production and consuming process, and these expenses or advantages put on others are not monetary in nature. An spillover or externality impact happens in this instance. An externality is defined as "an economic institution's influence on the wellbeing of others whose worth is not represented in market transactions [21].

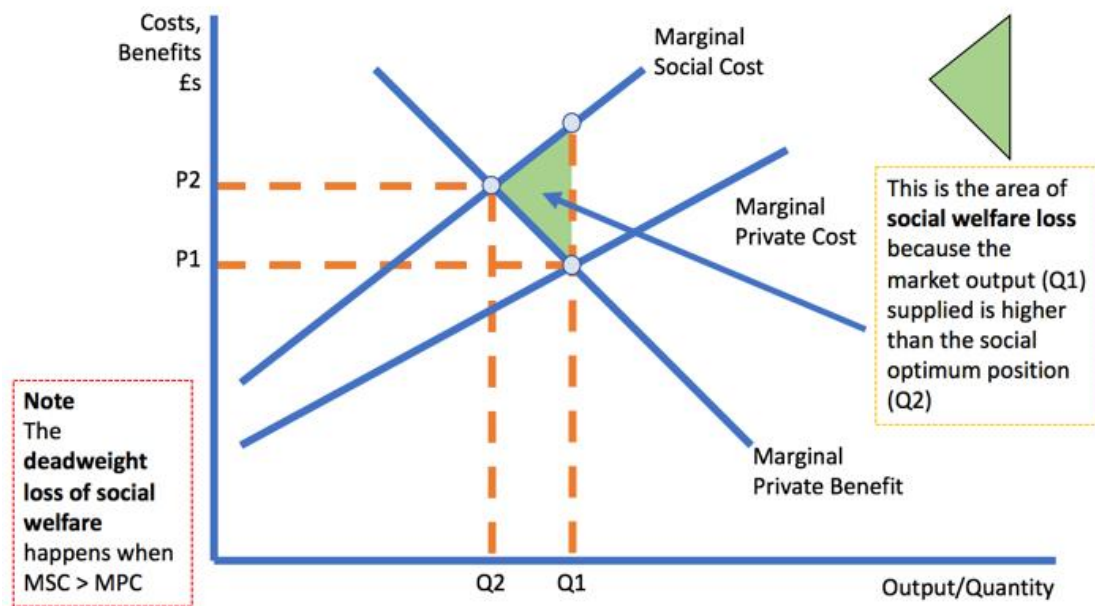


Figure 3-4. Externality and societal loss

(<https://i.stack.imgur.com/GdVbZ.jpg>)

Production or consumer activity can potentially result in positive or negative externalities [13]. Externalities can be classified into four types: first, external economies of production, where producers take certain economic actions that benefit others or society; second, external economic barriers to production, where producers take certain economic actions that harm others or society but do not possess the related compensation costs; and third, external economies of consumption, where consumers make certain economic actions that help others or society as well as do not bear the corresponding compensation costs; and fourth, external economic barriers to production, where producers carry out certain economic initiatives that harm others or society but do not have a matching . The fourth is the externally diseconomy aspect of consuming, in which consumers engage in specific economic acts that harm others or society but do not incur the associated costs [17].

Because the low-carbon character of urban low-carbon is a public utility, externality is an unavoidable attribute. The development of low carbon cities did not receive enough attention from decision makers in the early stages of urban development, resulting in developers lacking a clear understanding of urban low carbon measures and related knowledge, causing them to only focus on the economic benefits and not conduct economic benefit analyses of low carbon measures. Consumers of environmental items, on the other hand. Because of the externality of public goods and the existence of a self-interest motive, each city resident just evaluates the marginal cost and benefit, and the societal cost is ignored. resulting in their lack of knowledge about the importance of carbon emissions and the deterioration of the environment.

External impacts are more direct and dominating during urbanization growth and expansion, whereas external diseconomies build and are an unseen influence in the process of urban development. For a long time, the external economy has been concealed by the external economy.

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If external economic impediments such as urban carbon emissions induced by urban expansion are not addressed, the potential for urban development will continue to be lost [24].

3.1.5. Willingness to pay

In welfare economics, assessing the Willingness to pay for a specific product is a viable technique to evaluate the amount of welfare in monetary terms [25]. The price that customers appreciate or are prepared to pay for the goods and services they receive is referred to as willingness to pay. It's a measurement of the item's "total cumulative consumption" benefit. The best indication of consumers' Willingness to pay for a particular final consumer commodity in a market economy is the market price itself. This is because the consumer's enjoyment of the commodity must be at least equal to the cost of paying cash; under certain circumstances, the consumer's Willingness to pay cannot exceed the market price. These are the following conditions: (1) the consumer good is freely available in the market without rationing or other limitations; (2) there is no monopoly of purchasing power; and (3) the consumer good's supply and demand are fundamentally balanced.

Economics suggests that the price one is willing to pay for buying a certain product should be equal to the price one is willingness to accept for selling the same certain product, in the case of urban residents, for example, one case is that the monetary income of urban residents is W , In the other instance, the equivalent carbon emission intensity, E , should be non-exclusive and non-competitive, and urban thermal environment enhancement cannot be acquired directly through the market. The undifferentiated utility curve can indicate reasonable customers' choices. As seen in the figure, T_1 , T_2 , and T_3 represent two utility levels. T_1 , T_2 , and T_3 are two undifferentiated curves, which are a combination of various monetary earnings and different strengths of reduce carbon emissions effects, respectively. The utilities remain constant on the same undifferentiated curve.

First, we examine urban inhabitants' willingness to pay when it comes to reducing carbon emissions. Assume that the starting level of welfare for inhabitants is point a . Currently, visitors' monetary income is W_0 , the intensity of the urban low-carbon impact is E_0 , and residents' utility level is T_2 . When compared to point A , B has the same monetary income W_0 , the urban thermal quality is E_1 , which is better than E_0 , and the utility level of B is T_3 greater. When urban thermal quality increases from X_0 to X_1 , rational urban inhabitants are prepared to spend from W_0-W_1 to pay for the improvement of urban thermal quality, and urban residents' welfare level is point C . W_1 represents monetary income, the level of urban thermal environment quality is X_1 , and the utility level T_2 of point C is the same as point A . Urban residents are willing to pay W_0-W_1 to improve urban carbon emission mitigation X_0-X_1 , in which case the urban carbon emission environment improves, the monetary quantity decreases, and the welfare level remains the same. W_0-W_1 is the Willingness to pay of city residents who improve from X_0 to X_1 .

As the city's carbon emissions increase from X_0 to X_2 , there should be a monetary compensation of W_2-W_0 to maintain the public's welfare level. Point D depicts a larger monetary income and increased urban carbon emissions compared to point A . W_2-W_0 represents the bare minimum of acceptance that urban people can afford an increase in urban carbon emissions.

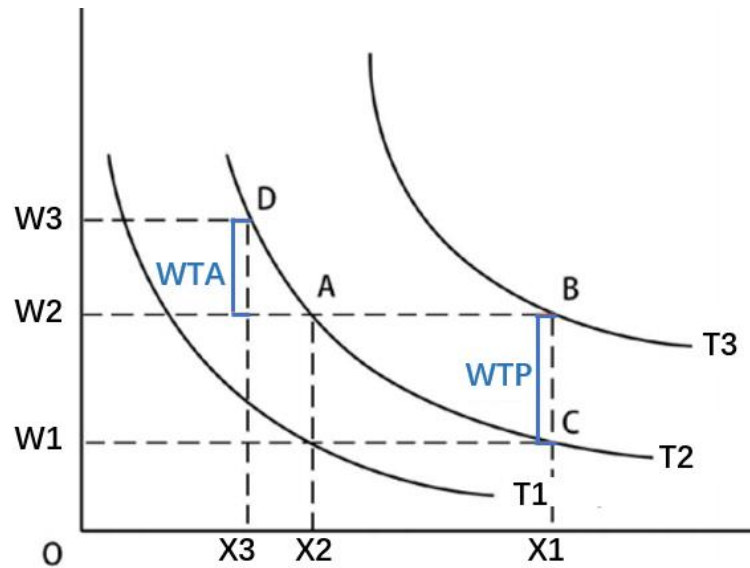


Figure 3-5. Comparison of willingness to accept and Willingness to pay [26]

3.2 Contingent valuation method

3.2.1 Concept of Conditional Value Method

In addition to the direct market price measure of revenue, the travel cost method, the alternative cost method, the characteristic price method, the intermediary goods method, and the conditional value assessment method are the main revenue evaluation methods for economic value measures currently. In circumstances where market prices are not accessible or are not immediately available, these five major methodologies are all used to determine value.

The Conditional Value Method is a widely used stated preference approach for determining an ecosystem's non-use value, usually under hypothetical market conditions, by directly asking respondents about their Willingness to pay for an ecosystem improvement or accept compensation for an ecosystem damage or loss. The non-use value of an ecosystem is estimated using the respondents' Willingness to pay or accept.

Willingness to pay and WTA are two ways for determining the amount of money in circulation. The two primary strategies for determining the economic worth of environmental products by measuring Willingness to pay and WTA are revealed preference methods and stated preference methods [27].

The revealed preference value assessment method is used to estimate the economic value of changes in environmental quality by inferring people's environmental preferences indirectly through market-related behavior, specifically the prices they pay or the benefits they receive in markets that are strongly linked to the environment. The trip cost method, the hedonic pricing approach, the market cost approach, and the benefit transfer approach are all examples of these approaches. Direct inquiry is used to elicit customer preferences for specific environmental goods or services using stated preference approaches [17]. The conditional value approach, It determines people's willingness to pay for the advantages of environmental improvement or environmental

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quality degradation in a hypothetical market and so evaluates the economic worth of a certain environmental good or service, is the most used stated preference approach. Both usage and non-use values may be estimated using the conditional value technique [24].

The Conditional Value Methodology is now the most successful way for estimating the non-use value of public environmental goods, both nationally and globally (market resources, such as environmental protection or the impact of pollution). It's a survey-based economic method. Although these environmental products benefit the public, there is no obvious market price for them since they are not sold directly - for example, clean air, attractive surroundings, realistic atmosphere, etc. - and obtaining values using price-based models is challenging. A valuation technique used to quantify these elements is the conditional value approach. Because it employs respondents' stated information for analysis rather than a price-based revealed choice model, the conditional value technique, which commonly takes the form of a questionnaire to acquire the required information needed for valuation, is also known as a "stated preference" model. Both models are based on tried-and-true methods. Typically, polls assess how much individuals are ready to pay (or tolerate) to keep (or be rewarded for) an environmental feature, such as the environmental value of a low-carbon approach. Typically, the conditional value approach involves a questionnaire administered in a fictitious market setting, in which respondents are classified according to the quantity or quality of the changed environmental good or service and asked how much they are willing to pay (WILLINGNESS TO PAY) or accept the improvement or loss of environmental quality. This method may be used to evaluate consumer preferences for public environmental products and services, as well as their economic worth.

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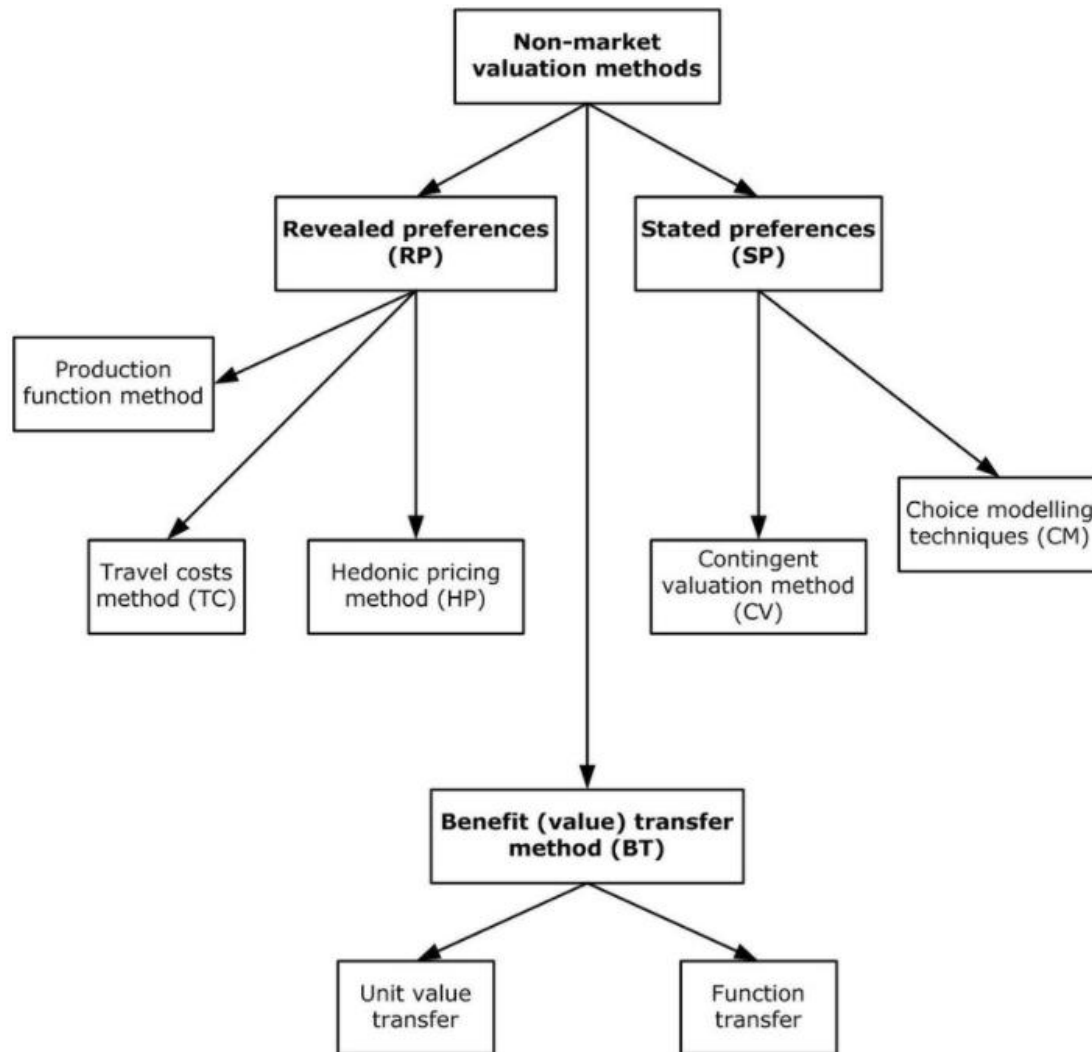


Figure 3-6. Non-market valuation approaches are classified (Saraev 2017)

3.2.2 Development of the Conditional Value Method

Ciriacy-Wantrup (1947) was the first to propose the conditional value approach as a mechanism for market valuation of non-market commodities. Davis conducted surveys to evaluate the worth of value hunters and visitors in specific wilderness regions in 1963, which was the first practical implementation of the concept. He compared the findings of his survey to value estimations based on travel expenses and discovered a strong association between the two.

Conditional Value Method has had its first phase of expansion in the decade from Davis's initial practice, with widespread application in attempts to evaluate the merits of non-market commodities or infrastructures. The acceptance and acknowledgement in economics that environmental assets' Option Worth and Existence Value are essential components of their total

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economic value is an important context for this development. Non-use Value encompasses both Option Value and Existence Value, with Conditional Value Method being the most generally used and authoritative Non-use Value technique.

The quick rise in the number of studies, as well as the extension of the study population and study area, as well as the experimentation with research methodologies, represented this decade's rapid progress. Ronald Ridker evaluated the advantages of improving air quality in Philadelphia and Syracuse in 1965, while Hammack and Brown performed a postal survey of hunters in the western United States in 1969 to determine their Willingness to pay for bird hunting. Haneman performed a public willingness-to-pay survey for improved water quality in Boston Bay in 1973 [46].

In 1979 and 1986, the US Water Resources Council (WRC) and the Department of the Interior (DOI) recognized the Conditional Value Method as one of two recommended approaches for assessing the economic worth of natural resources, and its development was encouraged [28]. It's becoming a popular way to assess natural resources, environmental values, and heritage [27] assets. When government agencies in the United States were given the authority to sue for damages to natural resources within their trustees' jurisdiction in 1980, this strategy was given top attention.

The conditional value assessment method was linked with stochastic utility maximization theory by Haneman of the University of California in 1984, laying the economic theoretical framework for the conditional value assessment method theory [47]. The conditional value assessment approach was suggested by the American academic community in 1989 as the primary method for determining the value of ecological resources, environmental and service heritage value, existence value, and other values [48].

Following *Ohio v. Department of the Interior*, the types of damages they were able to recover included non-use or existence value. Existence value cannot be assessed through market pricing mechanisms, so it was recommended that it be assessed through a contingent valuation survey. During this time, EPA held a major conference aimed at recommending guidelines for survey design.

Exxon Oil Company caused the largest crude oil spill in US history in Prince William Sound, Alaska, in 1989, and the Alaska government commissioned a research team of econometricians, environmental economists, psychologists, and social research experts to use the conditional value approach to assess the value of natural landscape and wildlife loss caused by the incident. However, the study's findings were criticized by a number of organizations and people, including Essenco, who said that several of the conditional value tests they had undertaken were inadequate. As a result, the National Oceanic and Atmospheric Administration (NOAA) stepped in in 1993 to organize a "Blue Ribbon Panel" led by two Nobel laureates in economics to study whether non-use values should be included in natural environmental damage assessment and whether the conditional value approach could be used for this purpose. The Panel eventually concluded that natural resource damage assessment should include non-use values and affirmed the conditional value approach as a method to evaluate the reliability and validity of natural resource goods, and published a report on the use of the conditional value approach in relevant journals and magazines,

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after which the conditional value assessment method officially became the mainstream method for evaluating non-use values in Western countries [29].

Following decades of growth since the publishing of the NOAA report, the Conditional Value Method evaluation technique has expanded significantly worldwide, and it is now extensively used and developed in the United States, the United Kingdom, Europe, Canada, Japan, and other nations, including many developing countries. In terms of geographical breadth of study expansion, as of 2005, Conditional Value Method research had covered 29 of the 30 Portfolio for Economic Cooperation and Development member nations, as well as more than 80 other developing countries.

3.3 Deficiencies and Improvements of the Conditional Value Method

Many economists, however, doubt the use of expressed preferences to determine readiness to buy things, preferring to depend on preferences displayed in restricted market interactions. Earlier contingent value studies frequently asked open-ended questions like, "How much would you want for compensation for the destruction of a given area?" or "How much would you pay to safeguard a certain area?" Strategic behavior, protest answers, response bias, and respondents bypassing financial limitations are all examples of faults in such polls. Early surveys used for environmental evaluation appear to show that individuals exhibit a general preference for environmental expenditure in their replies, which detractors of the system describe as an embedded effect [30].

In response to criticism of the Conditional Value Method, the National Oceanic and Atmospheric Administration formed a group of distinguished economists (headed by Nobel laureates Kenneth Arrow and Robert Solow) in 1993. (NOAA). The panel listened to 22 professional economists and issued its findings in 1995. Because of the inherent difficulty in determining correct economic values using survey methodologies, the NOAA panel recommended that contingent valuation studies be carefully developed and managed [31].

The NOAA panel's most important recommendations are as follows: 1 Personal interviews, rather than telephone or mall stop approaches, are employed to conduct the poll. 2 The survey is intended to be presented to respondents as a yes or no referendum on a specific tax to protect a specific resource. 3 Respondents are given thorough information on the resource and the conservation measures on which they will vote. Threats to the resource (best- and worst-case scenarios), a scientific assessment of its ecological value, and the expected results of the conservation action should all be included in this material. 4 Explain the income implications carefully to ensure that respondents understand their indicated readiness to pay to safeguard the specific resource in issue rather than the environment in general. 5 In order to guarantee that responders comprehend the points highlighted, ask clarifying questions. The fundamental premise behind these guidelines is that until the data are judged relevant, the survey operator has a high burden of evidence. Surveys that match these requirements are costly to do, thus the panel suggests creating a reference set of surveys against which future surveys may be compared and calibrated [32]. The NOAA panel also determined that there was a propensity for cautious value assessments in general, and as a result, they advised a contingent valuation survey to test Willingness to pay for the preservation of products rather than readiness to take compensation for losses, resources [17].

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Complete information is required when gathering information utilizing the conditional value strategy. Only if the information is complete will respondents' Willingness to pay represent their preferences [33]. Many researchers think that the manner in which information is gathered is critical in the study of Conditional Value Method [34]. The quality of the respondent's information has a considerable effect on the quality of Conditional Value Method.

Respondents' access to information in the Conditional Value Method study included primarily the respondents' needs and budget constraints, as well as the characteristics of the relevant environmental product or service, information on environmental resources and alternatives or complements to the relevant service, and the Willingness to pay value of other products. The kind or qualities of the environmental product or service, their personal circumstances (money, time, etc.), and the influence of friends and family all impact respondents' Willingness to pay values [35].

3.4 Scope impact of Conditional Value Method

The scope problem in the conditional value approach is referred to as the scope effect [79], the order effect [80], the embedding effect [81], and the decomposition bias [82], which refers to the fact that the Willingness to pay for the same public good valued as part of a more inclusive public good is lower than its Willingness to pay when valued alone, or the Willingness to pay for the same public good receiving wide variation across surveys, or the Willingness to pay for the same public good, or the degree of change in Willingness to pay does not correspond to the degree of change in the range of public goods to be valued [84], or Willingness to pay for public goods to be valued depends on the order of valuation questions [85], or Willingness to pay for changes in public goods to be valued as a whole is lower than Willingness to pay for individual changes valued independently and then summed, or respondents' Willingness to pay for public goods to be valued in general symbolic meaning rather than specific levels of supply is lower than their Willingness to pay for public goods to be valued. rather than the Willingness to pay for specific levels of supply [86].

3.5 Influencing factors

Due to the limits of the information gathering techniques, it is impossible to secure a comprehensive information status throughout the actual information collection process. Some studies lack crucial expert knowledge regarding environmental products or services in general, respondents' own demands and financial limits, or even alternatives or complementary products and Willingness to pay of other items [17]. We discovered in the relevant literature that the Conditional Value Method approach is inescapable owing to information gathering methods that result in biased information collection, which indirectly leads to lower public Willingness to pay when it comes to Willingness to pay valuation [36]. As a result, how to explain the qualities of environmental goods or services clearly, correctly, and fully, as well as their contextual information, to assure accurate feedback from respondents in a hypothetical market, has emerged as a major challenge for academics. The current answer is to provide as much information about the research to the respondents as feasible when administering the questionnaire. Furthermore, it is critical to reduce respondent weariness induced by extensive interviews, hence lowering poor Willingness to pay of respondents owing to questionnaire bias [37].

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Bergstrom et al. [38] shown in recent research that combining relative spending and presenting cost information, as well as the cumulative effect of the three pieces of information kinds, considerably raised bids. Blomquist and Whitehead [39] contended that giving information on the true cost of the goods in question might lower the number of zero-response, protest response answers. According to Akcura.[40], the questionnaire should be prepared in such a manner that the perceived difficulty of knowledge about the goods in question is reduced (more intelligible and acceptable), preventing the questionnaire information from being ignored because it is too cognitively demanding.

Embedding bias is sometimes referred to as part-whole bias and range effect. Do participants make the same decision for state S0 as they do for state S1 if T0 and T1 are two separate state sequences and state T1 is in both T0 and T1? If not, the experiment's results are suspected of having a "embedding bias" [41]. Similarly, owing to embedding bias, the Willingness to pay off the same environmental category will have a range of Willingness to pay values in the Willingness to pay computation. This means that the Willingness to pay value of the same environmental class varies widely depending on its breadth. Environmentally based goods (low carbon measures) are not assessed as a single product since they encompass a wide variety of benefits owing to overall environmental improvement [42].

Embedding bias has also been widely explored by relevant scholars, such as the Research Triangle Institute, who conducted conditional value method research on bird rescue. The study's findings revealed that the value of Willingness to pay remained constant while rescuing birds with varying sample sizes. As a result, the researchers engaged questioned the estimation results. This sparked a debate about embedding prejudice.

Carson contended that embedding bias existed exclusively in the appraisal of a product's intrinsic worth [43]. Other scholars have claimed that when measuring the non-use value of public environmental goods, findings are influenced by embedding bias in addition to intrinsic value [17]. Smith did a meta-analysis of five Conditional Value Method investigations of US national parks. These five studies involved on-site and remote surveys as well as assessments of use and non-use values. Embedded bias was determined to be statistically valid and economically justifiable in the meta-analysis.

Meta-analysis and certain research have acknowledged the possibility of embedding bias. If substitution and marginal utility decrease are utilized, the occurrence of embedding bias can be explained in part. Embedding bias can also arise if the respondents do not have the necessary resources or if the statistical instruments are not appropriately chosen [17]. Furthermore, embedding bias is frequently caused by poor questionnaire design and respondents' misinterpretation of the questionnaire's content. As a result, the design of surveys is critical. Even when embedding bias and range effects are included, the conditional value approach remains a suitable method for determining the non-use value of public environmental goods.

An accurate classification of the evaluated environmental products, a detailed description of the services and positive externalities generated by the environmental products, as well as a detailed description of the text combined with a graphical representation and an appropriate reference to alternative products, will significantly reduce the occurrence of embedding bias [44].

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The conditional value technique was prone to biases in respondents' cognitive skills and scales in the most current investigation. The data imply that the level of cognitive capacity of the respondents has an influence on the range effect. The range effect is negatively related to cognitive ability. Nunes [45] contended that adjusting for perceptual and experiential characteristics in the sample that influence respondents' attitudes and consciousness reduces the effectiveness of the range effect.

The ranking of resource types may also have an impact on the accuracy of Willingness to pay appraisal, which is referred to as the ranking effect. The appraisal of willingness-to-pay in the assessment questionnaire for public environmental-type resources or services will alter if the environmental resources being assessed varies in significance as well as kind. This effect is comparable to the embedded effect, which happens frequently in the assessment of public environmental resources.

Researchers have done further experiments to investigate the influence of the sequencing effect. Respondents' knowledge of a publicly available environmental product category can impact valuation findings, reducing the sequencing effect. That is, attitudes and understanding about a public environmental category product might have an influence on the findings.

Carson proposes that the sequencing effect may be impacted by options rather than income level. Another major source of sequencing bias is ineffective questionnaire design or technique. Allowing bid editing after the questionnaire or providing questionnaire information prior to delivery would lessen the probability of sequencing effects [43]. Appropriate responses to questionnaire questions, such as those asking about the effects of ranking effects in environmental products, or appropriate processing of Willingness to pay data, such as using technical means to exclude some questionnaires that do not match the actual situation, can effectively reduce the negative effects of ranking effects.

3.6 Willingness-to-pay elicitation methods

With the quick expansion of the economy, Conditional Value Method has also swiftly developed, and Conditional Value Method induction techniques have been continually created. From the early repeating bid type to the current single-boundary, double-boundary, and multi-boundary forms, the Conditional Value Method questionnaire form has evolved from open-ended to closed type, and from payment card type to the present single-boundary, double-boundary, and multi-boundary forms.

The duplicate bid method was first used in 1963, when a bid range was established. Respondents had to put bids within this range. The minimum and maximum values in the range correspond to the highest and lowest bid values, respectively. By repeatedly querying the respondent about the value of the acceptable amount. In turn, the respondent's Willingness to pay is calculated. The inquiry was halted until the reply replied in the negative. The outcome is the highest willingness to pay. However, there are certain drawbacks to this form of poll. The first is the cost of time; multiple questioning of respondents costs a lot of time, which raises the cost of the questionnaire. Second, this multiple-questioning strategy may cause respondents to get confused, which may impact the results. Finally, when endpoints are determined, the lack of a suitable theoretical

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underpinning can readily lead to valuation outcomes that are influenced by endpoint taking [49].

Canson presents a method to manage the selection of bid values using credit card-based bidding in response to the concerns raised above. Non-anchored payment cards and anchored payment cards are the two major techniques. The non-anchored payment card presents respondents with a series of bid values from which they must select their readiness to pay. Anchored payment cards give respondents with some background information in addition to bid values, and they also ask respondents about their readiness to pay for other public initiatives at the same time, giving them with binding background data. When the bid value is specified, however, there is a mean value due to the payment card type. This causes respondents to choose the mean value consistently and does not fundamentally address the valuation impact caused by range selection.

The open-ended inquiry approach allows for more unrestricted bidding. To begin with, the open-ended question does not specify a price range; instead, respondents directly react to the maximum or lowest Willingness to pay for public environmental products, which is used to investigate respondents' attitudes and intentions about environmental products. This approach is the most direct type of questionnaire, and it is simple to compute and evaluate. However, because there are no boundaries to the scope, there is frequently a very significant disparity in willingness to pay, and respondents' desire to pay may be impacted by their expertise of the issue. Willingness to pay may be strong when respondents are extremely familiar with the research subject, however when respondents are unfamiliar with the research issue, it typically leads to zero and protest replies, compromising the accuracy of the result estimation [50]. With the advancement of Conditional Value Method methodologies, open-ended questions are increasingly commonly utilized for pre-research.

Closed-form formats, also known as dichotomous choice problem formats, are classified into single-bounded and multi-bounded dichotomous choice formats [34]. In 1976, Heberlein brought Conditional Value Method to the closed-form issue structure and presented dichotomous conditional value assessment [51]. Bishop originally assessed the economic worth of animal hunting permits using the single-boundary dichotomous choice approach. Respondents in the single-boundary dichotomous choice technique do not have to pick the price of the bid value themselves, but just decide whether to accept the interviewer's offer. In the questionnaire, respondents answer "yes" or "no" to the bid value, a format that does not directly measure respondents' willingness to pay. Since the 1990s, dichotomous choice has grown in popularity in Conditional Value Method. A number of question forms for dichotomous choice have been devised, including single-boundary dichotomous choice, double-boundary dichotomous choice, and three-boundary dichotomous choice, among others.

This approach solves the problem of an open-ended lack of bid reference points, and it is more like buying behavior in the actual market, where consumers decide to "buy" or "not buy," and not only that, but the bid values proposed by interviewers are frequently the same as those set by pre-survey results. The pre-survey findings are frequently used to establish the bid prices given by interviewers. As a result, it is more realistic. Hanemann and Cameron [52] have since expanded on the DCCV hypothesis, making it more frequently utilized [53].

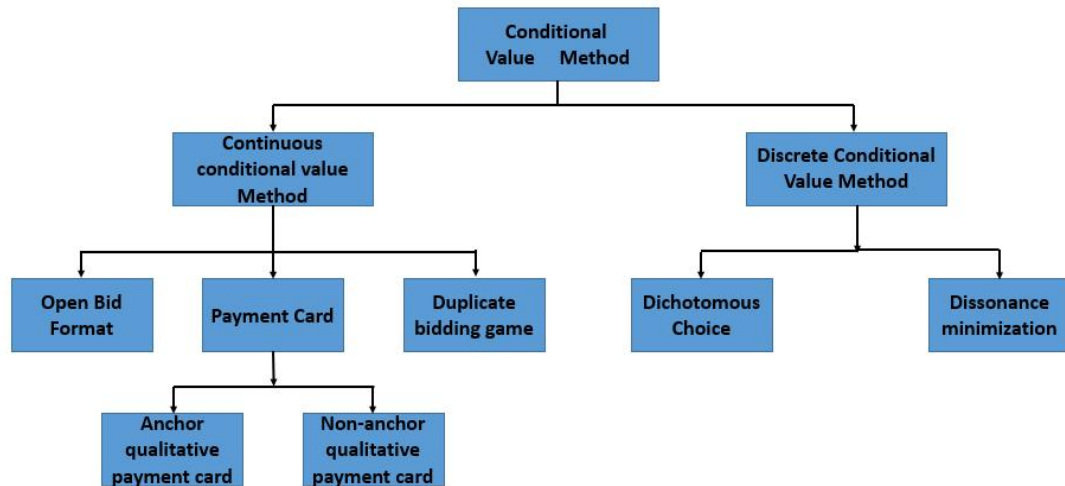


Figure 3-7 Willingness to pay guide technology in Condition Value

The dichotomous choice format is a more realistic way of asking questions since it models consumer market pricing behavior, in which respondents determine whether they wish to pay the price of a particular commodity. Because respondents can only say "yes" or "no" to a bid value without being compelled to offer a precise price, the dichotomous choice inquiry incentivizes individuals to tell the truth. The dichotomous choice question structure can address the issue of respondents' excessive misrepresentation of willingness to pay, but there are still challenges in choosing the number of bid values and their range, as well as estimating willingness to pay.

Some researchers, however, have questioned the validity of Hanemann's single-boundary dichotomous method, which he claimed may exaggerate respondents' WILLINGNESS TO PAY. Hanemann et al. verified the double-boundary dichotomous strategy, demonstrating that it can capture more information regarding respondents' Willingness to pay while also being more efficient and scientific than the prior single-boundary dichotomous approach. Currently, the most extensively used and popular approach in Conditional Value Method theoretical study is the two-boundary dichotomous conditional value assessment method.

The number of inquiries, which overcomes the difficulties and potential biases of single-boundary dichotomous selection format, is the most significant difference between single-boundary dichotomous and double-boundary dichotomous formats. If the respondent says "yes" to the proposed bid the first time, he/she will receive a greater bid the second time [37]. If the respondent answers "no" the first time, he/she will receive a lower bid [37]. It can lessen the likelihood of beginning point and approach bias. Furthermore, Willingness to pay findings obtained with the two-bounded dichotomous choice format are more accurate than Willingness to pay results obtained with the single-bounded dichotomous choice format. The technique necessitates the use of complicated statistical models in order to analyze data and only provide lower bounds for WTA or Willingness to pay values, which cannot eliminate strategy bias [17].

3.7 Bias in the Conditional Value Method itself

3.7.1 Bias in assumptions

Conditional value method is a method for determining the economic value of a public environmental product, such as natural environmental assets, in the absence of a trading market, by constructing a hypothetical market condition and directly asking people about their Willingness to pay for a public good and using that as its economic value. The conditional value technique gets its name from the fact that the resulting Willingness to pay or readiness to compensate value is dependent on the hypothetical market circumstances provided to the respondents. However, there are certain issues in hypothetical markets, where respondents complete their trading behavior in hypothetical market settings, but this is not always the same as their choice in actual market conditions, and this impact is difficult to demonstrate using actual market behavior. This is referred to as a possible prejudice.

Although some researchers have found that respondents' anticipated willingness to pay are lower than their actual willingness to pay, most studies reveal greater willingness to pay in hypothetical settings [56]. Researchers generally agree that when responses are uninformed with the assessment subjects, the danger of hypothesis bias increases. The primary source of hypothesis bias, according to social role theory, is respondents' social role conflict and identity uncertainty. According to social role theory, everyone is a collection of numerous roles that must be switched at any moment, which necessitates the cooperation of environment, context, and other roles. The hypothetical character of conditional value method makes such collaboration impossible to achieve, resulting in respondents' social role conflict and identity uncertainty.

As a result, it is critical to expand respondents' understanding about the respondents. By repeating the test technique, it may be useful to acquaint respondents with the conditional value approach study topic and the objects to be scored, hence decreasing hypothesis bias [57]. Some studies have also proposed that including a connection to the genuine compensation in questionnaire design might help reduce hypothesis bias [14]. Marina's study on nature reserves found discrepancies in the demographic features of users of nature conservation and those of non-nature reserves, but this did not change the fact that they were both eager to conserve nature reserves. In terms of life trajectories, those who regularly visit protected areas are more willing to pay to support protected area conservation, but there are also respondents who have not traveled to protected areas but plan to do so in the future and have an equally high willingness to pay, even if they have never participated in tourism activities. In other words, individuals who have used or will use protected areas are more likely to contemplate paying and are more conversant with protected area information than non-users. Even though users or the desired user group had a higher readiness to spend. The researcher hypothesizes that this is because this environmental resource has a direct influence on people, not because of how aware they are about this environmental product or not, but simply because they utilize it. As a result, Marina believes there is no need to limit the conditional value approach to individuals who are informed about environmental items. Users who are unaware of environmental products, as well as non-users who are aware of environmental products, have the same drive to value these resources. As a result, it is not fair to call the non-use values into doubt [58].

According to Jofi-analysis Sweet's of a survey of relevant data, he feels that hypothetical conduct

is typically a reasonable predictor of actual behavior of environmental consumers. Some academics have also advised that questionnaires be distributed using an indirect survey approach. That is, respondents would feel that their replies in an indirect survey will impact what they care about, indicating values that are closer to the reported Willingness to pay values.

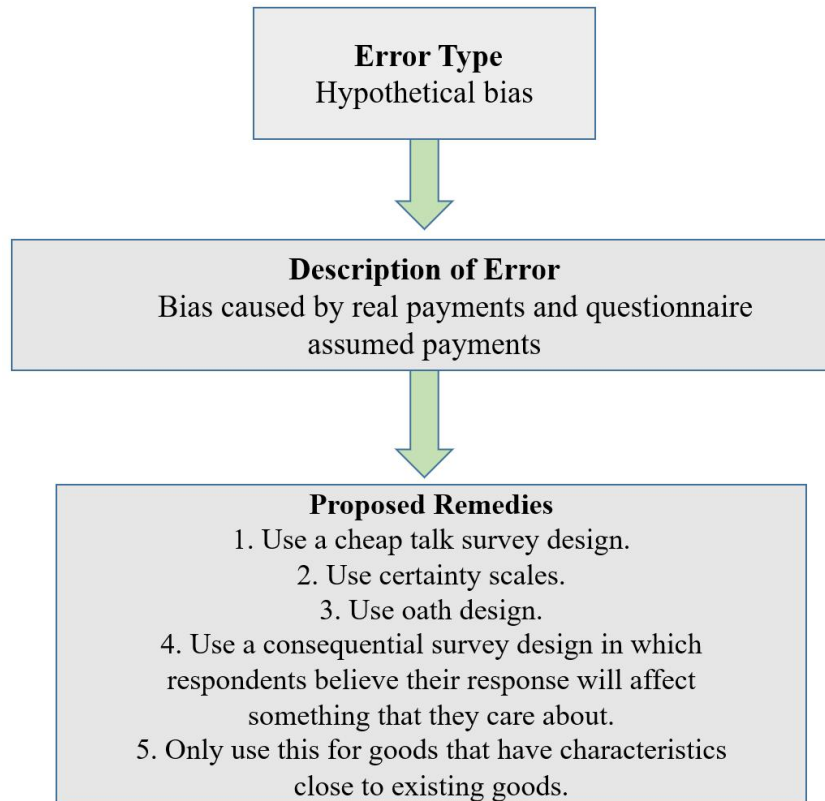


Figure 3-8 Assumption bias and its resolution

3.7.2 Information bias

The fundamental premise of neoclassical economics is complete information. Only when all information is available can respondents' Willingness to pay accurately represent their choices. Respondents must have the following information: information about the quality, type, and value of the assessed object; information about their own requirements and budget restrictions; knowledge about comparable products (substitutes, complements); and information about other people's Willingness to pay values.

Due to the length of the questionnaire, this study's questionnaire did not give much information to the respondents. To analyze the respondents' fundamental circumstances, The questionnaire urges respondents to "complete the questionnaire taking into account their real income" for their personal demands and financial limits, but it does not address related goods or other people's Willingness to pay. The Willingness to pay was not mentioned.

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Bias in survey information influences valuation outcomes in the applicable Conditional Value Method questionnaire. Research by Jie Zhang et al., for example, found that karst geological landscapes are particularly valuable natural heritage in the Yunnan-Guizhou area of China, even though both survey findings had the largest proportion of animal and plant value [59]. This demonstrates that respondents lack sufficient understanding about the rated items, resulting in a lower Willingness to pay for natural resources than for flora and fauna protection in the Yunnan-Guizhou area, implying that the public does not realize the value of natural regrets. As a result, while developing the hypothetical market, it is critical to communicate the features of the assessment objects as well as their background information to guarantee that the respondents have a comprehensive knowledge of the essential concerns. However, the more information in the questionnaire, the worse it is; in addition to the constraints of the questionnaire capacity, too much information may lead to boredom among the respondents. In the design of Conditional Value Method surveys, the appropriateness of the information presented in the questionnaire is still a topic worth investigating.

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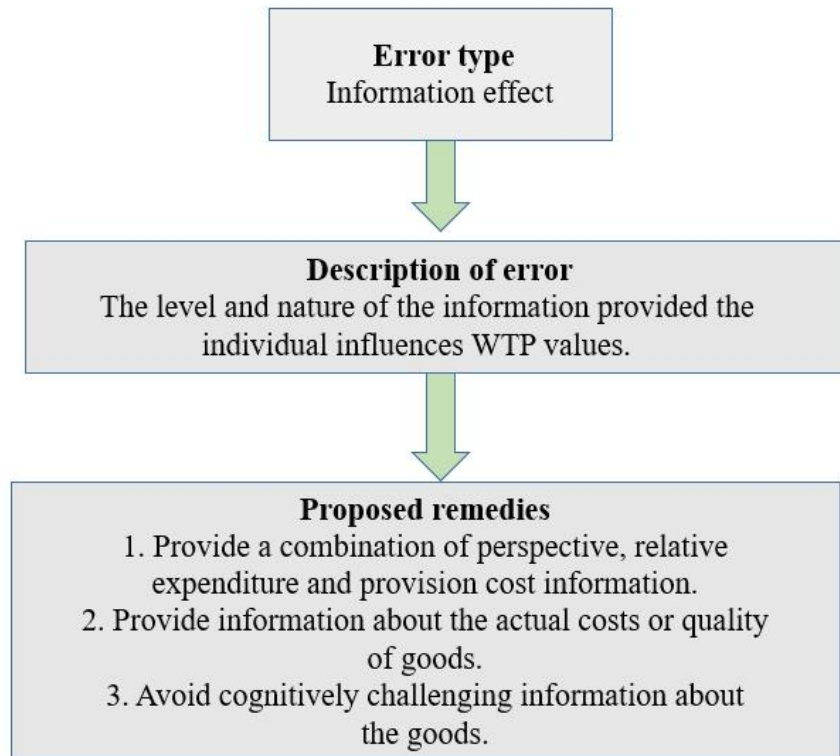


Figure 3-9 Information bias and its resolution

3.7.3 Protectability bias

The prejudice produced by respondents' proclivity to reject hypothetical markets and payment mechanisms is known as protest bias. The reasons for protest bias in low-carbon city-related studies include who pollutes and who governs, the fact that it is the government's responsibility to combat carbon emissions and has nothing to do with individuals, the perceived hypothetical market, and the lack of veracity of the questionnaire.

The protest payment rate is a test indicative of the validity of the questionnaire content since it indicates to the level of knowledge of the questionnaire among respondents. According to empirical research conducted in industrialized nations, a protest payment rate of 15% or less is considered typical. However, in developing nations, the lack of transparency in the flow of finances from government and other relevant organizations, the presence of corruption, and the public's suspicion of authority have all resulted in widespread protests. Although this study took various steps to avoid this bias (e.g., explaining to respondents in person, urging visitors to fill out surveys on the spot, etc.), the large proportion of protest bias remains a primary factor for the low Conditional Value Method evaluation results.

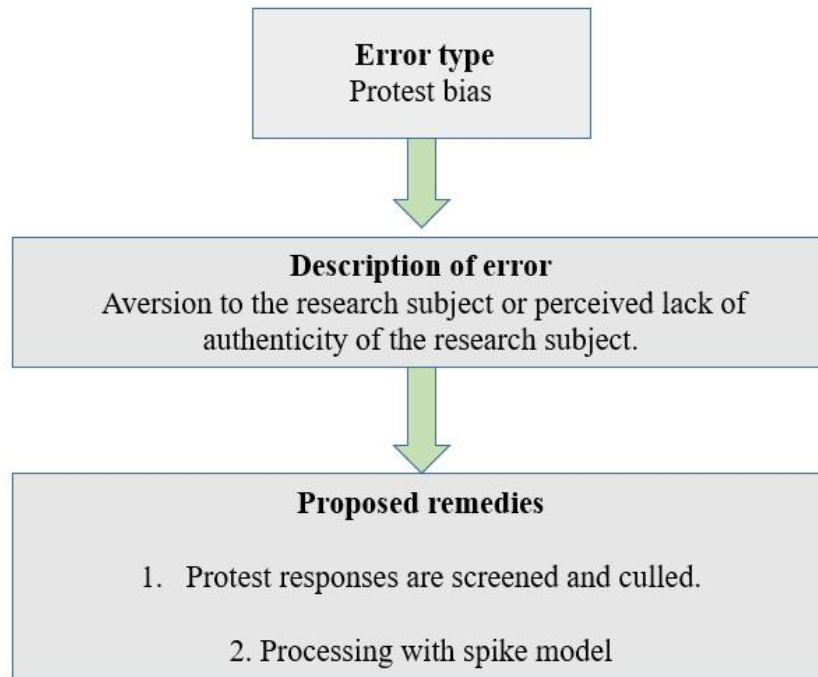


Figure 3-10 Protest bias and its resolution

3.7.4 Strategic bias

Strategic bias occurs when respondents actively inflate or lower their Willingness to pay values in their replies in comparison to their genuine willingness to pay. This suggests that the Willingness to pay value is skewed because of the respondent's strategic activity. Free-riding, cautious bias, over-promising, and flattery bias are all common causes. The first two may result in negative bias, whereas the later two may result in positive bias. It is extremely difficult to avoid strategic bias in Conditional Value Method design and survey implementation: to gain respondents' trust and avoid excessive protest responses, the hypothetical and virtual nature of the survey must be explained to respondents, which may lead to overcommitment (exaggerating one's Willingness to pay because one does not actually have to pay); and to overcome overcommitment bias, the questionnaire must emphasize the survey's validity. To overcome the overpromise bias, the questionnaire should emphasize the survey's authenticity and remind respondents to answer carefully based on their financial strength and spending power, which may make respondents wary of being duped or soliciting donations and begging.

Strategic bias occurs when respondents intentionally inflate or reduce their Willingness to pay values in their responses in comparison to their true willingness to pay. This means that the Willingness to pay value is skewed because of the respondent's strategic behavior. Free-riding, caution bias, over-promising, and flattery bias are all common causes. The first two may result in negative bias, while the latter two may result in positive bias. It is extremely difficult to avoid strategic bias in Conditional Value Method design and survey implementation: to gain respondents' trust and avoid excessive protest responses, the hypothetical and virtual nature of the survey must be explained to respondents, which may result in overcommitment (exaggerating

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one's Willingness to pay because one does not have to pay); and to overcome overcommitment bias, the questionnaire should emphasize the survey's importance. To overcome the overpromise bias, the questionnaire should emphasize the survey's authenticity and remind respondents to answer carefully based on their financial strength and spending power, which may make respondents wary of being duped or soliciting donations and begging.

It typically manifests as the respondent's belief that another respondent will pay more for the public good and thus, they do not need to pay, resulting in an underestimation of WILLINGNESS TO PAY. This is referred to as free-riding behavior. The survey's hypothetical and virtual nature must be explained to respondents if they believe that a lower Willingness to pay will influence future pricing policies and product supplements, or to gain their trust and avoid excessive protest responses that may lead to overcommitment.

Canon believes that the following factors contribute to the conditional value approach's strategic bias: To begin with, the amount of information is limited by the use of face-to-face interviews in a large number of conditional value surveys, which may lead respondents to believe that their Willingness to pay is only for scientific research and not for actual payments; despite the existence of budget constraints in the selection of payment methods and payment amount reminders, which can reduce the possibility of overextension; A relatively low willingness to pay, on the other hand, may result in a lack of support for the evaluated public environmental products or services, limiting the possibility of respondents providing an unrealistic willingness to pay. As a result, except for a few findings, most researchers believe that strategy bias has no effect on the validity and reliability of willingness-to-pay results [43].

There are various biases in the questionnaire that are not specific to the Conditional Value Method; that is, these biases caused by the questionnaire do not affect the use of the Conditional Value Method and have no impact on its validity. Researchers have proposed some improvements to the conditional value approach, the most influential of which is the NOAA's 15 guidelines on the valuation of resource and environmental non-use values, to improve the accuracy of the valuation and further reduce the bias in the questionnaire. These principles are applicable to urban environmental services such as UHI mitigation [31].

Related researchers have proposed methods to focus on reducing bias in their studies on the subject. The first step is to create a bias-reducing incentive induction mechanism. Second, the possibility of reducing bias is achieved by increasing the sample size, which reduces the impact of individual bias on the overall result. According to Prince, the method of inducing Willingness to pay influences the accuracy of the results [60], so the payment method should be well known to the public and preferably mandatory, such as living contribution, taxes, and so on. He believes that by doing so, he can effectively reduce free-rider behavior and bias. He contended that this would be effective in reducing free-rider behavior and bias. Larkin contended that providing detailed descriptions of the study subjects, as well as hypothetical background information about the risks and benefits they entail, could help to reduce bias. Furthermore, asking behavioral and empirical questions corresponding to different scenarios prior to asking core questions about Willingness to pay allows the investigator to capture the bias situation in different variable situations and helps to build a better model of willingness to pay. Furthermore, face-to-face interviews allow interviewers

to communicate directly with respondents, allowing interviewers to detect dishonest responses in a timely manner, making dishonest behavior more difficult and aiding in the reduction of bias in the questionnaire.

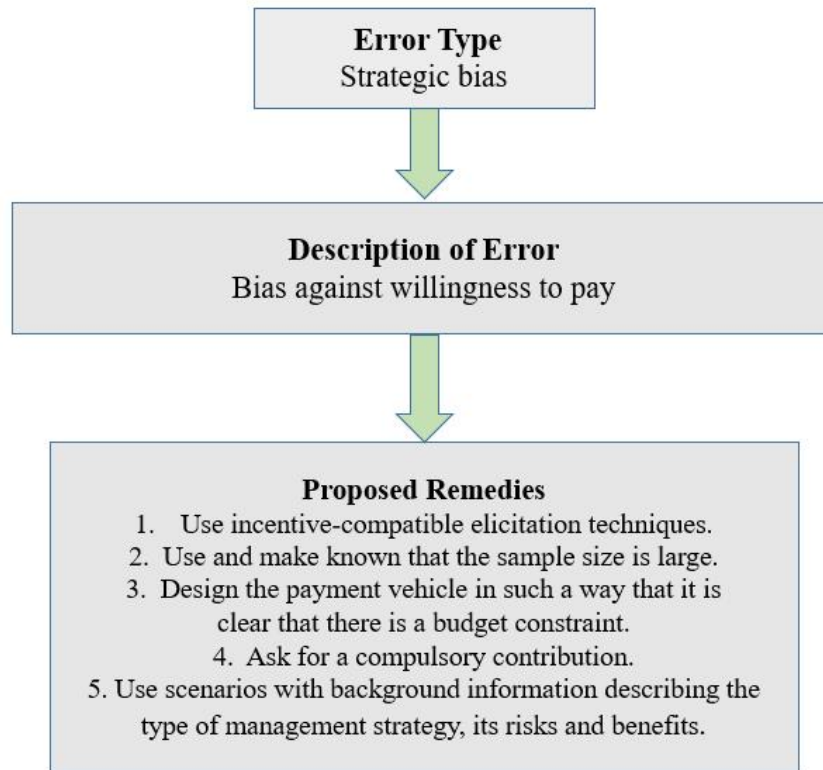


Figure 3-11 Strategic bias and its resolution

3.8 The Theory of Planned Behavior

3.8.1 Theory of Planned Behavior's connotation

What factors influence people's behavior, and how can that behavior be accurately explained and predicted? One of the most important aspects of social psychology is this. In social psychology, attitude is a key concept. It has always been a central concept in social psychology, and it is regarded as a key determinant of individual behavior. However, Lapierre (1934) observed in his study that attitudes do not always correspond with actual behavior of individuals. Other factors that influence an individual's behavior are possible. Wiecker (1969) also argued that attitudes cannot explain individual behavior on their own.

The Theory of Planned Behavior is a well-known social psychology theory that connects behavior and attitudes. The theory is based on expectancy theory and explains general individual decision-making from the standpoint of information processing. There are five components to it: behavioral attitudes, subjective norms, perceived behavioral control, behavioral intentions, and behavior. It provides a foundation for explaining human behavior. Human behavior, according to the Theory of Planned Behavior, is planned and the result of deliberate deliberation. In this context, behavior refers to the specific actions that individuals take, and such behavior is dependent on the actor's

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behavioral intentions. Behavioral intention is an individual's subjective decision about whether to perform a specific action, as well as the individual's willingness to perform a specific behavior. According to preliminary research findings, behavioral intentions are usually more accurate predictors of the specific behavior to be performed. It is the most direct and significant influencer of behavior. The individual's will does not completely control a person's behavior. It is also influenced by behavioral intentions as well as other practical control conditions such as the individual's abilities, perceived resources, and opportunities. A meta-analysis found that behavioral intention explains 22% of the corresponding behavioral variance [62]. In turn, behavioral intention is influenced by three antecedent variables: attitude toward the behavior, subjective norms, and perceived behavioral control.

The degree to which an individual holds a positive or negative evaluation of a specific behavior is referred to as attitude. It can also be viewed as a conceptualized attitude formed by an individual's evaluation of that specific behavior. Accurate perceived behavioral control can reflect actual control conditions and can thus be used as a proxy for actual control conditions to predict the likelihood of specific behaviors. The degree of perceived behavioral control influences prediction accuracy.

Subjective norms are the social pressures that people feel when deciding whether to engage in a particular behavior. When an individual makes a behavioral decision, individuals or groups who have a significant influence on him or her have a significant influence on whether he or she will adopt the behavior. When people have a positive perception of the resources, information, and opportunities available to them, or when they anticipate fewer future difficulties, they have relatively strong perceived behavioral control. Positive attitudes and subjective norms, as well as greater perceived behavioral control, lead to individuals having stronger intentions to perform and being more likely to exhibit the behavior. Depending on the specific behavior and situation, the relative importance of these three factors in predicting and explaining behavioral intentions and behaviors may vary. It is possible that attitudes alone have significant explanatory power in some cases; that attitudes and perceived behavioral control have significant explanatory power in other cases; and that all three factors have significant explanatory power in other cases. From the standpoint of beliefs, the Theory of Planned Behavior explains the formation of attitudes, subjective norms, and perceptual behavioral control [63]. Behavioral beliefs are thought to influence attitudes, normative beliefs determine subjective norms, and control beliefs serve as the foundation for perceptual behavioral control. An individual can have many beliefs about a behavior at the same time, but only a small number of behavioral beliefs are successfully acquired and reflected in the individual's attitudes and behaviors in each situation. These acquired beliefs, also known as emergent beliefs, serve as the cognitive and emotional underpinnings of attitudes, subjective norms, and perceptual behavioral control. In many fields, the Theory of Planned Behavior has been widely used as a behavioral prediction model. The Theory of Planned Behavior provides a fundamental theoretical framework for explaining people's behavior during organizational change. It is depicted in the figure below.

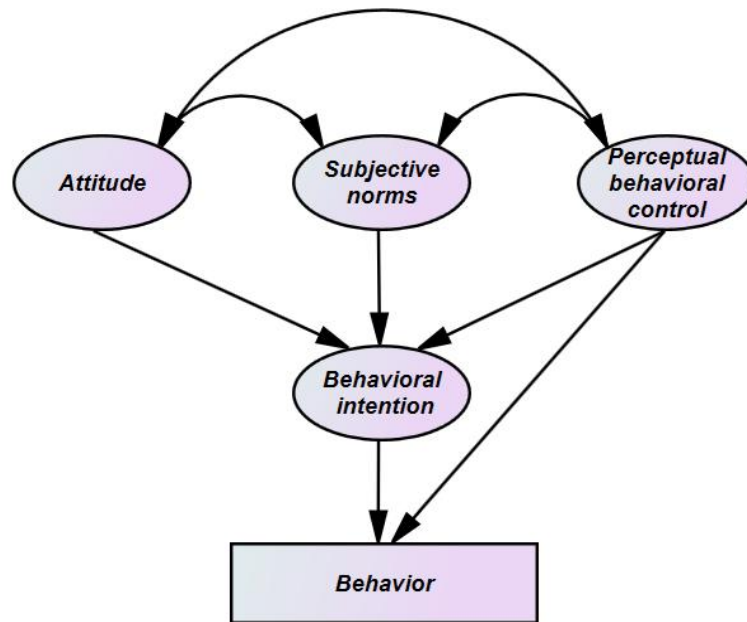


Figure 3-12 Traditional theoretical model of planned behavior

Although attitudes toward behavior, subjective norms, and perceived behavioral control can all be conceptually distinguished, Ajzen observed that these three variables have something in common: beliefs at times and are thus both distinct and related [67].

1. Subjective norms and behavioral attitudes are positively related. Individuals with favorable attitudes toward a behavioral choice are more likely to be subjected to increased social pressure, which leads to an increase in pro-environmental behavior, which leads to a more favorable attitude toward that behavioral choice.
2. Subjective norms are positively related to perceived behavioral control; the stronger the subjective norm, the more likely they are to have more resources available for a specific behavior; conversely, the stronger a person's perceived behavioral control, the more willing he or she is to engage in a specific behavior.
3. Perceived behavioral control is positively correlated with attitudes toward behavioral choices. The more positive a person's attitude toward behavioral choice, the more willing he or she is to prepare more relevant resources and overcome more obstacles. As a result, the stronger the perceived behavioral control, the more favorable the attitude toward the specific behavior.

3.8.2 The development of Theory of Planned Behavior

The Theory of Planned Behavior has progressed through three major stages. Theory of Planned Behavior evolved from Fishburn's [64] multi-attribute attitude theory proposed in 1963. The core concept of the multi-attribute attitude theory is that the intention to perform a behavior is determined by the attitude to perform the behavior, which is influenced by the outcome expectation. Ajzen [65] proposed the rational behavior theory, which is based on the multi-attribute attitude theory, in 1975. Rational behavior theory holds that behavioral intention has a direct influence on act execution and that attitudes and subjective norms determine behavioral intention. The rational behavior theory is based on the premise that individual behavior is controlled by volition (behavioral intention), whereas in practice human behavior is frequently

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controlled by more than behavioral intention; there are many other factors that can influence behavior, such as perceptions of various external factors [34], and this research approach, which requires assumptions about the environment, limits the theory's development. Ajzen [63] refined rational behavior theory in 1991 by proposing the Theory of Planned Behavior. Three control variables are added to behavioral intentions by the Theory of Planned Behavior. There are three of them: attitude, supervisor norm, and perceived behavioral control. The Theory of Planned Behavior has been widely applied to date. It is used to investigate various behavioral influences.

Sutton discovered, using a meta-analysis of the literature, that the theories of planned behavior and reasoned behavior could explain, on average, 40% to 50% of the variance in behavioral intentions and 19% to 38% of the variance in explained behaviors [70]. Armitage and Conner discovered that behavioral attitudes, subjective norms, and perceptual behavioral control explained 39 percent of the variance in behavioral intentions, and that perceptual behavioral control and behavioral intentions explained 27 percent of the variance in actual behavior based on 185 published documents [71]. Behavioral intentions explain more actual behaviors than perceptual behavioral control.

3.9 Application of relevant theories in the literature

3.9.1 Application of Theory of Planned Behavior Theory

The explanatory power of the Theory of Planned Behavior is increasingly unable to meet the requirements of researchers as research depth increases, and many researchers have added some variables to the Theory of Planned Behavior to try to improve the explanatory power of the Theory of Planned Behavior, with good results. Tan [34], for example, conducted a study on public support for the construction of urban electric vehicle exchange stations to reduce urban carbon emissions in the study of low-carbon strategies and demonstrated that policy perceptions can increase the explanatory power of the Theory of Planned Behavior. Kim [66] contended that social and demographic factors can also have an impact on the Theory of Planned Behavior. Choi [67] demonstrated that social responsibility influences the Theory of Planned Behavior's explanatory power. Explanatory power of theory, as well as people's willingness to compensate for voluntary carbon emissions The absence of an ethical component in the Theory of Planned Behavior has been criticized. Thgersen [68] argued that an individual's environmental behavior must consider not only psychological but also moral factors. Individuals' behavior is influenced by moral perception at the level of behavioral norms. Moral perception is defined in the normative activation model as a moral obligation to behave in a specific environment. To study household waste recycling behavior, Pakpour added variables such as moral obligation, self-assessment, action plan, and previous recycling experience to the Theory of Planned Behavior model. A questionnaire survey of the same study participants one and two years later revealed that previous behavioral experiences had a significant effect on household waste recycling behavior, and the final extended Theory of Planned Behavior model explained 47 percent of the variance in household waste recycling behavior. Personal interest perception is a critical factor driving individual behavior, and it is the dominant variable influencing behavioral intention in both the extended diffusion of innovations theory and the extended Theory of Planned Behavior [69]. To some extent, all the variables listed above can improve the explanatory power of the Theory of

Planned Behavior.

Table 3-1 Related Research on Theory of Planned Behavior

Research literature	Research field	Countries
Explaining interest in adopting residential solar photovoltaic systems in the United States	Wolske et al., (2017) [69]	United States
Implementing construction waste management in India	Tezeswi and MVN (2022) [72]	India
Sustainable entrepreneurial intentions	Romero-olmenares (2022) [73]	United States
Adapting the governance of social–ecological systems to behavioral dynamics	Bourceret et al., (2022) [74]	France
Householders' decarbonizing cooling behavior in a subtropical Metropolitan City	Lam et al., (2022) [75]	China
Financing wind energy projects	Gamel et al., (2022) [76]	Germany
Green buying behavior	Kumar (2022) [77]	India
Energy saving behaviors	Du and Pan (2021) [78]	China

3.9.2 The application of the Theory of Planned Behavior to the conditional value approach

The Theory of Planned Behavior has been widely used in recent years in the conditional value approach to investigate the factors influencing willingness to pay, in addition to predicting or explaining individual behavior. Zhang investigated the impact of Theory of Planned Behavior on Beijing residents' Willingness to pay to mitigate the heat island effect. Tan investigated the extended Theory of Planned Behavior to explain the Willingness to pay for electric vehicle charging stations. The conditional value approach combined with the Theory of Planned Behavior can be used as a model to predict or explain the public's Willingness to pay in this study. Thus, the predictive modeling framework of the Theory of Planned Behavior and its extensions as factors influencing Willingness to pay can be used to investigate economic behavior mechanisms. Furthermore, in our study, subjective norms, and perceived behavioral control, in addition to being closely related to attitudes, play a non-negligible role in willingness to pay. When moral

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perception, policy perception, and personal interest perception are included, the model's predictive power for Willingness to pay improves significantly.

Furthermore, in our study, subjective norms, and perceived behavioral control, in addition to being closely related to attitudes, play a significant effect in willingness to pay. When moral perception, policy perception, and personal interest perception are included, the model's predictive power for Willingness to pay improves significantly.

Theory of Planned Behavior and Conditional Value Method were used by A.M. Ryan [75] to empirically test the relationship between Willingness to pay and attitudes. A scenario for a case study was provided in the questionnaire, demonstrating that environmental advice investment is required, which diminishes people's motivation to safeguard the environment and the Theory of Planned Behavior variable was factored in. It was hypothesized that beliefs and political attitudes, rather than economic benefits, influence people's environmental protection behavior. Data analysis was used to test the relationship between Willingness to pay and attitudes, determining whether Willingness to pay could reflect individuals' attitudes. The Theory of Planned Behavior variable was not included in the first scenario. As a result, the logistic regression model produced better results when non-attitude variables were included. The least squares model fit results showed that the attitude did not fully explain the residents' willingness to pay. The entire study demonstrates that subjective norms and perceived behavioral controls have no influence on the factors influencing willingness to pay. Lopez [76] et al. investigated visitors' Willingness to pay for urban parks as well as their motivation to preserve public resources. The researchers chose an extended Theory of Planned Behavior model that included ethical considerations. When developing the questionnaire, a contingent valuation method was also used to map willingness to pay. Before asking the valuation questions, the hypothetical scenarios were carefully designed. Each respondent was given a detailed explanation of the public facilities available as well as the diversity of flora and fauna. The respondents were then asked what the most significant contribution they would be willing to make to the preservation of the city's parks would be. In data processing, Conditional Value Method was used to estimate the mean of willingness to pay, and structural equation modeling was used to investigate the direct or indirect effects of psychological factors on willingness to pay. The findings show that attitudes, subjective norms, personal norms, and perceived behavioral control explain 40% of the variance in Willingness to pay.

3.10 Application of research methods in this study

3.10.1 Study site selection

There are two main locations in this study, Hangzhou, Zhejiang Province, China, Qingdao, Shandong Province, China. The specific locations are shown in Fig 3-13.

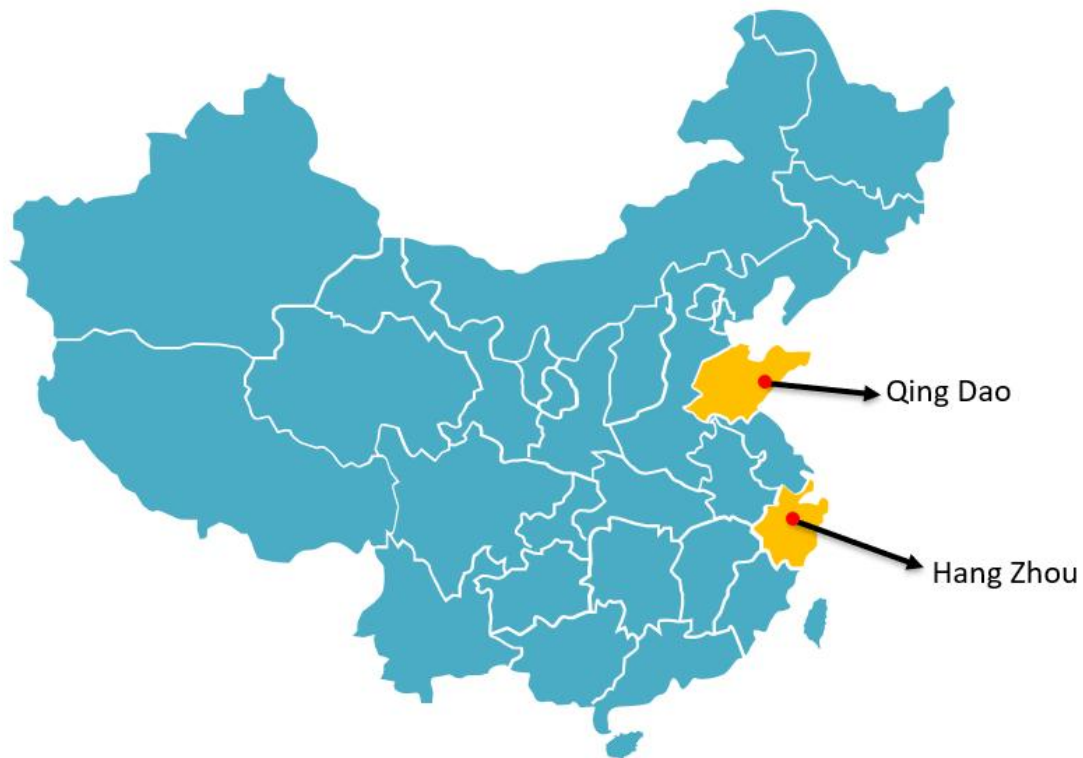


Figure 3-13 Research Location

3.10.2 Sample size

A larger sample size is generally required in studies of conditional value methods to improve the accuracy of estimates, so it is important to determine the sample size in advance. The sample size is determined by the overall size, the accuracy and reliability of the sampling, and the heterogeneity of the total sample. At a certain level of heterogeneity of the total sample, the Schaeffer equation can be used to determine the sample size [87] [88].

$$n = \frac{N}{(N-1)\delta^2+1}$$

Where n is the sample size, N is the total number, and δ is the acceptable sampling error. In 2021, the total populations of Hangzhou, Tai'an, and Qingdao are 12.2 million, 5.63 million, and 8.37 million, respectively. This means that Hangzhou, Tai'an, and Qingdao have N values of 12.2 million, 5.63 million, and 8.37 million, respectively. The sampling error δ is generally set to 0.05. Therefore, the statistical theoretical sample size for Hangzhou, Tai'an, and Qingdao is about 400 cases. Since there are multiple biases in the survey, the minimum sample size should exceed 600 to reduce the bias between the estimated and actual values to within 15% [89]. Survey yield is another important factor that affects the validity of survey results. Generally, a 70% response rate to a questionnaire is the benchmark for a successful survey, while a response rate of more than 75 percent is more desirable [90].

3.10.3 Questionnaire design process

To assure the questionnaire's dependability, it was expanded and enhanced by literature study studies, statistical researcher adjustments, and a pre-survey of the questionnaire. The questionnaire was created in the following manner.

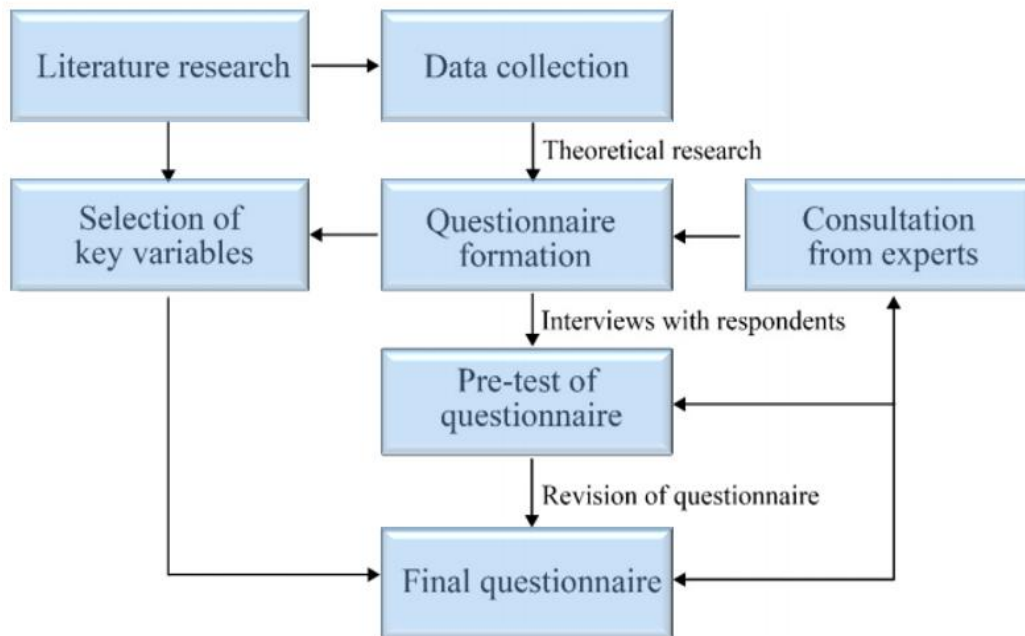


Figure 3-14. Questionnaire design

3.10.4 Access to information

In the conditional value approach, there are three main ways of obtaining information, telephone interviews, face-to-face interviews and web questionnaires. These three forms of questionnaires have different characteristics, and in our study, data were mainly collected using face-to-face interviews as well as web-based questionnaires [97]. Face-to-face interviews have certain advantages and are the more reliable way of data collection. This is because face-to-face interviews can have a high response rate and the interviewer can make factual and timely adjustments based on the respondents' responses [92]. The advantage of web-based questionnaires is that they can save time, and in the context of the global new crown epidemic, many face-to-face interviews are somewhat limited, so the benefits of web-based questionnaires are maximized. Information from the interviews can be collected without contact.

However, the web questionnaire also faces some problems, such as the proportion of young people using web products is significantly higher than that of older people, so the subject of the interview will be biased towards young people. This can lead to an unbalanced proportion of respondents' age distribution, making the results of the questionnaire more biased toward younger respondents, and the web questionnaire often leads to a lower response rate. Therefore, it is necessary to increase the sample size of online interviews compared to face-to-face interviews. With the popularity of the Internet and smartphones, more and more older people are now accessing the

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Internet. Schaffner [93] compared web-based and offline questionnaires in the context of the popularity of the Internet and found no significant differences. Therefore, we can also assume that the validity of web-based questionnaires is better in the current environment where the popularity of the internet has increased greatly [94].

With the development of the network, the network questionnaire software has also been developed significantly, in our distribution of network questionnaires we use questionnaire star as the questionnaire distribution platform. As of 2022 this platform has issued 160 million comprehensive questionnaires and 12.627 billion questionnaires were returned. Therefore, we can assume that the platform has a good reputation, as well as reliability.

Therefore, these two questionnaires were mainly used in our study, and face-to-face interviews were used in Hangzhou city to investigate mainly the willingness to pay for the construction of vertical greening and power exchange plants. And the willingness to pay for the renovation of wastewater treatment plants for resource utilization of wastewater in Tai'an City. In Qingdao, we used a web-based questionnaire for beach environmental protection and carbon emission reduction.

3.10.5 The way willingness to pay is valued

In our study, two main methods of inducing willingness to pay were used. In Chapter 2 we introduced the dichotomous formula, which is a valuation method with better validity and recommended by NOAA [91]. Therefore, the dichotomous formula is used as the estimation method of willingness to pay in our study. We chose the two-boundary dichotomous form of the dichotomous formula, which Chen demonstrated in a related study to have higher accuracy than the single-boundary dichotomous formula [96]. The data of the dichotomous questionnaire is characterized by the fact that the value of willingness to pay cannot be obtained directly, but the value of willingness to pay is estimated by the respondents' responses (yes or no). In this paper, the results of willingness to pay are estimated using random utility model based on the data characteristics of dichotomous questionnaires.

3.10.6 Payment Method

In our study, we chose two payment instruments, electricity, and water. The payment instrument has a very important role in the study of the conditional value approach because it provides the payment environment for the conduct of the experiments of the conditional value approach. To avoid payment bias due to unfamiliarity with the payment instrument, the payment instrument must be well known to the respondents and the payment instrument should have a clear link to the goods being valued [98]. In the second paragraph we present the payment instruments, which are mandatory and more likely to make the results accurate, and we chose a payment instrument with mandatory characteristics, the life contribution, to reduce the behavior of overcommitment of the respondents due to the payment instrument [99]. Impact on willingness-to-pay outcome estimates. In our pre-survey, the use of a publicly known payment instrument, the Living Contribution, was widely accepted by the respondents. This is the reason why we chose the life contribution as a payment method.

3.10.7 Payment Tools

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Some studies believe that respondents' inclination to maintain consistency in their replies to questions and assign socially acceptable actions may be a cause of common method bias. This may be caused among conditional value methods due to improper manipulation of the questioning of the questionnaire, also called method variance. This leads to an effect on the precision of the results. This in turn leads to incorrect conclusions [101]. To solve these problems, special training was given to the interviewers. used to answer the questions asked by the respondents to the questionnaire. We focused on the fact that the data were collected mainly for scientific research. Also, to avoid personal emotions of the interviewers to influence the results of the questionnaire, every three interviewers were grouped together. A statistical manager administered the data. To ensure the validity of the data. Also, all interviewers received interview-specific studies.

3.10.8 Factors influencing willingness to pay

With global warming and the emphasis on low carbon in various countries, individual attitudes toward products related to the public environment have received widespread attention, and more and more researchers have begun to study individual behavior toward the environment [100].

Initially, research on the factors affecting pro-environmental behavior focused on socioeconomic factors such as age, income, and family size. This sort of study was chastised for elucidating just the mildest levels of pro-environmental behavior factors. For these reasons, researchers have begun to focus more on a deeper psychological level. One of the most widely used explanations for the psychological level of research is the theory of planned behavior. The theory of planned behavior is an extension of the theory of rational behavior [102]. Rational behavior theory was proposed to explore the relationship between an individual's attitude and behavior. However, the theory of rational behavior is studied under the assumption that behavior is fully controlled by the will and has limitations for aspects of behavior that are not well controlled by the will. The theory of planned behavior can deal with this limitation very well. In the Theory of Planned Behavior, behavioral intention is a direct predictor of behavior and is influenced by positive and negative attitudes, subjective norms or support from family and friends, and perceptual behavioral control (perception of resources). We therefore use the Theory of Planned Behavior as the basic theory for studying the factors influencing public willingness to pay. We add the covariates of control behavior to the basic variables of planning theory, attitudes, supervisory norms, and perceptual behavioral control to better explore the influences on willingness to pay.

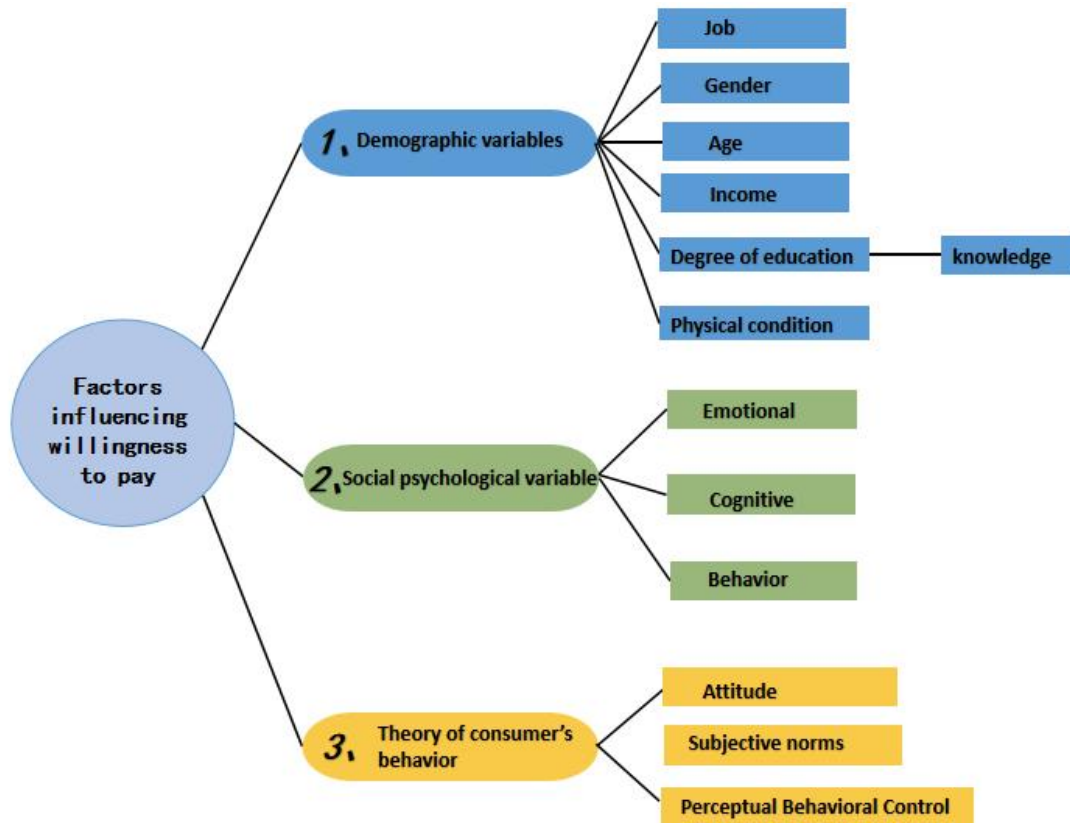


Figure 3-15. Determinants of willingness to pay

3.11 Data processing method

3.11.1 Valuation options for willingness to pay

In the conditional value approach, there has been a long-standing controversy about the values to be taken when estimating the results. The economic theoretical basis of willingness to pay is derived from the income compensation of consumer surplus [104], and in the economic theory the equivalence variable and the compensation variable are taken to be optimal for the mean value, but in the study of willingness to pay, the valuation results of willingness to pay are susceptible to extreme values because the residents' willingness to pay is discrete distributed. However, Carson believes that the mean value of willingness to pay should be used as the final estimation result in willingness to pay studies. This is because it can balance reasonableness as well as demonstrating the efficiency of the decision. But the median value better reflects the true willingness of the respondents [105]. Considering that the reasonableness of the findings is more important compared to the true willingness. Therefore, we choose the mean value of willingness to pay as the estimated result for discussion.

3.11.2 Valuation models

In our study, we use the two-boundary dichotomous conditional value method as our basic valuation model, but we also face some problems. Firstly, the reliability and validity of the conditional value method study should be widely concerned, and secondly, in the conditional value method-double-boundary dichotomous conditional value method, there has been

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controversy regarding the validity and reliability of the conditional value method since the constructed market is hypothetical [106-108]. The validity and reliability of the conditional value approach has been questioned for several reasons, one of which is that a significant proportion of respondents in the survey are unwilling to pay, i.e., there is a so-called "zero response" phenomenon. In developing countries, due to low-income levels and low environmental awareness, coupled with the unfamiliarity of the conditional value approach scenario, many respondents in the questionnaire choose not to pay. Depending on their motivation, zero-response groups can be further divided into "true zero response" and "protest response". A true zero response means that the marginal utility of the environmental change is zero and respondents therefore show no differential preference, whereas a protest response means that although the marginal utility of the environmental change is greater than zero, respondents choose to refuse to pay because they are dissatisfied with the payment instrument or are skeptical about the authenticity of the market [108]. The level of protectability is one of the important indicators of the validity and reliability of CVM [109].

In estimating willingness to pay, the traditional distribution function usually does not include zero payment samples [110], and it was found that the higher the zero response rate, the larger the bias of the willingness to pay estimated by the traditional model, and in early studies related to the conditional value approach, the zero response is usually addressed by direct deletion or by using a very small positive decimal close to zero instead of zero response in some researchers' studies. However, the above treatment faces some problems, direct elimination not only overlooks the very different economic ramifications of protesting and real zero responses, but it also reduces the quantity of reliable information and more likely reasons available. bias in sample selection [112]. And the use of non-zero positive decimals as a proxy for zero responders leads to a high degree of subjective arbitrariness due to the lack of theoretical basis. As countries around the world pay more and more attention to the environment, the assessment of the environmental value of public environmental products is increasing, and the identification approaches, drivers, and treatment tools regarding protest responses have attracted extensive attention from international academia.

How to handle the zero-response problem through a rigorous statistical model became another branch of conditional value approach research, and the Tobit model for analyzing constrained data became one of the first attempts to address this problem; However, because the regression coefficients of the Tobit model do not represent the marginal influence of the factors, it is impossible to determine how much the variables truly affect the likelihood of respondents joining the market or paying. [113]. Moreover, the Tobit model implicitly assumes the more demanding assumption that the corner point solution arises only from the respondents' budget constraints and not from considerations outside from income. Because of these factors, Kristrm proposed the Spike model based on a closed-ended survey to correct for the effect a large number of zero-response samples on willingness-to-pay estimation under a single boundary [114]. Kristrm argues that the standard distribution function may be thought of as a subset of the Spike model, with the fraction of zero replies in the questionnaire increasing as the WTP distribution becomes more asymmetric, the better the Spike model fits [115]. Therefore, we use the two-boundary dichotomous conditional value method combined with the spike model is used to cope with zero-response situations. problem in the questionnaire.

3.11.3 Underlying valuation models

In the two-boundary dichotomous conditional value approach, we used the method suggested by Johansson to model the estimation of willingness to pay. The method is estimated by specifying the difference in their utility by maximizing the difference in the random utility model. The expression of the model is shown below:

$$U = V (B,N;M) + \varepsilon \tag{1}$$

It is assumed that the independent variable U denotes the independent variable of individual utility, which contains the demographic as well as socioeconomic characteristics of the individual respondent (age, income, family status, gender, etc.), the status of the good being valued, and other factors that affect utility). It is the B in the formula (indicating the state of the service provided, such as the environmental quality associated with a low carbon city. The provision is 1 and the non-provision is 0), the income is N, and M denotes other variable factors. v is denoted as the indirect utility function. Then we can obtain the indirect utility function. Where maximum differentiation can be translated into an objective function of respondent utility. And the benefit is the random component.

The respondent will maximize his or her utility by demonstrating that he or she is willing to pay a specific offer, denoted by B. Then the formula can be expressed as

$$V (1,N-B;M) + \varepsilon_1 \geq V (0,N;M) + \varepsilon_0 \tag{2}$$

The result can be obtained by collating the formula

$$V (1,N-B;M) - V (0,N;M) \geq \varepsilon_0 - \varepsilon_1 \tag{3}$$

The left half of Equation 3 represents the utility difference, which we define as ΔV(A), and this part represents the meaning of the deterministic part of the system. The right half of Equation 3 represents the non-systemic stochastic part

Assuming that ε₀ - ε₁ is δ then H_δ (.) is the cumulative distribution function δ. Then the probability that a respondent gets "yes" to a given bid can be expressed as Equation 4

$$Pr \{ \text{answer is "yes"} \} = Pr \{ \Delta V (A) \geq \delta \} = H_{\delta} (.) [\Delta V (A)] \tag{4}$$

We can substitute the willingness to pay X as a random variable into the probability equation of Equation 4 is expressed as Equation 5

$$Pr \{ \text{answer is "yes"} \} = Pr \{ X \geq A \} = 1 - G_c (A) \tag{5}$$

where G_c (A) is the cumulative distribution function of willingness to pay X. Comparing Equation 3 and Equation 4 yields Equation 6

$$1 - G_c (A) = H_{\delta} [\Delta V (A)] \tag{6}$$

When performing formula calculations we usually assume that ΔV = R - TB, where γ = (a, b) is the vector of parameters to be estimated.

3.11.4 Traditional Conditional Value Method - Double Boundary Dichotomous Valuation

Model

In the traditional DBDC-CVM format, respondents will 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” will 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 will be asked for the second time; otherwise, they will 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 a WTP and that $T = N$ represents an unwillingness to pay. As a result, there are four possibilities of answers from respondents: willing-willing, willing-unwilling, unwilling-willing, and unwilling-unwilling. The binary-indicator variables are 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

$$\ln L = \sum_{i=1}^N \{H_i^{YY} \ln[1 - G_c(M_i^H; X)] + H_i^{YN} \ln[G_c(M_i^H; X) - G_c(M_i; X)] + H_i^{NY} \ln[G_c(M_i; X) - G_c(M_i^L; X)] + H_i^{NN} \ln G_c(M_i^L; X)\} \quad (7)$$

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

$$G_c(M_i; X) = [1 + \exp(\alpha - \beta A)]^{-1} \quad (8)$$

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.

3.11.5 Spike model

Since the relevant policies for the construction of BSS have been implemented in China only for a short time, residents may have an insufficient understanding of these policies. In addition, as a developing country, the overall public income in China is not high, environmental awareness is relatively weak and the public is relatively unfamiliar with CVM scenarios. Therefore, many respondents in the questionnaire survey choose unwillingness to pay (zero response). Therefore, we use the spike model proposed by Kristrom [120] and Benjamin [121] was combined with DBDC for treatment of zero responses.

The spike model allows the probability of 0WTP to be a certain positive decimal (Kristrom, 1997) and modified based on the traditional DBDC-CVM model. If a respondent’s answer in the DBDC-CVM model is unwilling-unwilling (H_i^{NN}), the respondent will be questioned. While, in the spike model, a respondent will first be asked whether he/she is willing to join the market again; if the answer is "Yes", the traditional double-bounded dichotomous inquiry will be conducted; if the answer is “No,” the reason why they are unwilling to join the market will be asked to judge whether the respondent belongs to a protest group. H_i^{NN} can be classified into H_i^{NNN} and H_i^{NNY} . The distribution function FWTP of spike model may be defined formula (3).

$$F_{WTP} = \begin{cases} 0 & \text{if } M < 0 \\ p & \text{if } M = 0 \\ G_C(M; X) & \text{if } M > 0 \end{cases} \quad (3)$$

$$F_{WTP} = \begin{cases} 0 & \text{if } M < 0 \\ [1 + \exp(\alpha)]^{-1} & \text{if } M = 0 \\ [1 + \exp(\alpha - \beta A)]^{-1} & \text{if } M > 0 \end{cases} \quad (4)$$

p is spike value which means the probability that WTP is 0 is between 0-1 [122-123]. The closer the spike value to the proportion of samples with zero response, the better the fitness of model. Assume that $G_C(M; X)$ complies with logistic distribution. According to the literature practice, the logistic function adopted for WTP's CDF may be expressed as the formula (4) [124], where, α and β are parameters of logistic function. The log-likelihood function of the model should be summarized as formula (5).

$$\ln L = \sum_{i=1}^N \{H_i^{YY} \ln[1 - G_c(M_i^H; X)] + H_i^{YN} \ln[G_c(M_i^H; X) - G_c(M_i; X)] + H_i^{NY} \ln[G_c(M_i; X) - G_c(M_i^L; X)] + H_i^{NNY} [\ln G_c(M_i^L; X) - G_c(0; X)] + H_i^{NNN} [G_c(0; X)]\} \quad (5)$$

Among the estimation method of the spike model, since maximum likelihood estimation achieves the optimal statistics. Therefore, it is widely used by researchers. We obtain the parameters of α and β using the maximum likelihood estimation method. In formula (4), The spike value was defined as $[1 + \exp(\alpha)]^{-1}$. Therefore, the mean value formula of WTP may be expressed as (6).

$$\bar{C} = (1/b) \ln[1 + \exp(\alpha)] \quad (6)$$

If $\alpha + f_i p$ is used to substitute α as per the method recommended by Benjamin [121], then f_i is a vector (including bid value) used to explain variables; p is the vector to be estimated. Hence, the internal consistency and validity of the conclusions may be verified through estimation of the model with covariates.

3.11.6 Structural equation model

We not only use a two-boundary dichotomous conditional value approach to estimate the factors influencing willingness to pay, but also predict willingness to pay through structural equation modeling to increase the accuracy of exploring the factors influencing willingness to pay.

Structural equation modeling is an emerging statistical approach that emerged in the 1970s, integrating factor analysis and path analysis statistical methods. It consists of two basic models: a measurement model, which represents the relationship between the measured and latent variables, and a structural model, which represents the causal relationship between the latent exogenous and latent endogenous variables assumed in the study [116]. In the structural equation model, the dominant variable, also called the observed variable is obtainable through direct observation or direct measurement. Latent variables, on the other hand, cannot be obtained by direct observation

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or direct measurement [119]. Structural equation modeling has become the most rapidly growing branch in the field of applied statistics in the last two decades.

Structural equation modeling is a comprehensive statistical method for analyzing the relationship between variables based on the covariance matrix of each type of variable. It is also known as covariance structural analysis. So far, structural equations have been widely used in the study of behavior explanation, prediction, etc. It is widely used in many fields of research such as behavior, psychology, and sociology. It is currently a frontier research area in multivariate statistical analysis [117]. Some researchers consider structural equation modeling as a combination of economic, social, and psychometric measures. It is an integrated application and improvement of statistical methods such as factor analysis, path analysis, multiple regression, and analysis of variance [118]. In the field of social psychology, variables such as individual satisfaction, motivation, and behavioral intentions cannot be measured directly and need to be measured indirectly through the observation as well as the assessment of some mediating variables. In contrast, structural equation modeling is an effective tool for measuring these variables and offers the possibility of multivariate statistical analysis of various types of mediating variables. AMOS is the most used analytical software for structural equation modeling.

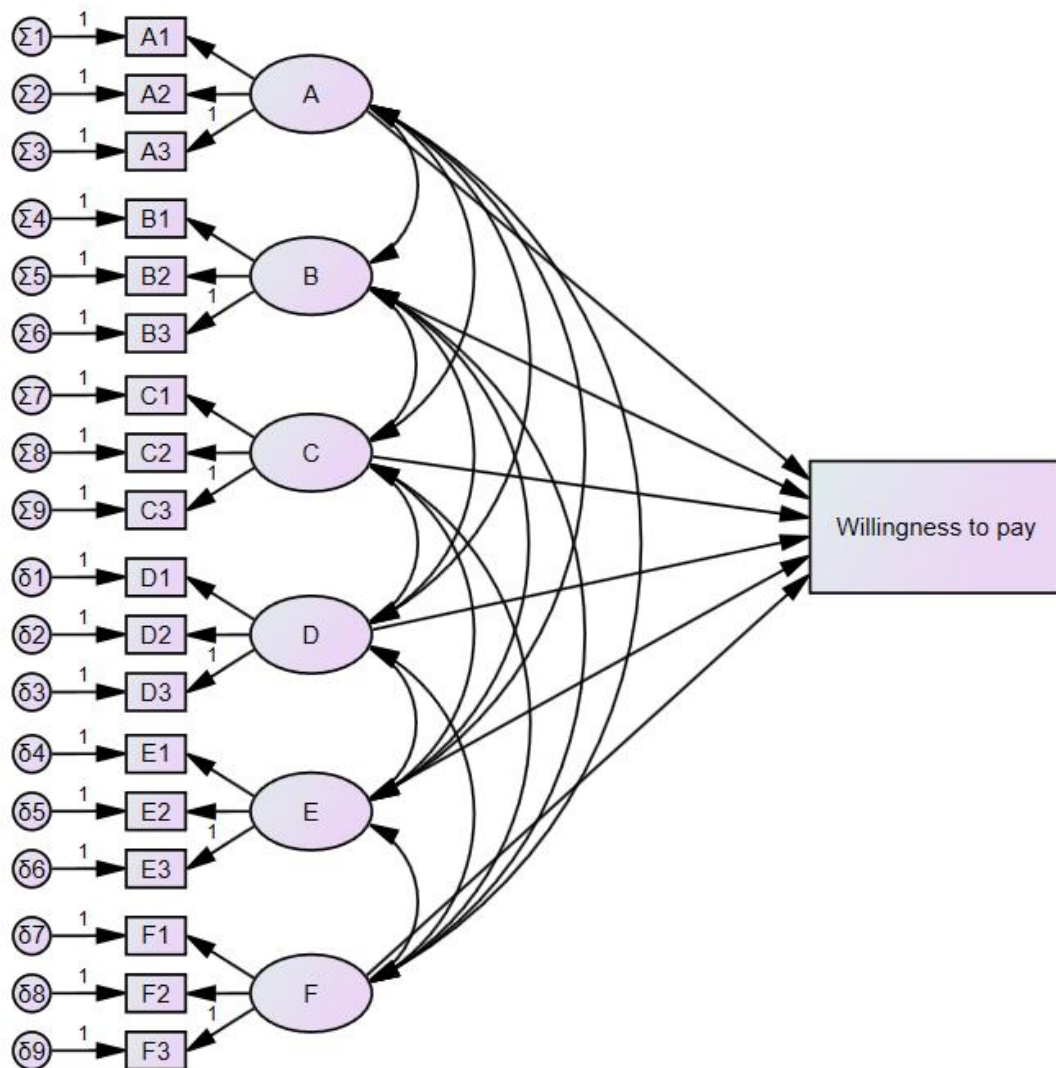


Figure 3-16. Structural equational model

The fitness index of a structural equation model is a critical metric for determining if a hypothetical model matches the real data. Absolute fitness indices, parsimonious fit indices, and incremental fit indices are the three basic types of fitness indices.

Some researchers have argued that the model's fitness index cannot be checked directly and that the model parameters should be checked for differential valuation before checking the model's fitness index. Firstly, it should be checked whether there are negative error variances; secondly, it should be checked whether they have large standard errors. If all types of data are more appropriate. Finally, it is necessary to check whether the values of the standardized parameters of each type of coefficients are greater than 1. The above tests can ensure the reasonableness of the model. If all of them are satisfied, then further estimation of the model fit index can be carried out. In our study, the following fitness coefficients are used

Comparative fit index (CFI), cardinality freedom ratio (χ^2 / df), goodness-of-fit index (AGFI), RFI (relative fit index), IFI (modified fit index), fitness index (GFI), root mean square error of approximation (RMSEA), and canonical fit parameter (NFI).

The reference indicators for each data item are shown in Table 4-1

Table 3-2 Reference indicators for data items

Fit statistics	Reference standard
χ^2 / df	<3.00
RMSEA	<0.05
GFI	>0.90
AGFI	>0.90
NFI	>0.90
RFI	>0.90
CFI	>0.90
IFI	>0.90

3.11.7 Advantages of structural equation modeling

The main advantage of structural equation modeling over other statistical techniques is that structural equation modeling eliminates the traditional approach of "validating factor analysis to estimate factor scores and then doing path analysis on factor scores" and can deal with multiple dependent variables at the same time. The specific advantages are as follows

- 1 Simultaneous estimation of factor structure and factor relationships

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Assuming that to understand the correlation between latent variables, each latent variables person is measured with multiple indicators or topics, a common practice is to first calculate the relationship between latent variables (i.e., factors) and topics (i.e., factor loadings) for each latent variable using factor analysis, which in turn yields factor scores as observations of the latent variables, and then calculate factor scores as correlation coefficients between the latent variables. These are two independent steps. In the structural equation, these two steps are performed simultaneously, i.e., the relationship between factors and topics and the relationship between factors and factors are considered simultaneously.

2 Handling multiple dependent variables simultaneously

Structural equation analysis can consider and deal with multiple dependent variables at the same time. In regression analysis or path analysis, even if the graphs of statistical results show multiple dependent variables, in fact, each dependent variable is still calculated one by one when calculating the regression coefficient or path coefficient. So, the graphs appear to consider multiple dependent variables simultaneously, but the presence of other dependent variables and their effects are ignored when calculating the effect or relationship on a particular dependent variable.

3 Measurement models that allow for greater flexibility

In the past, we only allowed each question (indicator) to be subordinated to a single factor, but structural equation analysis allows for more complex models. For example, if we use a math test written in English to measure a student's ability in math, the test score (indicator) is subordinated to both the math and English factors (because the score also reflects English ability). Traditional factor analysis has difficulty in dealing with models where an indicator is subordinated to multiple factors or where there are more complex subordination relationships such as considering higher order factors.

4 The degree of fit of the whole model can be estimated

In traditional path analysis, we only estimate the strength of each path (relationship between variables). In structural equation analysis, in addition to the estimation of the above parameters, we can also calculate the overall fit of different models to the same sample data and thus determine which model is closer to the relationship presented by the data.

5 The degree of fit of the whole model can be estimated

Variables such as attitudes and behaviors often contain errors and cannot simply be measured by a single indicator. Structural equation analysis allows for both the independent and dependent variables to contain measurement error. Variables can also be measured by multiple indicators. Correlation coefficients between latent variables calculated by traditional methods may differ significantly from those calculated by structural equation analysis.

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Chapter 4

***HANGZHOU CITIZENS' WILLINGNESS TO PAY
FOR LOW-CARBON MEASURES - VERTICAL
GREENING***

CHAPTER FOUR: HANGZHOU CITIZENS' WILLINGNESS TO PAY FOR LOW-CARBON MEASURES - VERTICAL GREENING

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Hangzhou is an emerging first-tier city in China, and with the development of urbanization and the increase of urban population, urban carbon emissions have also increased. Among them, the carbon emissions from old houses and transportation have increased most significantly. With the increase of carbon emissions, the greenhouse gases formed have seriously affected the living comfort of Hangzhou citizens. Therefore, the mitigation of urban carbon emissions has become a very urgent environmental issue for Hangzhou citizens. In order to solve the above problems, Hangzhou government has introduced countermeasures one after another. In terms of increasing carbon emissions from old neighborhoods, the General Office of Hangzhou Municipal Government has formulated a notice to further promote three-dimensional greening in urban areas of Hangzhou, requiring the city to achieve a target of 500,000 square meters of vertical greening coverage by 2050. For the problem of large amount of carbon emissions generated by the emission of fuel cars in the city, the Hangzhou Municipal Government requires the full promotion of electric vehicles to replace fuel cars and also requires the construction of electric vehicle exchange stations to be increased in order to further promote the city's energy upgrade to reduce carbon emissions.

However, unfortunately, studies on the environmental value assessment of the above measures are still very limited. Meanwhile, the government has formulated relevant policies, and public acceptance of low-carbon measures is of great importance for the implementation of the established measures. To explore the impact of the policies and to assess the environmental value of the above measures, we used the conditional value approach to assess the willingness of the public to pay for the above two urban low-carbon measures in Hangzhou. Based on the two-boundary dichotomous conditional value method, we used the spike model to deal with the zero response problem that appeared in the interviews. We also extended the theory of planned behavior by adding covariates to better explore the factors influencing willingness to pay. We also provide policy recommendations to induce better public participation.

4.1 Willingness to pay for Vertical Greening

The General Office of Hangzhou Municipal People's Government has promulgated the "Notice on Further Promoting Stereoscopic Greening in Urban Areas of Hangzhou" since 2015, which points out that the façade of existing buildings and utility structures in urban areas of Hangzhou with greening conditions will be fully covered with greening, with a new vertical greening area of more than 60,000 square meters per year, and the city will achieve a vertical greening area of more than 500,000 square meters by 2025 to reduce urban emissions of the city. However, very little attention has been paid to the economic benefits of this measure. In this section, we investigate the willingness of Hangzhou residents to pay for supporting the construction of vertical greening to mitigate urban carbon emissions and its determinants through face-to-face interviews.

4.2 Research background

Existing homes in China have the disadvantage of high energy consumption and high carbon emissions. Its energy consumption and carbon emissions account for 40% and 36% of the global total, respectively. China's existing building area has reached about 60 billion square meters, of which 75.3% is residential area, 9.9% is public building and 14.8% is production building. As of December 2020, only 2.902 million m² of existing floor space has been retrofitted to obtain the

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green building label [1]. In addition, along with the increasing urbanization, carbon emissions in the building sector will continue to rise further. The large amount of carbon emissions is the main reason for the increase of greenhouse gases, triggering climate warming and aggravating the greenhouse effect. The increase of greenhouse gases reduces the thermal comfort of urban residents, increases energy consumption in summer, and deteriorates air quality [2]. Vertical greening can effectively mitigate urban greenhouse gas emissions [3]. During the 14th Five-Year Plan of China, 11 key cities have been identified for the renovation of existing buildings, and Hangzhou, as a pilot city for renovation in southern China, has a pressing need for green renovation of existing buildings.

Existing buildings are relative to new buildings, and in China, they refer to buildings that were built before January 1, 2000. The purpose of retrofitting existing buildings is to maximize resource conservation (energy, land, water, and materials), protect the environment, and reduce carbon emissions during the life cycle of the retrofitted building, and to provide people with healthy, suitable, and efficient spaces for use, in harmony with nature [5].

High building density and insufficient greening have always been the problems faced by the existing residential areas in Hangzhou. Vertical greening gets rid of the limitations of traditional planar greening in terms of the number of plants and planting area, realizes the use of the smallest footprint to create the largest greening effect, alleviates the increasingly sharp contradiction between urban greening land and building land, and finds a breakthrough for increasing urban greening rate, as well as a new direction for urban land resource planning [4]. Therefore, this method is considered as an effective solution [6]. The Opinions of the State Council on Strengthening Urban Infrastructure Construction states that the use of vertical greening is recommended in residential renovation [5]. The Notice of the General Office of Hangzhou Municipal People's Government on Further Promotion of Stereoscopic Greening in Urban Areas of Hangzhou from 2015 states that the facades of existing buildings and utility structures with greening conditions in urban areas of Hangzhou will be comprehensively covered with greening, with a new vertical greening area of more than 60,000 m² per year, and the goal of achieving a vertical greening area of more than 500,000 m² in the city by 2025 [4].

Vertical greening is widely valued as a new greening technology. Decision makers should be aware of the economic benefits of this approach and the factors affecting public participation, which can help in making relevant investment decisions. However, the benefits of vertical greening (e.g., greenhouse gas reduction and air purification) cannot be assessed by traditional market pricing (environmental value). Estimating willingness to pay through the conditional value approach has become a common means of measuring its economic value [7] [8]. It is widely used in studies in the fields of environmental economics, health economics, cultural economics, tourism economics, transportation safety, biodiversity conservation, and ecosystem services, and research has covered almost every country in the world [9]. The conditional value approach is a survey that establishes a hypothetical market for changes in the quantity or quality of public goods, with the aim of guiding respondents to make choices among these hypothetical markets. Conditional value approach surveys ask respondents to state their willingness to pay for a decision to increase supply or avoid a decrease in the level of public good supply [9].

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Due to China's national conditions and policies, residents are not yet involved 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 started to receive widespread attention, which provides an important opportunity for public participation in urban environmental management. The measures of low-carbon cities are closely related to public life, which provides a space for public participation in urban environmental management. Therefore, an in-depth understanding of residents' acceptance and evaluation of vertical greening will not only help guide the formulation of policies, but also provide the necessary opportunities for better public participation in urban environmental management.

4.3 Literature Review

Vertical greening has received a lot of attention from researchers because of its positive externalities to the environment, and the related research focuses on three aspects.

First, in terms of energy saving, Rupasinghe and Halwatura (2020) [11] argued that by introducing vertical greenery on building facades, the maximum indoor temperature reached in a day can be reduced by 4.89°C, which can effectively reduce energy consumption and carbon emissions in summer. Li [12] showed that by increasing horizontal and vertical greenery in Zhejiang Province, China, the cold load can be reduced by 8.8% and heat load can be reduced by 1.85%, which can achieve energy saving and thus reduce greenhouse gas emissions.

Secondly, in terms of positive environmental externalities, Rosasc and Perini [13] confirmed the improvement of urban environmental quality by vertical greening systems and demonstrated its reliability. Victorero et al [14] demonstrated the significant effect of vertical greening in mitigating the urban heat island effect and in reducing urban carbon emissions. Wong et al. [15] concluded from laboratory simulation data that vertical greening has great potential for mitigating urban noise pollution. Medl et al. [17] demonstrated that vertical greening helps to reduce the refraction of sunlight and can have a positive effect on drivers.

Thirdly, in terms of economics, Perini and Rosasco [18] presented a model for cost-benefit analysis of vertical greening and evaluated its sustainability. Tam et al [19] evaluated the willingness of the public to pay for green roofs in Hong Kong, with a maximum of 235 USD/m². Bianchini and Hewage. Hewage. [20] evaluated the aesthetic value of green roofs and showed that green roofs can create about 3% additional value for buildings. Zhang et al [21] evaluated the public's willingness to pay for green roofs to mitigate the heat island effect. The willingness to pay was higher among those who had higher income, higher education, some environmental knowledge, and believed that green roofs could mitigate the heat island effect. Teotonio et al [22] evaluated the willingness to pay for green roofs and green walls in Portugal and found that they were willing to pay 2-4% of their rent to support green roofs or green walls. Age, education level, and income level have an impact on willingness to pay. Overall, they are more willing to pay for green roofs than green walls. And the public's willingness to pay decreases as the bid value increases. However, in this series of studies, there is no discussion of the environmental value of vertical greening in reducing urban greenhouse gases, and the public's willingness to pay and the

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factors that influence payment (participation) for reducing urban greenhouse gases. This is not conducive to decision makers to properly measure the economic value of vertical greening or to make relevant investment decisions based on public attitudes.

To address the above issues, this study has three main objectives. First, the environmental value of vertical greening for GHG emission reduction was explored. Second, we explored the public willingness to pay, i.e., the retrofitting of existing residential buildings with vertical greening to mitigate urban GHG emissions. Third, we investigated the factors that inject public payment (participation). The rest of the paper is organized as follows. The research methods used in this study are discussed in "Materials and Methods". The spike model and the willingness to pay estimation model are discussed in "Spike Model Optimization DBDC". The results and discussion are reported in "Results". The main conclusions of this paper and avenues for future research are presented in "Conclusions and Perspectives".

In this paper, existing research results are extended in four aspects. First, the effectiveness of the Spike model in dealing with zero response is verified. Second, the factors influencing willingness to pay were explored by adding covariates. Third, the factors influencing residents' participation in vertical greening were explored through the collection and analysis of feedback information. Fourth, the economic benefits of vertical greening in Hangzhou were preliminarily estimated to provide reference for policy makers to formulate policies.

4.4 Research method

4.4.1 Goods to be appraised

In this study, the product to be evaluated was the value of vertical greening in reducing carbon (greenhouse gas) emissions (regardless of other positive externalities). In each interview, the impact of greenhouse gases was presented to each interviewee. Subsequently, the benefits of vertical greening in reducing GHG emissions were introduced. In addition, the retrofitting of existing residential buildings in Hangzhou was discussed.

4.4.2 Factors affecting the Willingness to pay

There are many factors that influence willingness to pay. In traditional scoping tests, only socioeconomic factors are considered, not excess, which ignores affective, cognitive, attitudinal, and behavioral variables. Researchers have drawn two important conclusions from the study: respondents are likely to place a higher value on the public goods being assessed when they have knowledge, enjoyment and experience with them, and willingness-to-pay assessments are more likely to be valid when respondents have relevant knowledge, experience and positive attitudes toward the public goods being assessed. When people want to reveal their willingness to pay, they trust their own intuition, feelings, and basic values. Respondents' payment behavior must be thoughtfully planned, and more and more researchers are focusing on psychosocial factors, such as attitudes, beliefs, and values, to make people more successful in predicting their payment behavior [23].

4.4.3 Questionnaire design

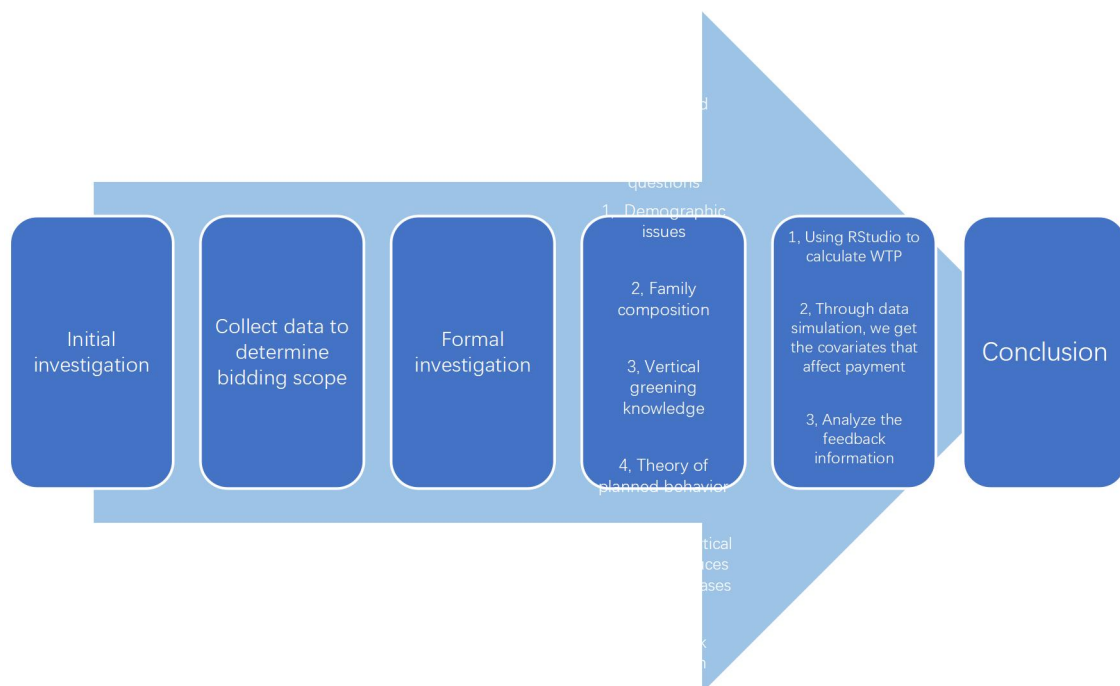
Prior to the interviews, 24 interviewees were selected, three from each group, obtaining eight groups in total. Each group had a manager and two interviewers to prevent the interviewers'

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personal emotions from influencing the statistical results [24]. This study provides guidance to the interviewees, including the background of the study, the significance of the study, and the interviewees' responses to the questions. To prevent data bias due to age, only residents aged 18-65 years were interviewed.

In willingness to pay inquiry, the selection of the number and limit of bidding points is very important. The minimum endpoint value should be accepted by 90% of respondents, while the maximum value should be rejected by 90% of respondents [25]. Combined with the data obtained from the presurvey, 10 bidding points, including 10, 25, 50, 100, 200, 400, 800, 1500, 3000 and 6000, were selected. To prevent the lowest (highest) bidding point from missing the lowest (highest) bidding value in the second round of inquiry, points 10 and 6000 were avoided in the first round of inquiry. Subsequently, we 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), and (1500/3000/6000) CNY. The middle amount in the data group was first selected for inquiry. If it was rejected, the lower amount was selected for inquiry; if it was allowed, the higher amount in the data group was selected for inquiry.

The interview process is shown in Figure 5-1. For respondents with a willingness to pay of greater than zero, the core valuation question on the willingness to pay was as follows: The Hangzhou Municipal Government has carried out vertical greening renovation of existing residential buildings to reduce the emission of greenhouse gases. Would you like to pay a certain amount of money by raising living expenses in the next 5 years? If a respondent answered "Yes," a higher bidding value was selected in the next round of inquiry; if the answer was "No," the lower bidding value was selected in the next round of inquiry. For those who opted to withhold payment, a zero response was employed for a judgment according to their decision. The collected data were processed by SPSS25 and RStudio to obtain the willingness to pay and relevant influencing factors.



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Figure 4-1. Interview process

The presurvey was carried out on February 17, 2021, and an open-ended questionnaire survey was conducted among 200 residents in Hangzhou at random, to obtain a more accurate bidding scope. A formal survey was conducted from February 20 to March 1, 2021. A total of 1500 in-terviews were conducted. In total, 369 respondents reported refusing to pay the expenses. It is necessary to further analyze the reasons why the interviewees were unwilling to join the market. A total of 5 question options were designed accordingly Figure 5-2. According to the protest response judgment standard [26], C, D and E can be considered protest responses, and A and B can be considered true zero responses. The statistical results show 250 true zero responses and 119 protest responses. Since the interviews were conducted at random, it could be assumed that the distribution of protesters in the sample was random. Therefore, the protesters were eliminated directly. There were 838 respondents whose willingness to pay was greater than zero with the response rate of the questionnaire being 77.0%. The number of valid samples, efficiency level and response rate of the questionnaire reach the standards recommended by the NOAA Review Committee [27].

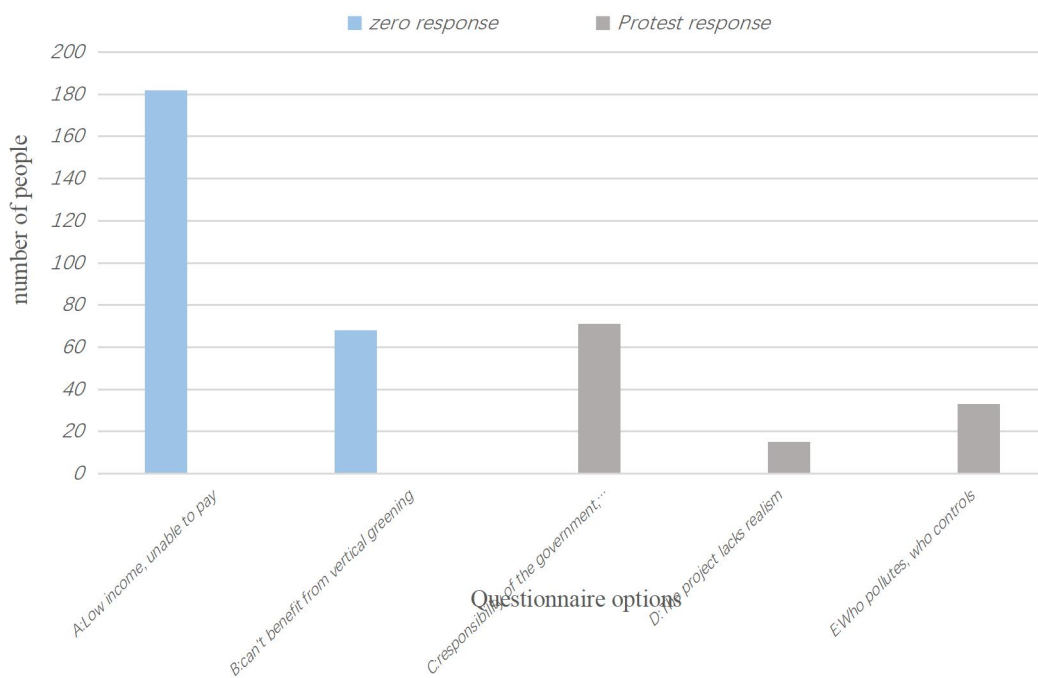


Figure 4-2. Reasons for not willing to join the market

On account of the differences in social conditions and economic characteristics of the re-spondents from different districts of Hangzhou City, in an attempt to ensure the accuracy of the questionnaire, sampling was performed based on the population distribution of the valid questionnaire to avoid representative deviation. As shown in Figure 5-3, the proportion of the sampled population is equivalent to the proportion of the actual population in each district, which indicates that the

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sample is more representative (Table 5-1).

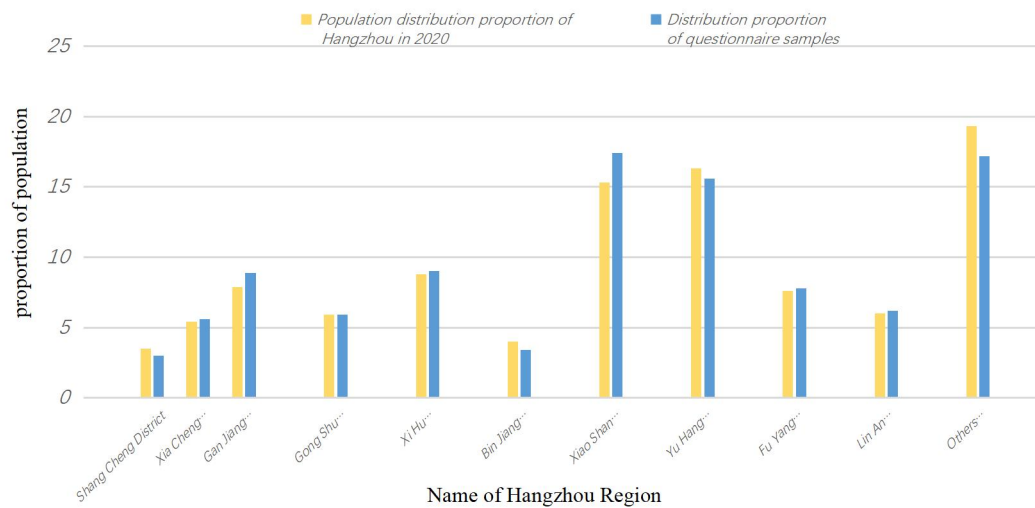


Figure 4-3. Distribution and population comparison

Table 4-1 Distribution of Hangzhou residents and questionnaire samples (Proportion)

District	Distribution of Hangzhou residents by urban areas in 2020 (percentage)	Population distribution of respondents by district in Hangzhou(percentage)
Shang Cheng	3.4	3.0
Xia Cheng	5.4	5.8
Gan Jiang	7.9	8.7
Gong Shu	5.9	6.0
Xi Hu	8.8	9.0
Bin Jiang	4.0	3.4
Xiao Shan	15.3	17.0
Yu Hang	16.3	16.0
Fu Yang	7.6	7.7
Lin An	6.0	3.2

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Others	19.3	17.2
Total	100	100

4.5 Result

4.5.1 Data analysis

The data of the 8 bidding groups mentioned above are summarized in Table 5-2. In the interviews, 91% of the respondents chose to pay a minimum of 10 CNY, while 90% of the respondents refused to pay 6000 CNY, which is equivalent to the results of the presurvey. Since the sample size has been increased, the endpoint value is deemed highly accurate. As shown in Fig. 4, with the increase in the bidding value, the proportion of people choosing YY and YN decreases, while the number of people choosing NNY and NNN is increases, which is consistent with the conclusion reached by Teotonio et al. [22]. It indicates that the higher the bid value is, the lower the willingness to pay in constant family income. There is a strong correlation between willingness to pay and bid value.

Table 4-2 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%)

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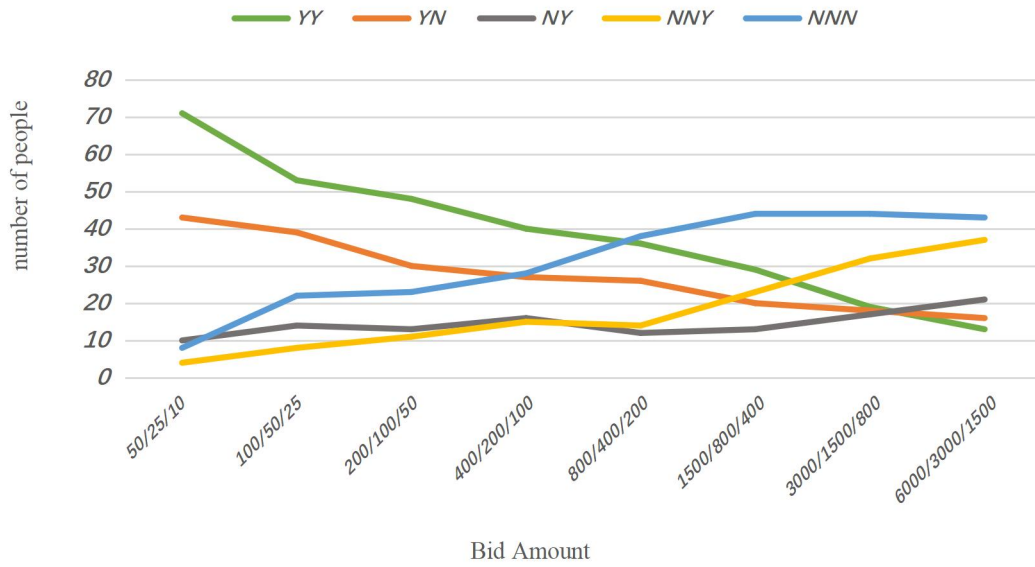


Fig. 4-4 Response distribution

The interview content was subject to the statistics summarized in Table 2 and to a comparison with the census data of the National Bureau of Statistics of China, with the results showing that some similarities in gender, job and census results and a large gap in the final educational background and age distributions. First, given our limited sample size and as Hangzhou, as an emerging city in China, attracts numerous colleges graduates each year, there is deviation between age and census data. Because there is no big gap in social factors or other aspects, this sample can be considered suitable for estimating trends for the whole population of Hangzhou (Figure 4-3).

Table 4-3 Gender of samples

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Gender	Male=1	551	50.6	0.50	0.50	0.50
	Female=0	537	50.4			

Table 4-4. Age of samples

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Age	18 ≤ Age < 44 =1	648	60.0	1.46	0.70	1.63
	44 ≤ Age ≤ 59 =2	390	35.8			

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59 < Age ≤ 65=3 50 4.2

Table 4-5 Working condition of the sample

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Job	Stable job=1	848	77.9	0.78	0.42	0.71
	other=0	240	22.1			

Table 4-6 Residential situation of the sample

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Housing conditions	Housing after 2000 years=1	772	71.0	0.71	0.45	
	Housing before 2000 years=0	316	29.0			

Table 4-7 Health status of the sample

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Physical condition	Health=1	918	84.4	0.84	0.63	
	others=0	170	15.6			

Table 4-8 Income of samples

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Income	More than 5500=1	758	70.0	0.70	0.46	
	others=0	330	30.0			

Table 4-9 Household composition of the sample

Variable	Option	Numbers	Proportion/%	Mean	Dev
Living	Not living alone =1	783	72.0	0.72	0.45

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conditions						
	Living alone =0	305	28.0			
Caring for children or elders	Caring for children or elders=1	539	49.5	0.50	0.50	
	other=0	549	50.5			

Table 4-10 Environmental knowledge (social psychology)

Variable	Option	Numbers	Proportion/%	Mean	Dev
Greenhouse effect knowledge	Knowledgeable =1	457	42.0	0.42	0.49
	other=0	305	58.0		
Vertical greening knowledge	Knowledgeable =1	539	45.7	0.46	0.50
	other=0	549	54.3		

Table 4-11 Theory of planned behavior

Variable	Option	Numbers	Proportion/%	Mean	Dev
Attitude	Believe vertical greening can alleviate the greenhouse effect =1	923	84.8	0.85	0.36
	other=0	165	15.2		
Subjective norm	Pro environmental behavior will =1	888	81.6	0.82	0.39
	other=0	200	18.4		
Perceived behavioral control	Able to participate in activities to improve greenhouse effect=1	765	70.3	0.70	0.46
	other=0	323	29.7		

4.5.2 Analysis of feedback information

During the interviews, the protest responders were excluded, and feedback information was collected from all of the respondents Fig. 5. In total, 209 respondents chose to withhold payment, and they believed that increasing their income and formulating corresponding compensation

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mechanisms would improve their participation in vertical greening. In addition, 41 respondents suggested that they did not know the relevant information about vertical greening and believed that the government should better promote environmental knowledge. Among the respondents reporting a willingness to pay, 771 believe that the government should disclose the flow of payment funds, increase information transparency, and ensure the rational use of expenditures; 205 respondents believe that representatives should be selected to supervise the government's behavior; and 112 respondents think that the binding force of relevant laws should be appropriately enhanced. In addition, the respondents were subject to questions about their participation patterns in vertical greening Fig. 6. There were 713 respondents who would choose to provide financial support, 115 respondents who would protect the vegetation of vertical greening spaces, 203 respondents who would actively publicize knowledge about vertical greening, and 57 respondents who had no spare time for related activities.

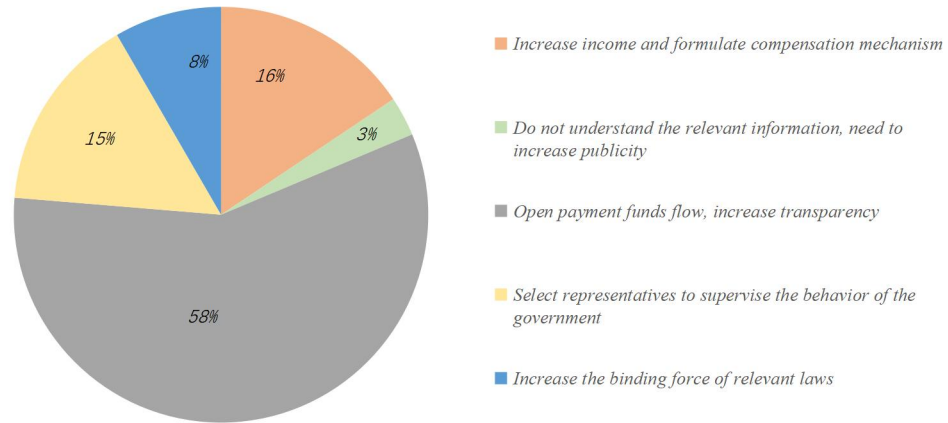
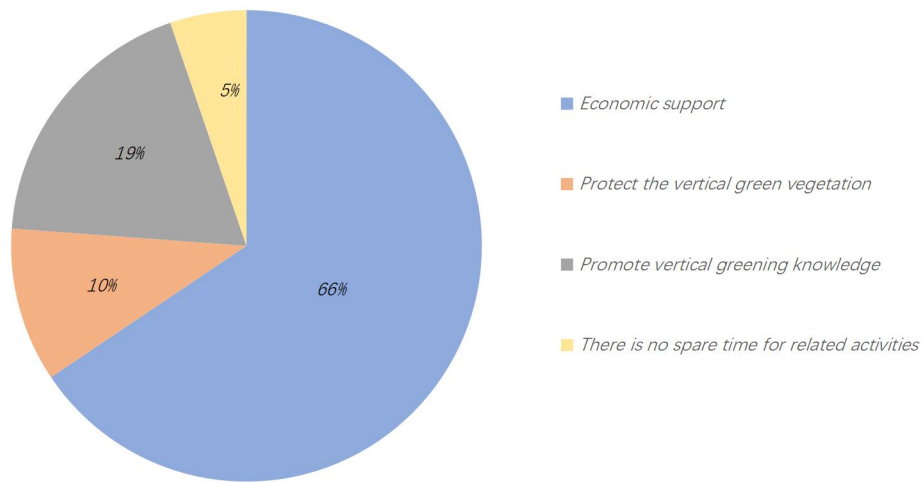


Fig. 4-5 Feedback on residents' participation in vertical greening

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Fi

g. 4-6. Feedback on residents' participation in vertical greening

4.5.3 Assessment of covariation and detection

A total of 15 variables were measured in the interviews, where the independent variables could be divided into 4 models according to their different types Table 3. The demographic characteristics are included in Model 1; the variable of family members is added in Model 2; the variable of environmental knowledge is added in Model 3; three variables of the Theory of Planned Behavior are added in Model 4. From a comparison of the models, 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. Those over 59 years of age are not as enthusiastic about environmental payment as young people. In Model 2, final education is statistically significant at the 5% level. 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 the willingness to pay. In all models, income is statistically significant at the level of 1%. The above analysis shows that income significantly affects the payment behavior of residents. The family members variable indicates that the presence or absence of elders or children in the family shows statistical significance at the level of 1%, which demonstrates that the composition of family members can have a significant impact on the payment of respondents, which is consistent with the conclusion reached by Teotonio et al [22]. 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 pay, which is consistent with the conclusion reached by Tan et al. [28]. In Model 4, the subjective norm variable is statistically significant at the level of 1%, and attitudes and cognitive behavior control are statistically significant at the level of 10%, which indicates that subjective norms can guide people's willingness to pay, which is consistent with the conclusion reached by Heberlein [23].

To ensure the accuracy of the results, the interval range of MTP was subject to verification with the Monte Carlo simulation method; Meanwhile, the partial correlation coefficient and single factor was employed to test the covariates in the model [29], and the results show that there is no abnormal value.

Table 4-12 Estimation results with covariates (1)

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Variable	Model 1		Model 2	
	Coef	p values	Coef	p values
<i>Demographic attributes</i>				
Gender	0.173	0.123	0.106	0.345
Age<44	0.220	0.075*	0.476	0.001***
59<Age	0.440	0.128	0.494	0.086*
Education	0.128	0.279	0.141	0.229
Job	0.078	0.628	0.163	0.318
Housing conditions	0.119	0.335	0.116	0.349
Physical conditions	0.847	0.000***	0.291	0.049**
Income	0.732	0.000***	0.652	0.000***
<i>Family members (social psychology)</i>				
Living conditions			0.210	0.119
Caring for children or elders			0.552	0.000***
<i>Environmental knowledge</i>				
Greenhouse effect knowledge				
Vertical greening knowledge				
<i>Belief and perceived resources</i>				
Attitudes				
Subjective norms				
Perceived behavioral control				

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spike	0.233	0.000***	0.234	0.000***
MTP	712.528 CNY	0.000***	720.341 CNY	0.000***
95% confidence interval	665.439~758.767CNY		665.439~758.767CNY	
99% confidence interval	651.383~774.277CNY		672.264~767.551CNY	

The unit for MTP is CNY *p<0.1; **p<0.05; ***p<0.01

Table 4-13 Estimation results with covariates (2)

Variable	Model 3		Model 4	
	Coef	p values	Coef	p values
<i>Demographic attributes</i>				
Gender	0.042	0.717	0.089	0.345
Age<44	0.017	0.000***	0.530	0.001***
59<Age	0.445	0.001***	0.623	0.086*
Education	0.235	0.048**	0.190	0.229
Job	-0.023	0.885	0.036	0.318
Housing conditions	0.129	0.302	0.145	0.349
Physical conditions	0.288	0.061*	0.159	0.049**
Income	0.775	0.000***	0.675	0.000***
<i>Family members (social psychology)</i>				
Living conditions	0.101	0.460	0.192	0.119
Caring for children or elders	0.429	0.003***	0.386	0.000***
<i>Environmental knowledge</i>				
Greenhouse effect	0.481	0.000***	0.370	0.006***

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knowledge

Vertical greening knowledge	0.543	0.000***	0.332	0.011***
<i>Belief and perceived resources</i>				
Attitudes			0.286	0.093*
Subjective norms			0.821	0.000***
Perceived behavioral control			0.282	0.088*
spike	0.238	0.000***	0.234	0.000***
MTP	737.188 CNY	0.000***	746.718 CNY74	0.000***
95% confidence interval	688.652~784.849CNY		698.145~794.413CNY	
99% confidence interval	674.164~800.835CNY		683.647~810.412CNY	

The unit for MTP is CNY *p<0.1; **p<0.05; ***p<0.01

4.5.4 Non covariate estimation results

The purpose of setting covariates is to determine the variables that could have a greater impact on the willingness to pay, which, would affect the valuation results, so non-covariates are employed for calculation. The results are shown in Table 4. The maximum likelihood function was employed to estimate the parameters with the spike's parameter being 0.238. The statistical results show that zero responses account for 23%, and the fitting degree can reach 96.6%. The 95% confidence interval of the willingness to pay is 657.95— 746.19, the 99% confidence interval is 643.57— 761.47, and the value of MTP is 702.55 CNY (107.77 USD), which is near the mean of the two intervals and statistically significant at the level of 1%, which proves that the fitting effect is good.

Table 4-14 Estimation results without covariates

Variables	Coefcient	T values	P values
spike	0.238	19.101	0 ***
MTP	702.551 CNY	30.337	0 ***
interval_95	657.946 CNY~746.187 CNY		
interval_99	643.571 CNY~761.468 CNY		

The unit for MTP is CNY *p<0.1; **p<0.05; ***p<0.01

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4.6 Discussion

Vertical greening can have many benefits in terms of environmental improvement, energy conservation and emission reduction. Most researchers of this field have studied the passive energy saving capacities of vertical greening [30] or the economic value of reducing energy consumption [18]. No related study has analyzed the economic benefits brought by reducing greenhouse gases, and policies are often "profit-oriented" on the grounds that economic benefits promote the implementation of policies. Future research may study the economic benefits brought by various measures of environmental protection to promote the formulation and implementation of environmental protection policies.

The average annual income of Hangzhou citizens was 9,510 USD in 2020 (The average annual household income was 45,990 USD), and the number of registered households was at 2,481,400 units (Zhejiang Bureau of Statistics). As covariates may affect the results, the non-covariates were employed for the calculation, and the results show that Hangzhou per household would pay 702.55 CNY (107.77 USD) per year, accounting for 0.023% of the total household income and a total payment of 267 million USD, which was higher than that the willingness of Beijing households to pay 148.58 CNY for green roof. This is probably because the Hangzhou households have a higher awareness of environmental protection [31,32]. As per the calculation of the 99% confidence interval, the total annual willingness to pay of Hangzhou citizens is between 245 million USD and 290 million USD. The 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 of 69 million USD in total. Therefore, the economic benefit of the project is valued at between 176 million USD and 221 million USD. These numerical results can guide policy-makers in formulating policies.

With "public participation" stipulated in the Environmental Protection Law of the People's Republic of China as one of the basic principles of environmental protection, more attention should be given to public participation and environmental assessment [33]. The renovation of existing residential buildings is the core goal of significant research and development projects in China according to the "13th Five-Year Plan," vertical greening is an important link in renovation, and public participation is especially needed for policy-makers to formulate the next plan. Heberlein et [23] criticize that in the traditional model, attention is only paid to the results of the willingness to pay, while the impacts of human emotions, subjective experience, and social psychology are ignored. Therefore, the covariates of the composition of family members, environmental knowledge and Theory of Planned Behavior are supplemented on a demographic basis, and the results show that whether there are elderly and child 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 affect the willingness to pay and participation. Researchers may thus further explore payment by supplementing variables in the framework of social psychology and the Theory of Planned Behavior.

4.7 Conclusions and outlook

4.7.1 Conclusions

CHAPTER FOUR: HANGZHOU CITIZENS' WILLINGNESS TO PAY FOR LOW-CARBON MEASURES - VERTICAL GREENING

Residential buildings are plentiful in China, and heavy emissions of greenhouse gases caused by high energy consumption and carbon emissions have placed considerable burdens on the environment. With the implementation of the renovation plan for existing residential buildings, vertical greening, as a key technology, has attracted extensive attention from the Chinese government for its economic benefits in reducing the emission of greenhouse gases. In this study, the following research results were obtained:

- (1) The spike mode and double-bounded dichotomous CVM are employed to address the zero response, and the obtained willingness to pay is statistically significant at the level of 1%, which verifies that the spike model can manage zero response results with better performance
- (2) Because there are differences in tax, it is easy to confuse respondents by regarding it as a payment method. In this study, it is found that living expenses are more effective as a payment method.
- (3) The annual willingness to pay 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 elderly and child family members, environmental knowledge and subjective norms exert significant impacts on residents' willingness to pay.
- (5) Anticipation of residents in environmental activities can be improved by increasing income, formulating compensation mechanisms, and increasing government transparency.

4.7.2 Outlook

- (1) The renovation of existing residential buildings is the core focus of significant research and development projects in China under the "13th Five-Year Plan" and involves numerous residential environment renovation projects. However, few studies have explored the application of willingness to pay in the renovation of existing residential buildings. Researchers can conduct thorough research from the perspective of the willingness to pay and influencing factors to guide the formulation and implementation of policies.
- (2) Most research studies, only consider two variables, namely, payment or withholding payment. However, there are 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 manage some complex multivariate research objects.
- (3) The protest rate is also a significant indicator in measuring CVM effectiveness and reliability, and it is also an important indicator for measuring the fitting degree of the spike model. However, there is still a lack of agreement on the definition of the protest response and true zero response, which needs to be verified through more comprehensive study by researchers.

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Chapter 5

HANGZHOU CITIZENS' WILLINGNESS TO PAY FOR LOW CARBON MEASURES – BATTERY SWAPPING STATION

CHAPTER FIVE: HANGZHOU CITIZENS' WILLINGNESS TO PAY FOR LOW-CARBON MEASURES – BATTERY SWAPPING STATION

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CHAPTER FIVE: HANGZHOU CITIZENS' WILLINGNESS TO PAY FOR LOW-CARBON MEASURES - BATTERY-SWAPPING STATION

5.1 Willingness to pay for battery-swapping station

In 2021, the construction of battery exchange facilities is included in new infrastructure projects to support electric vehicle substitution for fuel vehicles and reduce urban carbon emissions, in order to assess the environmental value of electric vehicle exchange stations, as well as to elicit their policy implications. We estimated the willingness of the public to pay for the exchange stations and their determinants in Hangzhou.

5.2 Research background

The development of new energy vehicles is important for promoting energy reform and alleviating urban air pollution to ease urban carbon emissions [34]. According to the National Bureau of Statistics, as of September 2021 the fleet of new energy vehicles reached 6.78 million, accounting for 2.3% of the total fleet. Among them were 5.52 million BEVs, 1.9% of the total fleet, making up most new energy vehicles. The Ministry of Industry and Information Technology states that the sales of BEVs will exceed 25% of total sales by the year 2025. As outdated fuel vehicles are gradually phased out, the fleet of BEVs will be significantly increased; this in turn significantly increases the public's demand for BEV energy replenishment. In this context, the National Development and Reform Commission announced in 2021 that battery swapping facilities would be included in new infrastructure projects, affording more attention to, and support for, BSSs.

BEVs have been criticized by the public due the long time to charge a car [35]. Even for a super charging pile, it takes over 30 minutes to fully charge a BEV (low power). The long charging time presents as an inconvenience to the public, and the urgency to solve the problem led to battery swapping, known as "battery swapping mode," as one satisfactory solution [36]. This operation allows efficient "charging" through the swapping of batteries via a robot at BSSs and generally takes 2 to 4 minutes [37], providing great convenience for travelling BEV owners. It is thus considered as the energy replenishment means most similar to traditional gas stations [38]. It is very important to promote electric vehicles to replace fuel vehicles and reduce carbon emissions in cities.

In China, most service providers of BSS business are BEV manufacturers whose business consists of 2 parts: the swapping and maintenance of batteries. Since many users worry that they will receive obsolete batteries and have their own interests harmed in battery swapping, they generally enter into a sales agreement concerning whether to accept separation of batteries when purchasing BEVs. Under such an agreement, a user only must pay for the price of the vehicle, excluding any cost of batteries, a cost that is instead apportioned on a monthly basis; specifically, a battery code is generated at initial instalment, so as to identify ownership of the battery, and no service fees or taxes ever arise from incurred installment payments, generally spanning a period of 5 to 7 years. During this period, the manufacturer will take charge of fault and maintenance of batteries unless human factors play a part in failure. The ultimate ownership of the batteries is vested in users. Since no extra costs means a reduced one-time expenditure when purchasing BEVs, most users accept the arrangement (Considering the life of the battery, it is actually more similar to the battery rental service).

BSS has been encouraged due to their reliance on clean energy [39]. Since there is no demand for

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instant charging, most batteries are charged using clean energy [40], which reduces the dependence on fossil energy. The Notice of National Development and Reform Commission on Further Improvement of Fiscal Subsidy Policies for Promotion of New Energy Vehicles asserts that BSS is important infrastructure and that the novel business mode of “battery swapping” should be encouraged. However, as of late 2020, a total of only 525 (47 stations in Zhejiang Province) BSSs were in use nationwide. This number accounted for only 1.5% of the total public charging stations and was far from meeting the people's demand. The contradiction between supply and demand is particularly prominent in Zhejiang Province where the fleet of BEVs is relatively larger than other regions. Therefore, in its “14th Five-Year Plan” for the development of charging infrastructure (Promulgated in July 2021), it is proposed that over 5,000 battery charging, and swapping facilities will be built within the province by the year of 2025, which drew wide attention from the public.

The Chinese government has formulated many policies to encourage construction and development of BSSs. Investors should first consider the public's attitude toward BSS construction and whether they will pay extra costs for the benefits (i.e., time saving or relief from urban air pollution due to use of clean energy) of BSSs. Investors should also assess the factors that influence the public's payment to help them better understand what they are investing in. Policy makers also need to understand the non-market value of BSS's positive externalities (environmental contributions, saving of time); this may prove helpful in carrying out a more comprehensive estimation of BSS's value and assist in formulating and revising policies. However, existing literature does not provide any satisfactory solutions to these problems. Thus far, most research has focused on studies at the technological level [38], lacking any discussion of BSSs from the economic perspective.

This paper offers discussion points on the public's attitude about BSS construction and estimates the BSS's non-market value from the economic perspective. The BSS's positive externalities may be positive influences in the fields of energy, environment and services. In this aspect, BSS may be considered as a public product whose development and construction may be impeded if the value of positive effects is not priced. The assessment of willingness to pay has become a common method for measuring non-market value [41]: willingness to pay refers to the maximum willingness of an individual to make a payment to obtain specific commodities or services or to avoid certain matters posing negative influences.

This paper contributes to the existing literature across the following three platforms: First, although China is devoting major efforts to promoting BSS construction, there is only limited economic study on the public's willingness to pay for BSSs; therefore, this study contributes to the expansion of existing relevant research into BSS. Second, there is zero response with contingent valuation method (CVM), and direct elimination of such data will result in the deviation of results. In this study, the combination of double-bounded dichotomous choice (DBDC) and spike model proposed by [42] is adopted for the first time for dealing with the zero-response problem in the willingness to pay for BSSs. The results suggest satisfactory fitting of the model, providing references for future researchers in dealing with zero response problems in battery charging and swapping of BEVs. Third, in addition to the traditional demographic variable, other covariates

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such as the theory of planned behaviour, policy concern and experience and knowledge relating to BEVs, and BSSs are added to offer new evidence for interpreting individuals' payment behaviours.

The remainder part of the paper is organized as follows: Part II offers a review of the existing literature; Part III introduces the methodology; Part IV presents analysis and discussions on the main results; and Part V offers a conclusion and policy implications.

5.3 Literature review

5.3.1 Study of willingness to pay for BEVs

BEVs are highly recommended due to their efficiency in relieving air pollution caused by internal combustion engines [43]. Nonetheless, the concept is still relatively novel. In the face of emerging new technologies and upgrading schemes, researchers generally evaluate willingness to pay for BEVs or its influencing factors from three aspects to provide effective recommendations for policy makers.

First, they consider improvement of the products' intrinsic attributes. Hidrue et al [44] evaluated the public's willingness to pay for BEVs and its influencing factors in the US. It was found that endurance mileage and charging time had significant influence on purchasers. They were willing to pay 35–75USD for BEVs for 1 additional endurance mile and 25–325USD for the reduction of 1 charging hour. Bansal et al. [45] evaluated consumers' willingness to pay for BEVs in India and found they were willing to pay 10–34USD for a reduction in charging time of 1 minute and 7–40USD for an increase in endurance mileage. Similar conclusions were reached by researchers [46-48] in Northern Europe, Ireland and China, respectively. Therefore, it can be considered that the public is very concerned about endurance mileage and charging time of BEVs.

Second, researchers consider the personal attributes of consumers, which are considered important factors influencing the willingness to pay for BEVs and new energy automobiles [49]. Among the factors are demographics [34,50,51,52], environmental awareness [34,53] and knowledge about new energy or BEVs [34, 52]. The research results of Cirillo [50] suggested that young people with high income and education were more apt to buy BEVs. Tan and Lin [34] believed that people with high income, private cars, knowledge about BEVs, environmental awareness and a high educational background had a higher willingness to pay. Ghasri et al [51] believed that gender would influence the public's willingness to pay but that income proved the determining factor. Other researchers suggested in-depth study of willingness to pay on a personal basis at the psychological level. Moons and Pelsmacker [54] held the opinion that sentiment, attitude and subjective norm all had a significant influence on willingness to pay for BEVs. Heberlein et al., [23] criticized the practice of considering only demographic information, asserting that more attention should be paid to interviewees' knowledge of and experience with researched objects and the psychological influence. The Theory of Planned Behavior [55] is a common method for predicting individuals' behaviours from the perspective of psychology, focusing on attitude, subjective norms and behavioural control; this method is widely adopted by researchers to explain why BEVs are purchased [56,57,58] and used [59, 60].

Third, studies focus on external policy. Noel et al [46] studied the willingness to pay and relevant policies for BEVs in five countries in Northern Europe, and the results suggested willingness to pay

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was related to policies. [61,62] carried out a study on the influence of subsidy policies to purchase, and the results indicated subsidy policies promoted the public's purchase of energy-saving automobiles. Yang et al [63] studied the influence of Chinese BEV policies on the public's purchase behaviours and found that people with concerns and interest toward BEV policies were more willing to use or purchase BEVs. Therefore, it is concluded that the concerns of policies significantly influence the public's behaviours.

5.3.2 Study of charging facilities of BEVs

Other researchers studied willingness to pay for BEV's charging facilities and its influencing factors. Tan and Lin, [34] evaluated the public's willingness to pay for construction of charging facilities in China and found that males with higher income or specific knowledge about new energy automobiles were more willing to pay for BEVs at the price point of 0.836 yuan/KW. Ardeshiri and Rashidi [51] evaluated the public's willingness to pay for fast-charging piles and carried out quantitative analysis of preferences for existing policies in Australia. Result showed that the public's willingness to pay was 31.9USD/year. Overall, there are limited studies on willingness to pay for charging facilities. In this paper, the researched object is BSS, which is a novel charging facility; no researchers have studied people's willingness to pay for it and the influencing factors. In fact, most current studies on BSSs are at the technological level [38], such as charging strategies [64,65], battery swapping technologies [66] and selection of sites [35,67], etc.

5.3.3 Relevant studies on contingent valuation method

Willingness to pay can be measured using CVM [68]. CVM is a method where interviewees' economic behaviors at a hypothetical market are examined based on their preference revealed from answering guided questions, whereby the consumers' willingness to pay is obtained, and the value of commodities or services is measured. It is considered an effective means to evaluate the non-use value of a specific public commodities and service products [69]. This method was also recommended by US National Oceanic and Atmospheric Administration (NOAA). At present, this method has been widely applied in new energy products, urban green land protection and environmental commodity evaluation, etc. [70,71,72,73]

There are three main kinds of inducing techniques for CVM:

- (1) Open-ended: Respondents directly bid for the highest acceptable willingness to pay. The disadvantage here is a lack of a reference point on the "maximum payment," which induces a low response rate to the questionnaire [74].
- (2) Payment-card: The interviewers can set multiple price options for the respondents to choose the most acceptable option. However, it is prone to cause "rounding consumption," namely that the willingness to pay of respondents would be concentrated on the integer bidding points provided by interviewers [75].
- (3) Dichotomous choice: Interviewers randomly question respondents within the determined bidding value range to observe whether they accept or reject the bid value. In contrast, respondents under the dichotomous choice only need to answer "accept" or "reject" for a certain bidding value, free from the necessity to provide a specific value for their willingness to pay. This contributes to preventing strategy bias in an incentive-compatible approach [76].

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Dichotomous choice can be divided into single-bounded dichotomy and double-bounded dichotomy, whose difference is the number of questions for respondents, with single-bounded once and double-bounded twice. [Cai et al.](#), [77] demonstrate that the accuracy of double-bounded is significantly higher than that of single-bounded. Therefore, NOAA recommends the method of using DBCD-CVM to induce the willingness to pay of respondents.

In CVM, there are often zero responses concerning the willingness to pay [78], which influences the evaluation results. There are three solutions: First, when a traditional Logit or Probit model is used for estimation, let's assume that willingness to pay distribution is greater than 0 or directly delete the zero responses [79]. However, human intervention will result in the deviation of results. The higher the probability of zero responses in the samples the greater the deviation of estimation with the traditional model. Second, the proportion of zero responses is reduced by distinguishing protest responses and true zero responses, thus removing the protest responses. A protest response belongs to certain aspects of evaluating interviewees' protest other than turning the evaluation of environmental products and services into zero. When protest responses are included in samples for discussion, there will be deviation in estimation results [80]. Nonetheless, the problems cannot be solved fundamentally. Third, the spike model [42] is used for processing data after the deletion of protest responses. The concept of the spike model was initially proposed by Kristrom. In this model, it is assumed that the distribution function of willingness to pay may not be zero at the zero point, which makes up for the drawbacks of traditional models such as an inability to process willingness to pay samples where there are zero responses and the deviation in overall estimation. Benjamin et al. [81] expanded the spike model to allow for the addition of covariates in estimating overall willingness to pay, thus enabling discussion of influencing factors of willingness to pay. [Yoo and Kwak](#) [82] first verified the validity of spike models and found that they were significantly better than traditional models in dealing with zero response; furthermore, the greater the proportion of true zero responses, the better fitting effect of a model. Currently, spike models have been widely used for evaluation of willingness to pay relating to renewable energy, mitigation of urban heat islands and wind power generation [83,84]. Overall, however, the application of this model remains limited.

Through literature review, it can be found that the public is much concerned about endurance and charging time of BEVs and is willing to pay extra fees for improvement of endurance and fast charging. Therefore, it's of great significance to study the public's attitude toward and willingness to pay for BSS construction. Regarding the influencing factors of willingness to pay for BSSs, a discussion is included in Section 4.2 informed by the experience of predecessors. In this paper, the CVM-DBDC recommended by NOAA is used as the persuasive technology of willingness to pay and the spike model is adopted to solve zero response problems.

5.4 Data collection

5.4.1 Data collection site

Questionnaires were conducted in jurisdictions in Hangzhou, Zhejiang and China. Hangzhou ranks highest in China in terms of sales and BEV parc. According to the National Bureau of Statistics, as of October 2021 Hangzhou ranked in the top 5 in China in terms of sales of BEVs. In Hangzhou, the BEV

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parcs have exceeded 200,000, accounting for nearly 10%. However, only 35 BSSs have been put into use, causing great supply-and-demand tension. Therefore, the Hangzhou municipal government focused great attention on BSS construction and has formulated a series of policies to promote BSS construction. Moreover, Hangzhou shows considerable potential for supporting BSS construction due to its strong economy. Hence, the survey was carried out in Hangzhou.

5.4.2 Means of questionnaires

There are three main ways to investigate environmental products [34], namely the online questionnaire survey, telephone interviews and face-to-face interviews. A low response rate is common in the online questionnaire survey while the limitations of cost and duration must be considered in telephone interviews. In comparison, a high response rate can be obtained through face-to-face interviews, which is conducive to collecting immediately feedback from the public and understanding the public's attitude and emotion towards the research object. Therefore, the face-to-face interview is selected as the survey method in this study, which is consistent with the recommendation of NOAA [85].

5.4.3 Instruments of payment

First, interviewing instructions are provided for 24 interviewers, including the research background, content, relevant policies, respondents' rights and answers to feedback questions. They are subsequently divided into eight groups, with three members in each group, including one manager and two interviewers, which could avoid any adverse impacts from the interviewers' emotions on the statistical results [24]. A total of 1051 respondents from 13 districts of Hangzhou City are randomly selected based on the population proportion for face-to-face interviews. To ensure the accuracy of the results, the respondents shall be between 18 and 65 years old (in accordance with *Road Traffic Safety Law of the People's Republic of China*, people 18 to 65 years old can apply for a driver's licence, and those over 65 years old are prohibited from applying for a driver's licence).

The face-to-face interview is divided into three stages: pre-survey, initial survey and formal survey. The purpose of the pre-survey is to determine the bid value, bid range and instruments of payment. In the initial survey, we queried all interviewers about whether they were able to represent their family in giving the answers and whether they were residents of Hangzhou. The formal questionnaire followed (Appendix A. Table A1, A2, A3).

Based on the results of the pre-survey, a total of 8 groups of bidding values are arranged. Combined with the data obtained from the pre-survey, 10 bidding points (including 5, 10, 25, 50, 100, 200, 400, 800, 1,600 and 3,200) are selected. To avoid missing bidding points in the second round of inquiry, points 5 and 3,200 are avoided in the first round of inquiry. The bidding values of the eight groups are (5/10/25), (10/25/50), (25/50/100), (50/100/200), (100/200/400), (200/400/800), (400/800/1,600) and (800/1,600/3,200) CNY in the order from small to large. (The middle amount in the data group is first selected for inquiry. If rejected, the lower amount in the data group will be selected for inquiry; if it is allowed, the higher amount in the data group will be selected for inquiry.)

The formal questionnaire consists of four parts: the first part is the demographic information about

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interviewees, which covers sex, age, education background, individual income of interviewees and whether their family owns BEVs. The second part focuses on interviewees' experience and knowledge of BEVs and BSSs, their concerns about policies and environmental awareness. The third part is about the theory of planned behaviour, which includes attitude, subjective norms and perceived behavioural control. The core question about willingness to pay for BSS construction is whether the family is willing to pay extra consumption taxes if the Hangzhou Municipal Government intends to double the efforts to promote BSS construction in response to the Zhejiang Province's objective of building more than 5000 BSSs by the year 2025. There are multiple answers in each question ([Appendix A. Table A3](#)).

5.5 Result

5.5.1 Data statistics

In this study, interviews were conducted with 1051 interviewees in Hangzhou who were able to represent families. Among them, 360 interviewees rejected payment. There were 15 unqualified questionnaires (deleted). Then, a judgment was made on whether the 360 rejection samples constituted a protest response in accordance with the criteria of protest response in relevant literature [86,87,88]. There were five circumstances in total, where circumstances A and B constituted a true zero response and circumstances C, D and E constituted a protest response.

A: Inability to make payment due to low income

B: No benefit from BSS

C: The government should assume the liabilities and pay for BSS construction

D: The project lacks reality

E: The new infrastructure has nothing to do with me

Among them, 128 chose A; 68 chose B; 130 chose C; 19 chose D; and 30 chose E. The protest samples were deleted since they were randomly distributed. Finally, an analysis was made of the 872 questionnaires that conformed to the requirements on sample size required for Schaeffer equation [89,90]. The distribution of the 872 interviewees' residential places was compared against the population distribution of each jurisdiction released by the Statistics Bureau of Hangzhou. It can be learned from Figure 1 that the population distribution of samples closely aligns with the official data. Hence, the samples were strongly representative.

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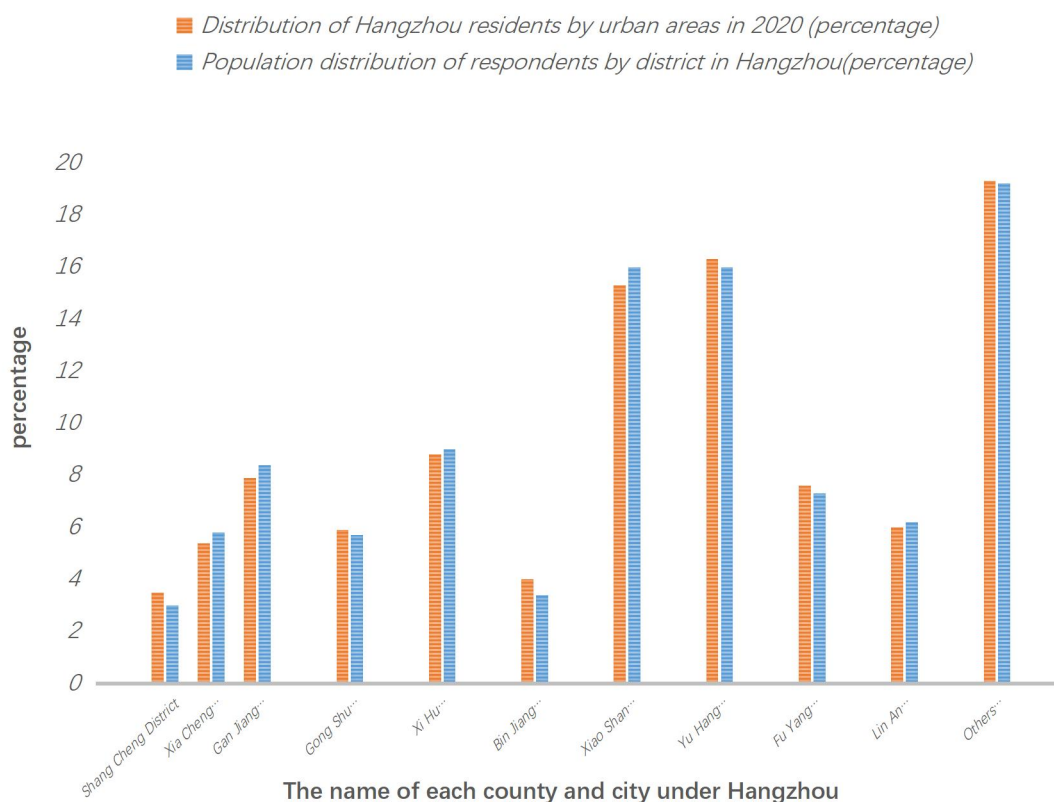


Figure 5-1. Comparison between the proportion distribution of samples in each jurisdiction of Hangzhou and the official data of population distribution (Source: Statistics Bureau of Hangzhou <http://tjj.hangzhou.gov.cn/>)

The statistics of bidding groups suggested respective distribution response, as shown in Table 1. With increased bid value in bidding groups, the public with willingness to pay gradually declines and those who reject payment gradually increase. In the minimum bidding group, about 93% of interviewees agreed to pay a minimum cost of 5 CNY; in the maximum bidding group, 9% of interviewees agreed to pay a maximum cost of 3200 CNY; this conforms to the recommended value range [25,91]. A total of 77% of interviewees' willingness to make payment was greater than 0, which was similar to the result that 74.2% peoples were willing to pay for fast charging piles in Australia [92]. There were 22% samples with zero response. Therefore, the spike model was adopted for estimating willingness to pay.

Table 5-1. Distribution of response of each bidding group

Bid Amount	YY	YN	NY	NNY	NNN	SUM
(25/10/5)	52 (47%)	34 (32%)	11 (10%)	4 (4%)	8 (7%)	109(100%)
(50/25/10)	43 (39%)	35 (33%)	11 (10%)	10 (9%)	10 (9%)	109 (100%)

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(100/50/25)	36 (33%)	30 (28%)	13 (12%)	10 (9%)	20 (18%)	109(100%)
(200/100/50)	29 (27%)	29 (27%)	15 (14%)	10 (9%)	26 (23%)	109 (100%)
(400/200/100)	28 (25%)	28 (27%)	15 (14%)	11 (10%)	27 (24%)	109(100%)
(800/400/200)	22 (20%)	24 (22%)	16 (15%)	17 (16%)	30 (27%)	109 (100%)
(1600/800/400)	14 (13%)	21 (19%)	14 (13%)	23 (21%)	37 (34%)	109(100%)
(3200/1600/800)	10 (9%)	17 (16%)	12(11%)	26 (23%)	44 (41%)	109 (100%)
sum	234 (26%)	218 (25%)	107 (13%)	111 (13%)	202 (23%)	872 (100%)

The mean value of covariates in samples was calculated, with a standard deviation shown in Table 2. The official data about gender, age, work, final education and average monthly household income were available from the Statistics Bureau of Hangzhou. Upon comparison, it was learned that there was significant difference between the data of final education and age and the official statistics, while the data of gender, work and income were close to the official statistics. The deviation from the official statistics is probably due to many college students flowing into Hangzhou every year since it is an emerging innovative city. It is also possible that there is certain limitation of sampling due to the limited size of samples. Except for age and educational background, there was no difference in terms of other variables. Therefore, we believe that the samples are suitable for pre-estimation of the entire population.

According to the mean value, it was also found that those with BSS experience and relevant knowledge were obviously fewer than those with BEV experience and relevant knowledge. This is probably because there is already a certain scale of BEVs; furthermore, many sales outlets provide more opportunities concerning the public's experience and knowledge. The BSS is, however, still a novel concept, and moreover, there are relatively fewer batter swapping stations to offer the public adequate knowledge and experience relating to BBS. Over half of the public expressed some attentions to BSS policies and believed that BSSs will contribute to environmental protection. In the psychological covariate questions relating to Theory of Planned Behavior, most of the public gave positive responses.

Table 5-2. Sample statistics and definition of variables

Variable	Mean	Dev	Census
Gender (Male =1, Female=0)	0.51	0.50	0.50
Age (18 ≤ Age < 25 =1, 25 ≤ Age ≤ 55=2,	1.98	0.76	1.63

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55 < Age ≤ 65=3)

Final education (University degree or above=1, others=0)	0.62	0.49	0.41
Job (Have stable job=1, others=0)	0.70	0.47	0.71
Monthly household income (More than 15389CNY=1, others=0)	0.68	0.47	0.70
Does your family own an BEVs (Yes =1, NO =0)	0.11	0.32	
Attention to BES policy or Not (Yes =1, NO =0)	0.53	0.50	
Have BSS experience (Have experience =1, No experience =0)	0.26	0.44	
Have BEVs experience (Have experience =1, No experience =0)	0.56	0.49	
Think BSS is good for the environment (Yes =1, NO =0)	0.51	0.50	
Have BEVs knowledge (Have the knowledge =1, NO =0)	0.54	0.50	
Have BSS knowledge (Have the knowledge =1, NO =0)	0.25	0.44	
Attitude (Consider that BSS will provide a convenient service and is very important =1, NO =0)	0.71	0.45	
Subjective norm (Use BSS will be supported by families=1, NO =0)	0.72	0.45	
Perceived behavioral control (Have sufficient resources to support BSS construction =1, NO =0)	0.67	0.41	

5.5.2 Estimation with covariates

Table 3 reveals the estimation results when parameters were estimated with maximum likelihood function. Based on different attributes of covariates and by reference to the previous studies in Section 2.1, there were a total of five estimation models (Model 1-5). Model one contains 8 demographic characteristics. Tan and Lin [34] believed that interviewees with private cars were more apt to make payment. Therefore, whether an interviewee's family had BEVs was included into Model one for discussion. According to the study by Peters et al, [93] and Yang et al, [94], relevant policies will cause an influence on payment; furthermore, those with more interest and concern toward relevant policies were more apt to make payment. Hence, based on Model one, the variable of concerns toward BSS policies was added into Models 2-5, to study its influence on interviewee's willingness to pay. The people with more knowledge of the researched object, relevant experience and stronger environmental protection awareness were more apt to make payment [23,95]. Thus, BSS experience was added into Models 3-5. In Models 4-5, the variables relating to BSS knowledge and environmental awareness were added. Ajzen [96] pointed out that

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behavioural intention might influence the willingness of payment, thus the three covariates in Theory of Planned Behavior were added into Model 5. The obtained data are analyzed by partial correlation coefficient to avoid the deviation in traditional method, but no significant abnormal values were observed.

Among the demographic characteristics in Models 1–5, the income and whether with possession of BEVs demonstrated statistical significance at the 1% level. This means that families with above-average income and BEVs had higher willingness to pay, which is consistent with the conclusion reached by Tan and Lin [34]. There was no correlation between genders and willingness to pay. In Models 1-3, there was certain correlation between the education of interviewees and willingness to pay; in Models 4–5, however, such correlation did not exist. This differs from Cirillo’s opinion [97] that gender and education background had significant influence on willingness to pay. This is probably because BSS was a new concept and the public had limited knowledge of it. The willingness to pay of interviewees aged above 55 was negative, because seniors showed low acceptability regarding new things. The covariate of policy concern showed statistical significance at the 1% level, indicating that interviewees with more concern about BSS policies had higher willingness to pay for BSS construction; this is consistent with the research results of Yang et al., [94] concerning the influence of Chinese BEV policies on willingness to pay. Therefore, it’s presumed that public concern about policies has significant influence on willingness to pay, particularly in developing countries like China where such policies will have significant influence on industrial orientation. In Models 3–5, interviewees with BEVs and BSS experience had higher willingness to pay, which means that increased experience opportunity for the public might be helpful in promoting the public’s engagement in BSS construction. In Models 4-5, the people with more knowledge about BEVs and BSSs and environmental awareness had higher willingness to pay, which is consistent with the conclusion reached by Tan and Lin [34]. In Model 5, there was a strong correlation among attitude, subjective norm, perceived behavioural and willingness to pay; this means that interviewees who believe BSSs are important and can provide convenience services for the public, the interviewees whose use of BSSs is supported by their families and the interviewees who have adequate resources to support BSS construction are willing to make more payment for BSS construction. This study result aligned with other research conclusions [23.34.54] asserting that Theory of Planned Behavior had a significant influence on payment.

Table 5-3. Estimation results with covariates

Variable	Model 1		Model 2		Model 3
	Coef	p values	Coef	p values	Coef
Constant	-0.271	0.805	-0.031	0.857	-0.231
<i>Demographic attributes</i>					
Gender	0.012	0.501	0.089	0.672	0.041
18 ≤ Age < 25	0.196	0.632	0.161	0.703	0.121

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25 ≤ Age ≤ 55	0.543	0.316	0.605	0.891	0.121
55 < Age ≤ 65	-0.014	0.522	-0.219	0.750	-0.449
Income	0.821	0.000***	0.551	0.000***	0.619
Final education	0.218	0.061*	0.259	0.031**	0.211
Employment	0.089	0.577	0.039	0.801	0.065
<i>Policy attention</i>					
Attention to BSS policy			1.231	0.000***	0.909
<i>Relevant experience</i>					
BSS experience					1.161
BEVs experience					0.869
<i>Relevant knowledge and beliefs</i>					
Think BSS will be good for the environment					
BEVs knowledge					
BSS knowledge					
<i>Theory of planned behavior</i>					
Attitude					
Subjective norm					
Perceived behavior control					
Bid	0.004	0.000***	0.004	0.000***	0.004
spike	0.251	0.000***	0.254	0.000***	0.254
MTP	407.463	0.000***	415.589	0.000***	426.157
95% confidence interval	378.126 ~ 434.023		387.157 ~ 445.021		399.448 ~ 454.017
99% confidence interval	372.456 ~ 445.216		379.801 ~ 455.753		390.457 ~ 462.543
Wald statistic	696.812	0.000***	699.554	0.000***	705.117

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Log-likelihood -1512.611 -1476.458 -1464.146

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

Table 5-4. Estimation results with covariates

Variable	Model 4		Model 5	
	Coef	p values	Coef	p values
Constant	-0.552	0.836	-0.713	0.768
<i>Demographic attributes</i>				
Gender	0.026	0.799	0.043	0.651
18 ≤ Age < 25	0.119	0.831	0.159	0.821
25 ≤ Age ≤ 55	0.726	0.811	0.566	0.803
55 < Age ≤ 65	-0.589	0.528	-0.690	0.412
Income	0.591	0.000***	0.557	0.000***
Final education	0.177	0.149	0.172	0.241
Employment	0.095	0.469	0.037	0.821
<i>Policy attention</i>		0.026		
Attention to BSS policy	0.914	0.000***	0.765	0.000***
<i>Relevant experience</i>				
BSS experience	0.807	0.000***	0.961	0.000***
BEVs experience	0.876	0.015**	0.748	0.000***
<i>Relevant knowledge and beliefs</i>				
Think BSS will be good for the environment	0.760	0.022**	0.714	0.033***
BEVs knowledge	0.783	0.026**	0.707	0.023**

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BSS knowledge	0.813	0.000***	0.705	0.000***
<i>Theory of planned behavior</i>				
Attitude			0.241	0.039**
Subjective norm			0.299	0.053*
Perceived behavior control			0.233	0.045**
Bid	0.004	0.000***	0.004	0.000***
spike	0.255	0.000***	0.256	0.000***
MTP	433.514	0.000***	445.418	0.000***
95% confidence interval	406.123~ 462.315		418.147~ 472.475	
99% confidence interval	397.152~ 471.326		409.142~ 484.127	
Wald statistic	704.322	0.000***	749.598	0.000***
Log-likelihood	1436.602		-1466.265	

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

5.5.3 Estimation without covariates

Table 4 presents the estimation results without covariates. The setting of covariates may have an impact on the valuation results [31]. Therefore, we use a model without covariates to estimate the willingness to pay. The function of the maximum likelihood estimation is adopted for the estimation of parameters. The Spike value is 0.247, which is almost identical to the zero response (23%) in Table 1, indicating that the estimated data is consistent with the data in this study. The spike model is well simulated. Since the value of p is less than 0.01, the Wald statistics rejects the null hypothesis with the estimated parameter being zero. Moreover, Krisky and Robb's parametric bootstrap method (including 5000 repetitions) is adopted to obtain 95% and 99% confidence intervals of the estimated value [98]. They were 370.13–429.16 CNY and 361.75–441.86 CNY, respectively.

In Hangzhou, the annual average willingness to pay per household was 400.52CNY (62.71USD), which was higher than that of the willingness of Australian households to pay 31.91USD for fast-charging piles every year [99]. This is probably because there is more urgent demand for BSSs due to larger BEV parc in China. The higher willingness to pay of the public in China may be also because of BSSs' advantages over fast-charging piles in terms of charging efficiency and environmental protection.

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Table 5-5. Estimation results without covariates (Estimation result of the willingness to pay)

Variables	coefficient	T values	P values
constant	0.617	9.887	0 ***
beta	0.002	26.866	0 ***
spike	0.247	24.650	0 ***
MTP	400.521	26.322	0 ***
interval_95	370.125~429.157		
interval_99	361.754~441.863		
Wald statics	733.411		0 ***
Log-likelihood	-1742.366		

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

In 2021, there are a total of 4,436,000 permanent households in Hangzhou. When the annual willingness to pay is expanded to all households in the city, the total amount paid by households for BSS construction is about 1.78 billion CNY (0.28 billion USD); it can be considered that the value of BSS's positive externality in Hangzhou is 1.78 billion CNY. The data suggests that the construction cost of BSS bodies in China is about 2.70 million CNY (excluding batteries). On this basis, that is sufficient for constructing 658 BSSs every year in Hangzhou. Since there is a considerable amount of money for BSS construction in Hangzhou, it is guessed that there's high feasibility to promote BSSs in this city. Considering that Hangzhou is just one central city in the Zhejiang province, we presume it is feasible for Zhejiang Province to construct 5000 BSSs by the year 2025.

5.4.4 Descriptive Analysis

As the public still did not have much knowledge about the novel concept of BSSs, the inquiry on how those with knowledge about BSSs obtained the information may help decision-makers in deciding about reasonable means of information communication. We interviewed 218 people with knowledge about BSSs. Among them, 29 learned from books, 106 from the internet, 60 from TV, 10 from newspapers, 6 from community publicity and 7 from other means (Figure 2).

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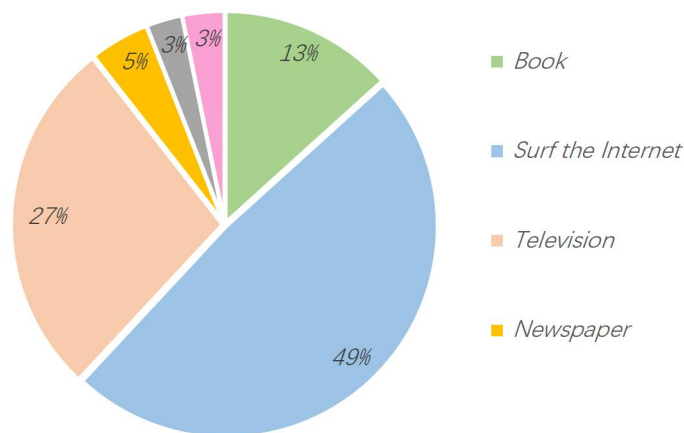


Figure 5-2. Public information sources of the BSS

We also collected all interviewees' suggestions for the government. 301 interviewees suggested some increase of BSS construction within communities; 103 interviewees suggested strengthening publicity on the value of BSSs and BEVs regarding environmental improvement; and 158 interviewees suggested the provision of more subsidies to the use of BSSs within communities. Interestingly, all these interviewees rejected making payment. 117 interviewees suggested an increase in subsidies to purchase BEVs that support BSSs; 118 interviewees suggested the formulation of relevant policies to realize integrated BSSs nationwide; and 75 interviewees made other choices (Figure 3).

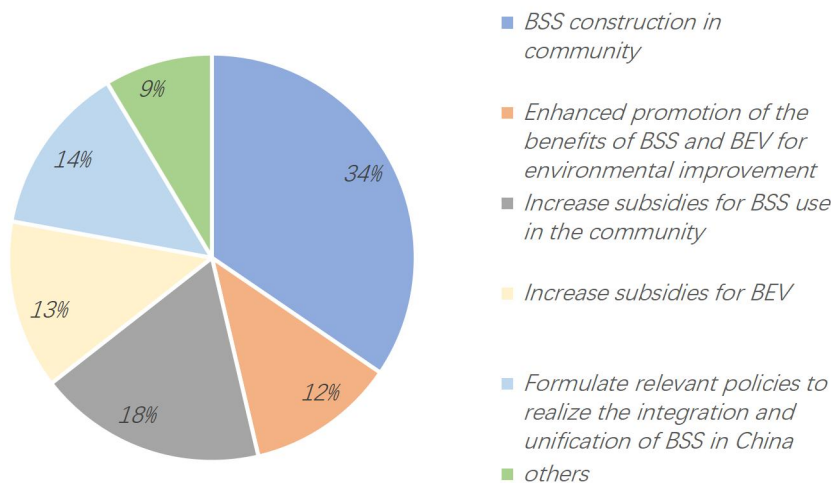


Figure 5-3 Suggestions for government for promoting citizens' participation regarding construction of BSS

5.6 Conclusion and Policy Implications

5.6.1 Conclusion

We carried out a random survey on the public's attitude toward BSS construction and their

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willingness to pay in Hangzhou, Zhejiang, China. With DBDC in CVM as the persuasive technology for the public's willingness to pay, a total of 1051 samples were collected. After deletion of protest samples and invalid samples, there were 872 valid samples. The willingness to pay of 77% households in Hangzhou was greater than zero. The remaining 23% zero response samples were treated with the spike model, where the result suggested that the fitness of the spike model was satisfactory and that the average annual willingness to pay of households was 400.52CNY (62.71USD). the value of BSS's positive externality in Hangzhou is 1.78 billion CNY (0.28 billion USD). In addition, the influencing factors of willingness to pay were also discussed. The main findings are summarised as follows:

First, families with above-average income, or have BEVs and some interviewees with higher education are willing to pay more for BSS construction.

Second, if interviewees or their families are concerned about BSS policies, they are willing to pay more for BSS construction.

Third, if interviewees have experience with BEV or BSS or knowledge about BEVs or BSS or the belief that BSS is helpful for environmental protection, they are willing to pay more for BSS construction.

Fourth, if interviewees believe that BSSs are important to them and will bring convenience (attitude), or if their use of BSSs will be supported by their families (subjective norm), or if they have adequate resources to support BSS construction (Perceived behavioural control), they are willing to pay more for BSS construction. The covariate in the theory of planned behaviour has considerable influences on interviewees' payment behaviour.

5.6.2 Policy Implications

The following policy implications may be proposed based on these conclusions. First, in developing energy policies, policymakers should consider measures to raise public awareness of the energy and environmental positive externalities associated with BSS and to increase public interest in policies to make people aware of the need for BSS. Second, it is necessary to mention public willingness to pay when developing energy policies related to BSS. As more than 76% of the public in our study would pay extra for BSS construction, incorporating willingness to pay into the development of energy policies may help increase investors' interest in new energy products. Third, the public's experience of new energy products is very important. In our study, respondents with BSS or BEVS experience are more willing to pay. Therefore, increasing user experience should be included in the scope of the energy policy, which may help to promote new energy products.

We admit that there are significant limitations to this study. Since only interviewees in Hangzhou were surveyed, the result is subject to restrictions such as regional influence, sample size and local government policies. Therefore, the study scope should be expanded to provide more accurate and more effective policy recommendations.

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Chapter 6

***WILLINGNESS TO PAY FOR ENVIRONMENTAL
PROTECTION COMPARED TO WILLINGNESS
TO PAY FOR REDUCING URBAN CO₂
EMISSIONS AND FACTORS AFFECTING
WILLINGNESS TO PAY***

**CHAPTER SIX: COMPARISON OF WTP FOR ENVIRONMENTAL PROTECTION
AND WTP FOR MITIGATION OF URBAN CO₂ EMISSIONS IN QINGDAO AND
FACTORS INFLUENCING WTP**

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CHAPTER SIX: SHANDONG HOUSEHOLDS' WILLINGNESS TO PAY FOR LOW CARBON CITY MEASURE

6.1 Introduction

In this section, we develop models for predicting payments for environmental protection and payments for low-carbon urban strategies, based on traditional Theory of Planned Behavior models, to which we add some variables to extend the models. We also compare them. In order to explore the similarities and differences between them, and to provide implications for the promotion of low carbon city construction measures.

Firstly, in Model 1 we capture the variables related to environmental protection and willingness to pay through the protection of the beach environment by Qingdao citizens. The beach environment provides a variety of services such as aesthetics, habitat for marine and terrestrial flora and fauna, protection from coastal hazards, recreation, and income-generating opportunities [1,2,3]. These services have accelerated the development of tourism and urbanization in coastal areas, creating coastal population centers and coastal dependent economies.

Coastal tourism has always occupied an important position in China. According to "China's 21st Century Ocean Agenda" in 1996 and "National Ocean Economic Development Plan" in 2003, coastal tourism was proposed as a new pillar industry of regional economy, and "coastal resort tourism" was identified as one of the 12 most important national tourism routes in 2009. With the development of coastal tourism, the beach environment is getting more and more attention from people. Coastal tourism has led to debates on the environmental impact and compatibility of human activities [4], and beaches are one of the most important natural capital assets in coastal areas [1,5], and it is of great importance to achieve the protection of the beach environment. However, beaches are currently being eroded [6,7,8,9] negatively impacting the normal functioning of beach ecosystems [10].

Qingdao is a coastal city in Shandong Province, China, and is a famous tourist city with a long coastline, many bays and high-quality beaches. In recent years, with the rapid development of tourism and the increase in the number of tourists, the beaches of Qingdao's seaside landscape have faced problems such as beach pollution and harmful algal growth [11]. The pollution of beaches has a negative impact on the sustainable development of the city, so it becomes very important to protect the beach environment.

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Fig 6-1 Qingdao City Administrative Map

As a public good with important impacts on the environment and ecosystem, the beach environment is an environmental good among public resources with characteristics of public interest and environmental behavior, but its value has not been priced, which is not conducive to quantifying the value of public goods and enabling decision makers to formulate relevant conservation measures and policies. Therefore, it is essential to put a value on it. Researchers have done extensive studies on the willingness to pay for beaches. Liu et al., [11] assessed the non-use value of tourism resources in Qingdao beaches. Choi et al., [12] studied the willingness to pay to prevent beach erosion. However, there are relatively few discussions on beach environmental protection.

We also explored the influencing factors that affect residents' willingness to pay for environmental protection. First, most of the research to date on the nature of individual pro-environmental behavior has been limited to variables of social factors such as demographics [13,14]. However, these variables have been criticized for explaining only modest differences in measures of environmental behavioral intentions and behaviors [15]. Researchers then turned to focus on psycho-social constructs such as attitudes, subjective norms, and beliefs, which studies have shown to better predict people's environmental behaviors. A common feature of these studies is that they are based on the idea that people's behavior is influenced by their thoughts and feelings about the environment and pro-environmental behavior. The most popular approach in this type of research is the Theory of Planned Behavior (TPB), which was introduced and developed by Ajzen in 1991. It reflects the individual's attitudes, subjective norms and perceived resources towards a particular behavior can help us to better understand environmental behavior [16].

Since the implementation of low-carbon city construction measures is fundamentally about environmental protection, it is important to explore the mechanism of public influence on environmental protection payments for the implementation of environmental policies and the

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promotion of green low-carbon city measures. However, no study has so far compared the behavioral variables of low-carbon city construction measures and environmental protection payments. to explore the differences between them.

Therefore, we discuss in Model 2 the willingness of Qingdao citizens to pay for the mitigation of CO₂ emissions in the city and evaluate the factors influencing the mitigation of CO₂ emissions and compare the variables of Qingdao citizens to protect the beach environment and mitigate CO₂ emissions.

This paper differs from previous studies in the following main points. First, this paper extends the model of the original Theory of Planned Behavior and explores its relationship with the behavioral motives of environmental protection and payment for low-carbon city construction measures. Second, there are many studies that apply the extended TPB model to explain people's behavioral intentions to improve the urban environment. For example, waste separation, urban heat island, wetland conservation, etc. Or for flora and fauna conservation such as wetland animal protection. However, to our knowledge, research on beach environmental protection is limited, and research on the difference between environmental protection behavior and low-carbon urban construction behavior is even more scarce.

6.2 Research method

6.2.1 Goods to be appraised

The products evaluated in our study have two main aspects

The first is for the environmental value of beach protection. (In the interview, each of our interviewees introduced the impact of environmental damage to the beach, and then the importance of beach protection, and the relevant policies of Qingdao municipal government on beach protection).

The second is the willingness of Qingdao citizens to pay for the mitigation of urban carbon emissions. (In the interview, we first introduced to each interviewee the impact of carbon emissions on the environment, and then introduced the importance of reducing urban carbon emissions, and the relevant policies of Qingdao municipal government on reducing urban carbon emissions).

The same group of respondents was selected for the above two control groups. They responded to the following two sets of questions separately. to ensure the validity and reasonableness of the questionnaire.

6.2.2 Survey and design

We conducted a pre-survey prior to the formal survey study with the purpose of determining the range of values for the conditional value method and determining the acceptance of the questionnaire. The pre-study for the willingness-to-pay survey used a payment card-style bid format, and 50 respondents were interviewed prior to the survey. The formal study began on July 6, 2021 and lasted 12 days. We took the form of an online questionnaire and eventually received 526 valid questionnaire responses.

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In the elicitation method of willingness to pay, we used a two-boundary dichotomous conditional value method, and the study showed that the elicitation method of willingness to pay has a great impact on willingness to pay, and the results of payment card-based or open-ended valuation are prone to bias, so we used a dichotomous formula to estimate the results, which is considered to help respondents can have a more complete understanding of the evaluation process and is an incentive-compatible elicitation method, which is also very effective in reducing the bias of the strategy [18].

Numerous studies have shown that the method of elicitation of willingness to pay has a significant impact on people's willingness to pay [18]. Therefore, we chose the dichotomous choice format as an elicitation method for willingness to pay. The advantage of the dichotomous choice format is that it helps respondents to go through a complete assessment process. In addition, as an incentive-compatible elicitation method, it allows for the prevention of strategic bias [17]. Regarding the choice of payment instrument, we used taxation, which respondents should be familiar with, as the payment instrument. Because it is a mandatory payment method, it reduces the risk of free-rider pairs [17] and the risk of over-pledging. In terms of payment frequency, we chose the annual fee as the frequency of payment.

The first part contains demographic information and socio-economic characteristics of the respondents, and the second part discusses the respondents' willingness to pay for beach protection and reduction of CO₂ emissions in the city respectively. The core questions of willingness to pay are: 1. If the Qingdao municipal government needs funds to protect the beach environment, based on your personal experience and the information mentioned above, how much your household would be willing to pay annually to protect the beach environment, considering your personal circumstances; 2. If the Qingdao municipal government needs funds to reduce the city's carbon dioxide emissions for environmental protection. Based on your personal experience and the information mentioned above, how much would your household be willing to pay annually to mitigate the city's CO₂ emissions, taking into full consideration the individuals. Based on the results of the pre-survey we chose five bid groups (10/20/40), (20/40/80), (40/80/160), (80/160/320), (160/320/640) to estimate the willingness to pay.

6.3 A model based on the theory of planned behavior

The theory of planned behavior is an important foundation for predicting and explaining individual behavior [16]. Some researchers argue that people will behave in a particular way if they believe that their behavior will lead to a particular outcome, if their significant family and friends would support their behavior, and if people believe they have the resources and ability to perform a certain behavior, people will tend to perform the specific behavior.

The theory of planned behavior is a further development of the theory of rational behavior. The theory of rational behavior assumes that people's behavior is effective when it is controlled by volition, while most human behavior is controlled by some non-volitional factors [19,20]. The theory of planned behavior increases the scope of the theory of rational behavior and compensates for the deficiencies of the theory of rational behavior in the context of nonrational control by including some variables that are not related to volitional factors. The original theory of planned

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behavior suggested that behavioral intention is the most proximal predictor of behavior, and that behavioral intention is influenced by three factors: 1. Attitude: people's positive or negative evaluation of a behavioral choice. 2. Behavioral intention: an individual's tendency to perform something. 3 Perceived behavioral control: the ease or difficulty of performing the behavior. Several studies have generally concluded that more positive attitudes, more positive social norms, and stronger perceived behavioral control can enhance people's willingness to perform a particular behavior.

In this study, structural equation modeling was applied to calculate the factors affecting WTP. Data processing was performed using AMOS25 and descriptive analysis was performed using SPSS24.

According to the model of the theory of planned behavior, a respondent is more likely to pay for environmental products if he/she holds positive attitudinal behavior choices, if the respondent's family and friends support his/her behavior, and if the respondent believes that he/she can participate in activities to protect urban lakes to mitigate the UHI effect. Therefore, based on the above discussion, the following 2 sets of hypotheses were made.

Group 1 (Qingdao City Beach Environmental Protection)

H1-1: Individual willingness to pay increases if attitudes toward protecting the beach environment are more positive.

H1-2: Individuals' willingness to pay increases if subjective norms about protecting the beach environment are more positive.

H1-3: People's willingness to pay will increase if perceived behavioral control over the protection of the beach environment increases.

In the theory of planned behavior, there is less discussion about its intrinsic variables, which is not conducive to better prediction of people's payment behavior, so we propose the following hypothesis to discuss the relationship between the variables of the theory of planned behavior.

H1-4: If attitudes about protecting the beach environment are more positive, people's subjective norms about behavioral choices are also more positive.

H1-5: If attitudes about protecting the beach environment are more positive, people's perceived behavioral control over behavioral choices will increase.

H1-6: Perceived behavioral control over behavioral choices increases if subjective norms about protecting the beach environment are more positive.

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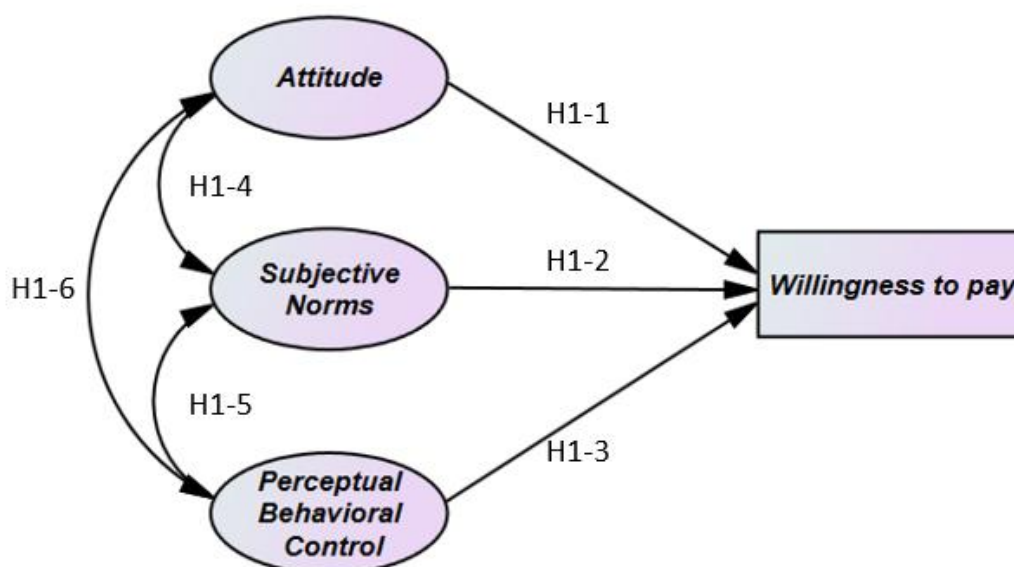


Fig 6-2 Traditional Theory of Planned Behavior Prediction Model (The environmental protection)

Although many studies have pointed out that the theory of planned behavior framework can be used to predict people's behavioral intentions and behavior towards environmental protection, however, many researchers believe that its explanatory power is limited. Therefore, many researchers have proposed extended versions based on the theory of planned behavior aiming to improve its explanatory power [21,22].

In China, the management of environmental policy has been top-down, and the public lacks the opportunity to participate in environmental management. 2015 saw the inclusion of public participation in environmental management in the Environmental Protection Law of the People's Republic of China. This indicates that individuals can truly participate in environmental protection. In China, environmental strategies as well as low-carbon strategies cannot be separated from the influence of policies. The mitigation of urban CO₂ emissions and the protection of the beach environment in our study are due to a series of studies conducted after the central government has formulated relevant policies. Therefore, policy perception is a very important influence on public behavior. Unfortunately, the discussion of policy perceptions has been particularly limited. Urban low-carbon strategies and environmental policies. We therefore include policy perception as a non-independent variable in the theory of planned behavior to discuss the impact on pro-environmental behavior. We propose the following hypothesis:

H1-7: Policy perceptions are positively correlated with individuals' environmental attitudes.

H1-8: Policy perceptions are positively correlated with individuals' subjective environmental norms.

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H1-9: Policy perception is positively correlated with individual control of perceptual behavior.

H1-10: The more policy-aware individuals are, the more willing they are to pay.

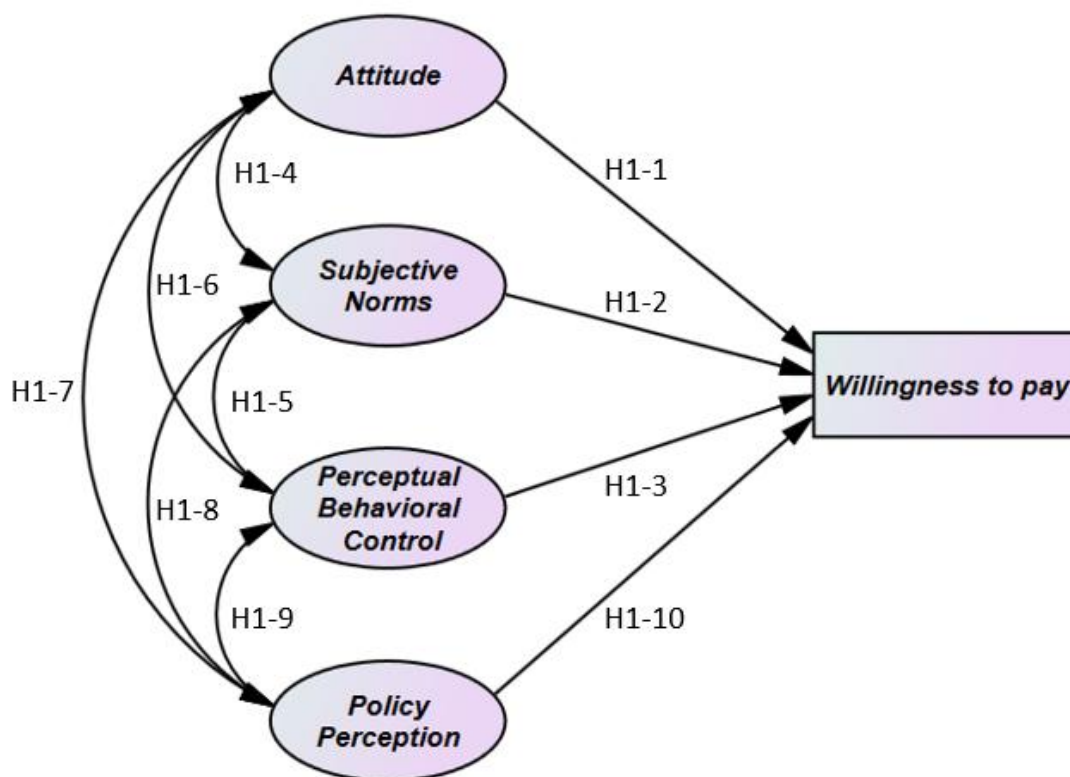


Fig 6-3 An expanded theoretical model of planned behavior (The environmental protection)

Group 2 (mitigation of urban CO₂ emissions in Qingdao)

H2-1: Individual willingness to pay increases if attitudes toward reducing urban carbon emissions are more positive.

H1-2: Individual willingness to pay increases if the subjective norms for reducing urban carbon emissions are more positive.

H1-3: People's willingness to pay will increase if perceived behavioral control over reducing urban carbon emissions increases.

In the theory of planned behavior, there is less discussion about its intrinsic variables, which is not conducive to better prediction of people's payment behavior, so we propose the following hypothesis to discuss the relationship between the variables of the theory of planned behavior.

H2-4: If attitudes toward reducing urban carbon emissions are more positive, people's subjective norms about behavioral choices are also more positive.

H2-5: If attitudes toward reducing urban carbon emissions are more positive, people's perceived behavioral control over behavioral choices will increase.

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H2-6: Perceived behavioral control over behavioral choices increases if subjective norms about reducing urban carbon emissions are more positive.

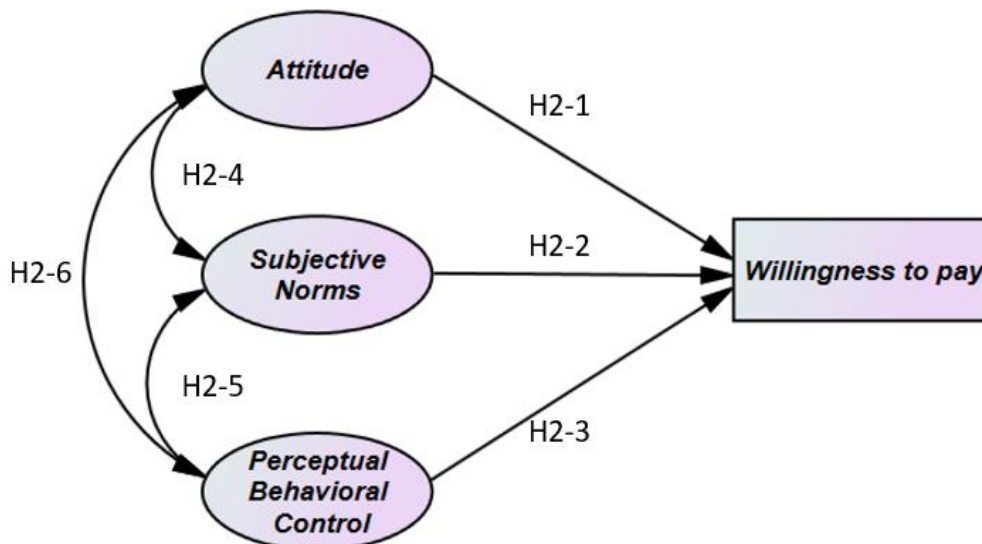


Fig 6-4 Traditional Theory of Planned Behavior Prediction Model (mitigation of urban CO₂ emissions in Qingdao)

Based on the previous section, we likewise add policy perception to model 2 to formulate the following hypotheses.

H2-7: Policy perceptions are positively correlated with individuals' environmental attitudes.

H2-8: Policy perceptions are positively correlated with individuals' subjective environmental norms.

H2-9: Policy perception is positively correlated with individual control of perceptual behavior.

H2-10: The more policy-aware individuals are, the more willing they are to pay.

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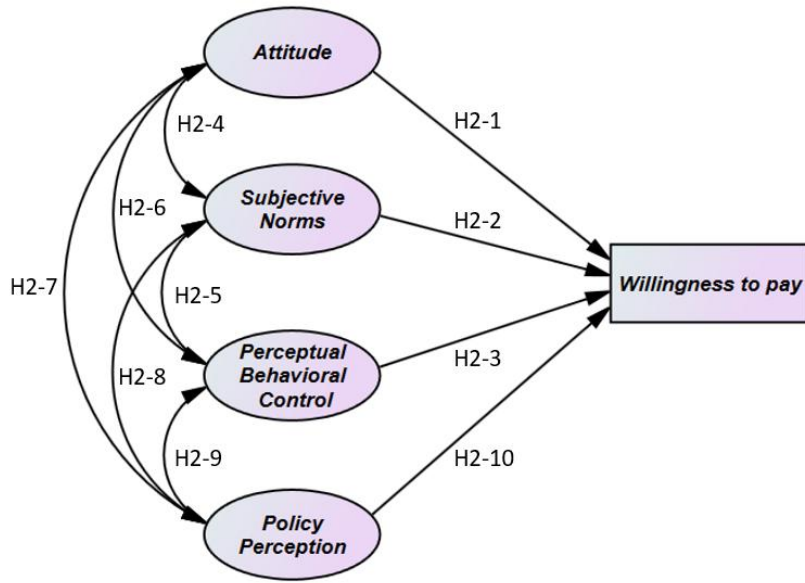


Fig 6-5 An expanded theoretical model of planned behavior (mitigation of urban CO₂ emissions in Qingdao)

Fig 6-11 The structural equation model is shown in the figure below

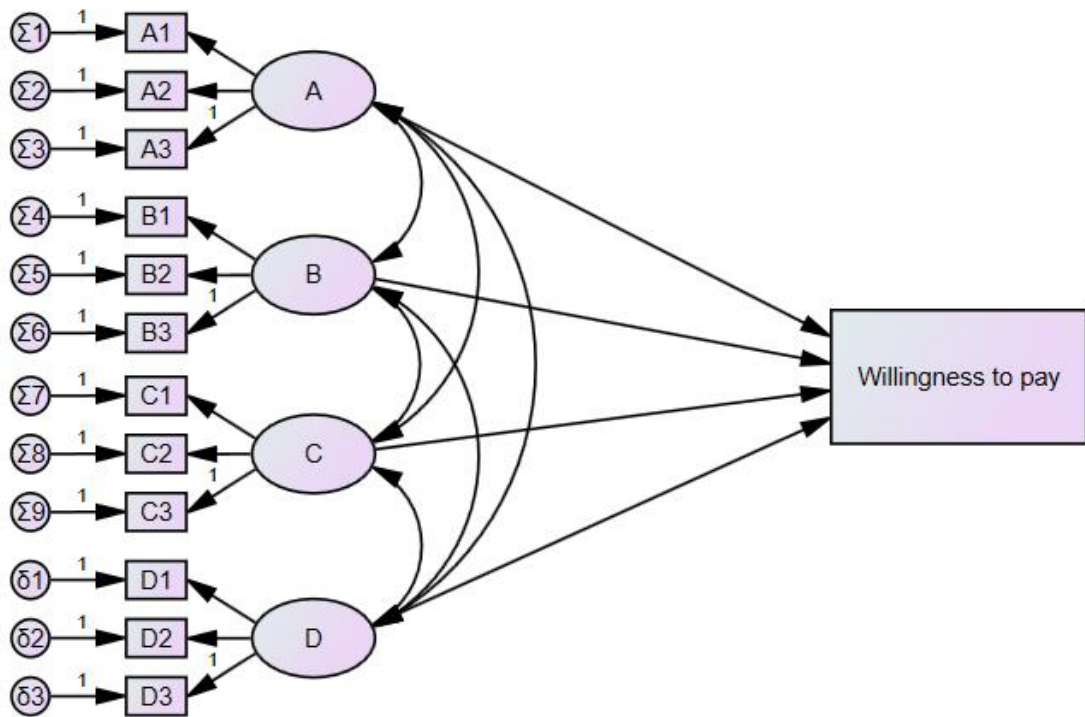


Fig 6-6 The structural equation model

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6.4 Results

6.4.1 Willingness to pay analysis

As shown in Figure 6-3, in the data compilation interviews for the following five bid groups in the interviews on the willingness to pay for the beach environment in Qingdao, 240 respondents in the questionnaire group agreed to pay a higher amount, accounting for 45.7% of the total number of respondents, and 75 respondents refused to pay anything, accounting for about 14.3% of the total number of respondents. The data show that the willingness to pay decreases as the amount of the tender increases, and the corresponding number of respondents who refused to pay increases.

Table 6-1 Response distribution (The environmental protection)

Bid amount	Y-Y	Y-N	N-Y	N-N	SUM
(10/20/40)	78	8	11	8	105
(20/40/80)	54	13	24	14	105
(40/80/160)	45	15	25	20	105
(80/160/320)	33	28	28	16	105
(160/320/640)	30	28	30	17	105
SUM	240	92	118	75	525

As shown in Figure 6-4, in the interviews on the willingness to pay for the reduction of urban carbon emissions in Qingdao in the following five bid groups of data collation interviews, 265 of the questionnaire group agreed to pay a higher amount, accounting for 50.4% of the total, of which 59 respondents refused to pay anything, accounting for about 11.2% of the total.

Table 6-2 Response distribution (mitigation of urban CO₂ emissions in Qingdao)

Bid amount	Y-Y	Y-N	N-Y	N-N	SUM
(10/20/40)	80	15	11	6	105
(20/40/80)	54	14	24	7	105
(40/80/160)	45	16	22	16	105
(80/160/320)	34	24	21	18	105
(160/320/640)	32	28	26	12	105

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SUM 265 97 104 59 525

By comparison we can develop that the percentage of respondents agreeing as well as refusing to pay changes with the different objects of payment among the same respondents, and in the comparison between group 1 and group 2 we can find that respondents prefer to pay for reducing carbon emissions in the city. And for protecting the beach environment, the percentage of paying is less than the percentage of paying for low carbon in the city. It indicates that the public may show more concern for living more closely with urban carbon emissions.

Table 6-3 Willingness to pay estimation results (The environmental protection)

Variable	Model with covariates
Constant	-0.001***
Bid	-0.005***
Gender	0.063*
Income	0.001***
Education	0.037**
Age	0.22
Family number	0.54
Presence of children or elder	0.06*
95% confidence interval	239.12-346.79 CNY
99% confidence interval	227.39-346.79 CNY
Mean WTP	287.14 CNY
log-likelihood	-992.98
Wald statistic (p-value)	519.88

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

Table 6-4 Willingness to pay estimation results (mitigation of urban CO₂ emissions in Qingdao)

Variable	Model with covariates
----------	-----------------------

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Constant	-0.001***
Bid	-0.004***
Gender	0.021**
Income	0.000***
Education	0.037**
Age	0.33
Family number	0.13
Presence of children or elder	0.000***
95% confidence interval	245.48-359.88 CNY
99% confidence interval	222.15-362.12 CNY
Mean WTP	293.57 CNY
log-likelihood	-998.56
Wald statistic (p-value)	508.74

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

By comparing the above data, we can find (Table 6-5, Table 6-6) that the public's willingness to pay 293 CNY to reduce urban carbon emissions is greater than the willingness to pay for the protection of the beach environment. We suspect that the reason for this may be that urban carbon emissions are closely related to our lives, while the protection of the beach environment may be more important to people who have more preferences for tourism. But so far there is no research on this. Further development is needed.

Respondents who responded in protest were excluded from the web-based questionnaire, and feedback was collected from respondents who refused to pay to better identify the factors that felt they were paying. The majority of those who refused to pay felt that the factor that influenced them to pay was income (51 percent) and that a proper increase in income would improve their ability to pay. Others felt that environmental protection and reducing the city's carbon emissions should be the responsibility of the government (22%). The government should be the one to pay for this. Not individuals. Some respondents also believe that top-down management tends to lead to a lack of transparency in the funds they pay and that they lack trust in government departments (13 percent). They would prefer that the relevant departments could increase the transparency of

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the flow of funds to ensure the proper use of their expenditures. Some respondents also believe that representatives should be selected to monitor the government's actions and that the binding force of relevant laws should be appropriately increased (10 percent).

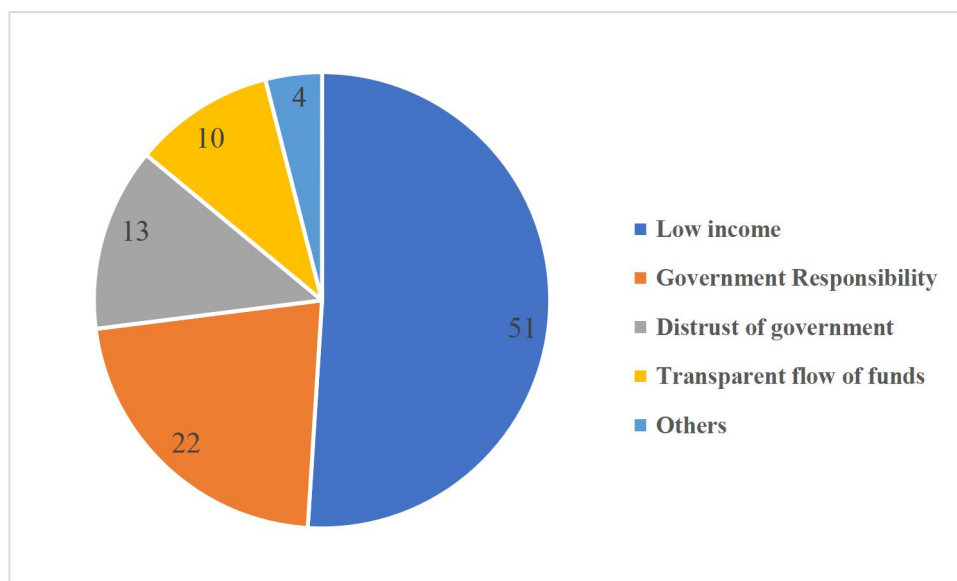


Fig 6-7 Reasons for refusal to pay

6.4.2 Measurement models

Table 6-5 Reliability and validation factor analysis for an extended theoretical model of planned behavior (The environmental protection)

Scales	Mean	β	CR	AVE
Attitude ($\alpha=0.84$)				
I think paying for protecting the beach environment is positive	5.42	0.79	0.84	0.65
I think paying for protecting the beach environment is responsible	5.44	0.81		
I think paying for protecting the beach environment is ecological	5.51	0.82		
Subjective norm ($\alpha=0.83$)				
I think people who are important to me will pay for protecting the beach environment	5.07	0.77	0.83	0.62

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I think people who are important to me will support the action of paying for protecting the beach environment	5.35	0.81		
I think people who are important to me will support me paying for protecting the beach environment	5.46	0.80		
Perceived behavioral control (0.86)				
I think my payment will improve the beach environment	5.28	0.86	0.86	0.68
It is not difficult for me to pay for protecting the beach environment	4.92	0.83		
I think I have time, money, and resources to pay for protecting the beach environment	4.88	0.80		
Policy Perception($\alpha=0.86$)				
I care about protecting the beach environment	5.35	0.89	0.86	0.76
I think I will pay for the protection of the beach environment	5.66	0.86		

α reliability (Cronbach's alpha coefficient); β (standard regression weight); CR (composite reliability); AVE (average variance Extracted)

Table 6-6 Reliability and validation factor analysis for an extended theoretical model of planned behavior (mitigation of urban CO₂ emissions in Qingdao)

Scales	Mean	β	CR	AVE
Attitude ($\alpha=0.84$)				

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I think paying for reducing urban carbon emissions is positive	5.12	0.82	0.84	0.64
I think paying for reducing urban carbon emissions is responsible	5.08	0.78		
I think paying for reducing urban carbon emissions is ecological	5.33	0.80		
Subjective norm ($\alpha=0.85$)				
I think people who are important to me will pay for reducing urban carbon emissions	4.85	0.81	0.85	0.65
I think people who are important to me will support the action of paying for reducing urban carbon emissions	5.12	0.79		
I think people who are important to me will support me paying for reducing urban carbon emissions	5.33	0.83		
Perceived behavioral control ($\alpha=0.84$)				
I think my payment will improve reducing urban carbon emissions	5.06	0.81	0.84	0.65
It is not difficult for me to pay for reducing urban carbon emissions	4.78	0.79		
I think I have time, money, and resources to pay for reducing urban carbon emissions	5.12	0.82		
Policy Perception($\alpha=0.84$)				
I care about protecting the reducing urban carbon emissions	5.33	0.86	0.84	0.73
I think I will pay for the protection of reducing urban carbon emissions	5.21	0.85		

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α reliability (Cronbach's alpha coefficient); β (standard regression weight); CR (composite reliability); AVE (average variance extracted)

We determined the reliability and validity of Model 1 and Model 2 (Table 6-8 and Table 6-9), and Larcker [46] argued that if the squared correlations of the different constructs are smaller than the AVE of each construct. then the validity of the discriminant validity is confirmed. The values of the discriminant validity of attitudes, supervisor norms, perceived behavioral control, and policy perceptions in Model 1 and Model 2 are smaller than the diagonal AVE values. This indicates that the validity of both models is better.

Table 6-7 The scales ' discriminant validity (The environmental protection)

	Attitude	Subjective norm	Perceived behavior control	Policy Perception
Attitude	0.79			
Subjective norm	0.61***	0.80		
Perceived behavior control	0.58***	0.56***	0.80	
Policy Perception	0.62***	0.71***	0.77***	0.81

*** p <0.01 The diagonal is the value of AVE

Table 6-8 The scales discriminant validity (mitigation of urban CO₂ emissions in Qingdao)

	Attitude	Subjective norm	Perceived behavior control	Policy Perception
Attitude	0.81			
Subjective norm	0.62***	0.83		
Perceived behavior control	0.59***	0.56***	0.82	
Policy Perception	0.64***	0.73***	0.78***	0.83

*** p <0.01 The diagonal is the value of AVE

6.4.3 Hypothesis testing

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The fitness of the initial model 1 (chi-square 246.7, RMSEA=0.082, GFI=0.914, CFI=0.907, NFI=0.902) and the initial model 2 (chi-square 252.3, RMSEA=0.081, GFI=0.922, CFI=0.913, NFI=0.911) was acceptable (statistically significant at the 1 percent level). The results showed that in the traditional theoretical model of planned behavior, the respondent's attitude and supervisor norms were factors that influenced the respondent. And the effect of perceived behavioral control on behavior was not demonstrated. Therefore hypothesis (H1-1 H1-2 H2-1 H2-2 is accepted) and hypothesis (H1-3 & H2-3 is rejected) . In both models our hypothesis for the intermediate variables that affect willingness to pay, there is a relationship between attitude, subjective norms, and perceptual behavioral control in both models. and are statistically significant at the one percent level. In Model 1 of the traditional theory of planned behavior, attitudes, subjective norms, and perceptual behavioral controls explain 63% of the variance in willingness to pay. In model 2, 65% of the variance is explained. This indicates that the traditional model is more capable of explaining the public's ability to explain urban low carbon emissions than beach environmental protection by 2 percent.

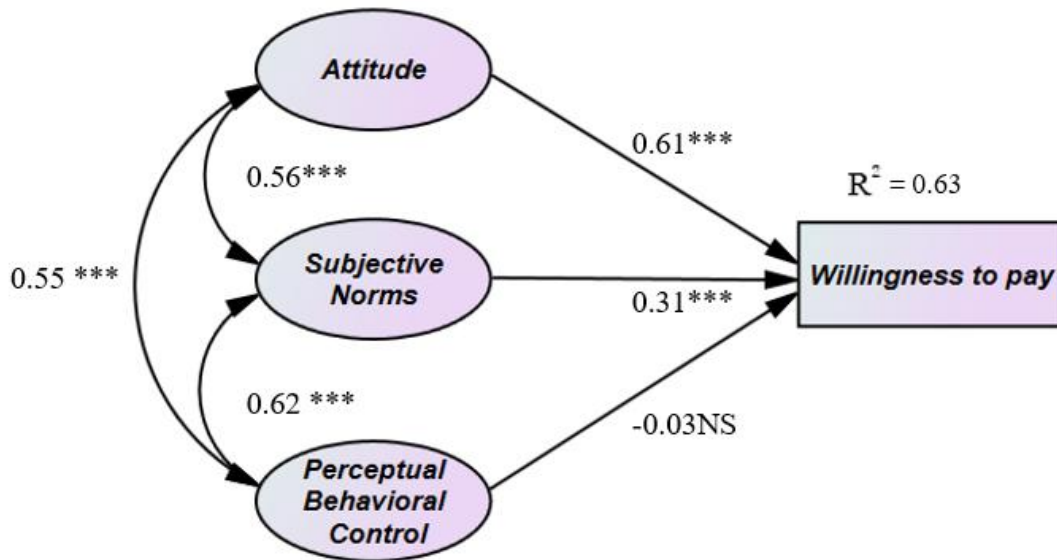


Fig. 6-8 The original theoretical model of planned behavior (The environmental protection)

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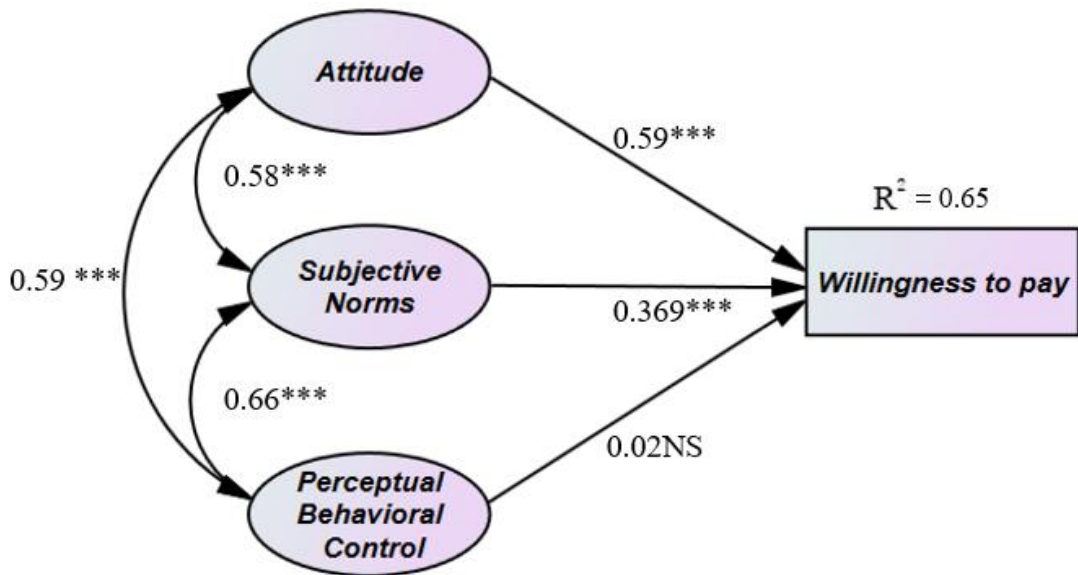


Fig 6-9 The original theoretical model of planned behavior (mitigation of urban CO2 emissions in Qingdao)

In the extended theory of planned behavior, the parameters in model 1 are chi-square 253.6, RMSEA=0.079, GFI=0.903, CFI=0.911, NFI=0.923 and in model 2 the parameters are chi-square 259.7, RMSEA=0.083, GFI=0.924, CFI= Both models are acceptable and statistically significant at the 1 percent level. We can find that policy perception is the dominant variable in predicting willingness to pay in both model 1 and model 2. This further validates our speculation that the perception of policy in developing countries can influence the final behavior.

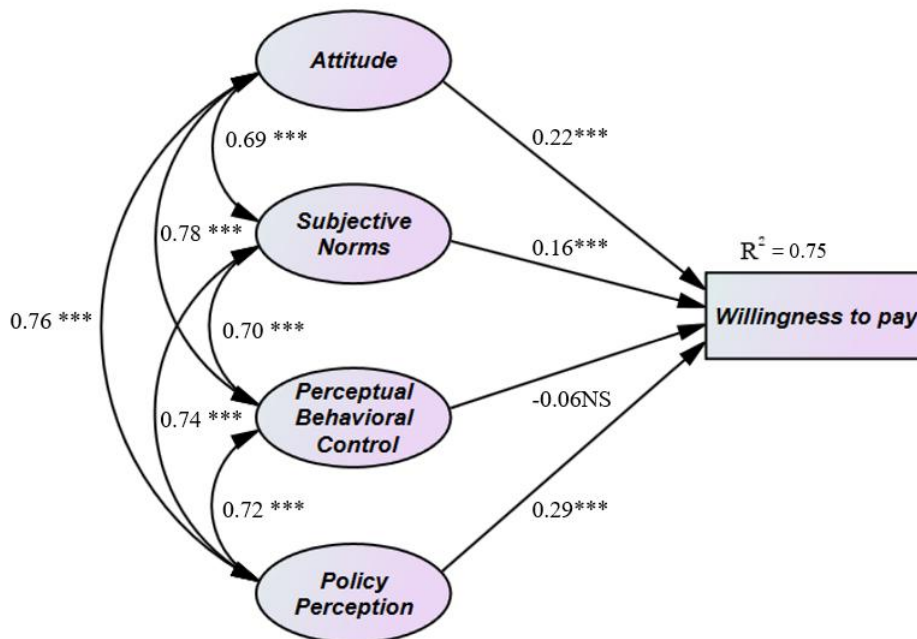


Fig 6-10 An expanded theoretical model of planned behavior (The environmental protection)

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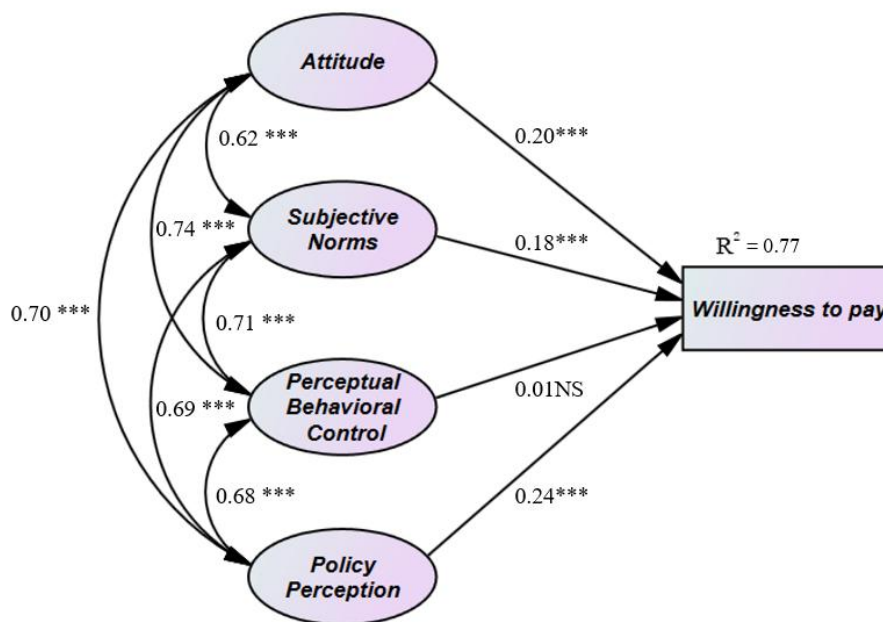


Fig 6-11 An expanded theoretical model of planned behavior (mitigation of urban CO₂ emissions in Qingdao)

6.5 Discussion

In our study, the Theory of Planned Behavior did predict outcomes well, with attitudes, subjective norms, and perceptual behavior control predicting 63% of the variance in the traditional Theory of Planned Behavior Model 1 and 65% in Model 2. As they argue, after extending the theory of planned behavior with policy perceptions, the explanatory power of the two models for willingness to pay increases by 12 percent each.

In the estimated result of willingness to pay, Qingdao citizens pay 287.14CNY for beach environment and 293.57CNY for low carbon in the city. Since we are a one-time questionnaire for the same group of respondents. Therefore, we can assume that Qingdao citizens are more willing to pay for reducing the city's CO₂ emissions. And the number of people who refuse to pay for beach environmental protection is higher than the number of people who refuse to pay for reducing CO₂ emissions in the city.

While both reducing urban carbon emissions and protecting the beach environment were studied in the public environment category, the study subjects who were closer to individuals were more likely to be paid. We speculate that those who are not willing to pay for the beach environment may not go to the beach very often, and therefore the beach environment is not important to them. In contrast, CO₂ emissions from cities are closely related to life. Therefore, the willingness to pay for low-carbon cities and the amount is higher than the amount for beach environment protection.

The extended version of the theory of planned behavior has more explanatory power than the traditional theory of planned behavior for willingness to pay. In our study the explanatory power

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of the model with the inclusion of policy perceptions increased to 12 percent compared to the traditional model when the beach environment was the subject of study, and to 12 percent when the reduction of urban carbon emissions was the subject of study. Therefore, we can consider our model to be somewhat adaptive. Since the two questionnaires were done by the same respondents, the principle of a single control variable was met.

6.6 Conclusion

This study uses the Theory of Planned Behavior to discuss the factors influencing willingness to pay and extends the traditional Theory of Planned Behavior using policy perceptions. By comparing the public's willingness to pay for beach environmental protection and urban low carbon, and the influencing factors. We came to the following conclusions. First, there is a significant positive correlation between income level and willingness to pay, followed by a higher level of education and households with elderly or children who show more concern for environmental issues. Regarding the interpretation of willingness to pay, attitudes and subjective norms can directly influence the public's willingness to pay. Perceptual behavioral control, on the other hand, does not show a significant effect on behavior in our study. When policy perception is used to extend the theory of planned behavior, policy perception is the dominant variable in the theory of planned behavior, suggesting that individuals who are more perceptive about policy in China will have a stronger willingness to pay. However, it is not clear whether this applies if we are in a developed country. Also, the specific kinds of policy perceptions lack relevant discussion. Further research is needed.

We also surveyed those who refused to pay, and low income was the main reason for refusing to pay, or they thought that environmental protection and low carbon cities were not relevant to them, so we should increase publicity related to environmental protection, etc. This might promote their participation in environmental protection, or low-carbon cities.

In the comparison of willingness to pay for beach environmental protection and urban low carbon strategies, and the factors influencing willingness to pay we found that although both are demonstrations of individual pro-environmental behavior, their willingness to pay is also different. The public's willingness to pay for low-carbon city construction is stronger and the amount paid is higher. Therefore, we guess that the closer the public environmental products are to the individual's life, the higher the individual's willingness to pay. The public environmental products that are not closely related to individuals' lives will have a relatively low willingness to pay for them.

CHAPTER SIX: SHANDONG HOUSEHOLDS' WILLINGNESS TO PAY FOR LOW CARBON CITY MEASURE

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Chapter 7

CONCLUSION AND POLICY IMPLICATIONS

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According to a report by the United Nations Office of the High Commissioner for Human Rights, more than 4 billion people will be living in cities by 2020, and as urbanization continues to grow, there will be a massive movement of people to cities, especially in developing countries. By 2050, it is expected that more than 60% of the world's population will be living in cities. As a result, urban pollution, increased carbon emissions, and heat island effect have become important factors affecting people's normal life. In response to this, countries around the world have proposed measures to address the problem. With the signing of the Paris Climate Agreement, China has set the goal of achieving carbon peaking by 2030 and carbon neutrality by 2060. This study assesses the environmental value of low-carbon strategies by analyzing the public's attitudes toward urban low-carbon strategies and their willingness to pay for these strategies. And further discusses the factors that influence people's payment for these strategies. and the predictors. It contributes to the better realization of low-carbon urban development.

In previous studies, the environmental values and benefits of low-carbon city strategies have often been overlooked. First, the environmental value of public environmental products is non-market based and their benefits cannot be assessed through normal evaluation systems. Second, China's top-down management model makes decision makers more concerned with the actual value of a strategy than with the environmental value. Since the total public resources for urban construction and development are limited, if the environmental value of a low-carbon city cannot be quantified, then the corresponding measures for low-carbon city construction will lead to a lack of reference standards for decision makers in further strategy implementation, resulting in mistakes or failures of the strategy. Therefore, it is necessary to establish a set of evaluation system for public environmental products adapted to China. Based on the above reasons we mainly made the following research.

We focus on low-carbon measures in Tai an, Qingdao, and Hangzhou, Zhejiang Province, China. We also discuss the willingness of the public to pay for them. Several major technologies are included: vertical greening, construction of power exchange plants, and upgrading of wastewater treatment plants (through upgrading to net zero emissions and recycling of wastewater resources to reduce carbon emissions). A comparison is also made between Qingdao citizens' willingness to pay for the above-mentioned public environmental products and their willingness to support low-carbon cities.

Since the implementation of urban low-carbon strategies and measures belong to public environmental products, their environmental value cannot be simply quantified by conventional means. Therefore, the value of urban low-carbon measures should belong to non-market value. Therefore, we use the conditional value approach to estimate the environmental value of public environmental products. The conditional value approach is a common method for measuring the environmental value of public environmental products. We also use the demographic information of respondents, socio-economic information as variables to discuss the influencing factors of willingness to pay. We also used the theory of planned behavior to predict the willingness to pay.

7.1 Conclusion and Policy Implications

The research flow of this paper follows theoretical research-methodological research-experimental research-conclusion.

CHAPTER SEVEN: CONCLUSION AND POLICY IMPLICATIONS

The first chapter is an overview, which mainly provides an overview of the background of the study and the purpose of the study. The study of urban low carbon city construction strategies is of great social importance for achieving the goal of carbon neutrality and the formulation of related policies. The importance of the study is mainly reflected in the integrated study of certain strategies and technologies that are of interest to researchers and the economic benefits that are of interest to policy makers in the construction of low carbon cities in China. The impact of individual characteristics of low-carbon city strategies on the payment behavior of low-carbon city construction is studied through statistical and other technical means. To discuss the feasibility of the measures. The environmental and economic values are assessed to quantify this value visually, so that policy makers can better formulate and modify policies and make further policy recommendations to help low carbon city construction based on individual characteristics. In summary, the purpose of this study is to assess the environmental economic value of low carbon city strategies and to discuss the factors influencing respondents' willingness to pay for public environmental products in order to establish an environmental value evaluation system that takes into account both low carbon city researchers and policy makers.

Chapter 2 provides a review of the literature on the evaluation of climate value conditions for low carbon strategies and summarizes relevant past research. Through the literature review we find that there are significantly more studies on low carbon cities in developed countries than in developing countries. As for the valuation method of willingness to pay, there are many researchers who believe that the conditional value approach has some shortcomings. However, the research on how to address this deficiency is not particularly extensive. Therefore, we conducted an in-depth study to address this deficiency. Secondly, we also found from the literature review that there has been very limited discussion of the theory of planned behavior and policy perception as two influencing factors in studies related to individuals' willingness to pay for low-carbon city strategies. However, the theory of planned behavior has been widely used in the discussion of individual behavior (including willingness to pay). Therefore, in the next study we add the Theory of Planned Behavior and Policy Perceptions as influencing factors to discuss their effects on willingness to pay.

Chapter 3 is the methodology, which contains two main parts, the theoretical background and the experimental design. The first part mainly explains the relevant theoretical background. The focus is on explaining why low carbon cities have economic value, and the components of their economic value, as well as the estimation methods. In the estimation of the economic value of the environment, estimation through questionnaires to individuals is a common method to obtain respondents' willingness to pay. Exploring the influencing factors of willingness to pay can help to better implement the established low carbon strategies and to obtain higher environmental economic value. It is of great practical importance [1]. In the previous paper, we found that the research on planned behavior is more limited in the study of low-carbon urban strategies. Therefore, we elaborate on the theory of planned behavior for predicting willingness to pay. And we explain the economic value theory of urban low carbon strategies. The second part is the design of the experiment of our study, which contains the information collection method, questionnaire design, estimation model, and payment method. The peak model is also used to compensate for the problem of zero response affecting the accuracy of estimation results in the

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current conditional value approach. The peak model is also used to estimate the environmental value of urban low-carbon strategies. The estimation method of the peak model is explained, and its advantages over the traditional model of the peak model combined with the two-boundary dichotomous valuation model for estimating willingness-to-pay results.

In Chapter 4, we studied the low-carbon city construction strategy-vertical greening in Hangzhou City, Zhejiang Province, China. The results of the study show that households in Hangzhou pay 702.55CNY (104.18USD) per year for vertical greening, respectively, and the percentage of respondents who refuse to pay is less than thirty percent. Therefore, we believe that a significant number of respondents in HCM City are willing to pay for the construction of a low-carbon city. This also illustrates the feasibility of these measures in terms of economics. The environmental economic value of vertical greening in HCM City is 1.43 billion CNY (0.21 billion USD). Age, household composition (elderly, young children), income level, environmental knowledge, and subjective norms in the theory of planned behavior were statistically significant at the one percent level. In contrast, attitudes, and perceptual behavior controls were statistically significant at the five percent level, so we concluded that the above variables would have a significant effect on willingness to pay. This also supports our conjecture that the theory of planned behavior can have a good explanatory power on willingness to pay.

In Chapter 5, we studied a low-carbon city construction strategy - EV battery exchange stations in Hangzhou, Zhejiang Province, China. The results of the study show that the willingness of households in Hangzhou to pay for EV exchange stations is 400.52CNY (6.27 billion USD) per year, and the percentage of respondents who refuse to pay is less than thirty percent. Therefore, we believe that a significant number of respondents in HCM City are willing to pay for the construction of a low-carbon city. This also indicates the economic feasibility of building electric vehicle exchange stations. The environmental economic value of electric vehicle exchange stations in Hangzhou is about 1.78 billion CNY (263 million USD). Income level, policy concern, experience with the exchange station, experience with EVs, and knowledge of them were all statistically significant at the one percent level. Attitudes perceived behavioral control were statistically significant at the five percent level. Subjective norms were statistically significant at the ten percent level. The above variables would have a significant effect on willingness to pay. This also supports our speculation that the theory of planned behavior can have a good explanatory power for willingness to pay.

In Chapter 6 we discuss households' willingness to pay for environmental protection and reducing urban CO₂ emissions in Qingdao, Shandong Province, and compare these two study subjects. to explore the differences in willingness to pay for different environmental products and the factors affecting the payment in a control variables approach (keeping respondents constant). The results show that Qingdao residents' willingness to pay for reducing urban carbon emissions is 293.5CNY (43.52CNY). The willingness to pay for environmental protection in Qingdao is 287.1CNY (42.57CNY). It can be found that Qingdao residents are more willing to pay for reducing urban carbon emissions. We speculate that the willingness to pay is influenced by the degree of correlation between public environmental products and individual life and health status. In our comparison of Qingdao residents' willingness to pay for public environmental products, we developed a predictive model based on the theory of planned behavior to predict Qingdao

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households' willingness to protect the beach environment and reduce urban carbon dioxide emissions. In addition to the three main predictive variables of the Theory of Planned Behavior: attitudes, supervisory norms, and perceived behavioral control, we extended the Theory of Planned Behavior by adding the variable of policy perceptions, based on our previous research that policy perceptions have a significant impact on willingness to pay. The results show that the extended Theory of Planned Behavior model has better predictive power than the traditional model. The predictive power increased by twelve percent, with policy perception being the dominant variable in predicting willingness to pay. This confirms our suspicion that policy perception has a direct or indirect effect on willingness to pay under the top-down management model in China.

Chapter 7 We summarize the article. At the economic value level, this study explains the reasons for the economic value of urban low-carbon strategies based on the economic value of labor theory and subjective economic value theory. In terms of valuation methods, combined with previous research results, this study concludes that the traditional conditional value method has some shortcomings for the estimation of willingness to pay, especially the zero-response treatment problem for the interviewed individuals is not effectively addressed. The peak model combined with the two-boundary dichotomous conditional value method can be a good solution to the shortcomings of the traditional method in the valuation problem. In terms of experimental subjects, we mainly discuss three strategies for low-carbon cities, namely, the construction of electric vehicle exchange stations, vertical greening and the mitigation of urban CO₂ emissions. And by comparing the difference between Qingdao citizens' willingness to pay for beach environmental protection and the willingness to pay for reducing urban CO₂ emissions, we further discuss the difference in individual willingness to pay for different public environmental products and the difference in their influencing factors. We argue that the theory of planned behavior can predict willingness to pay better, but the explanatory power of the theory of planned behavior is enhanced when some variables are added. And the theory of planned behavior is applicable to different public environment products. The explanatory power of the Theory of Planned Behavior increases by 12 percent when the same covariates are added to expand the Theory of Planned Behavior. Combining the number of households in each city, we evaluated the environmental economic value of vertical greening in Hangzhou, Zhejiang Province at 1.433 billion CNY (\$212 million), the environmental economic value of electric vehicle battery exchange stations at 1.780 billion CNY (\$263 million), the environmental economic value of beach environmental protection in Qingdao at 810 million CNY (\$120 million), and the environmental economic value of reducing urban The environmental economic value of CO₂ emissions reduction in the city was concluded to be 827 million CNY (122 million USD).

Based on the above experiments and discussions, as well as the findings of previous researchers, this study proposes the following policy implications.

1. The non-use value of public environment products should be valued

So far, most of the respondents do not know what the non-use value of public environmental products is. This is because the use of willingness to pay to value the environment has so far

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remained within the scope of scientific research and has not been promoted as an evaluation indicator. First, researchers do not have a reliable, stable, and uniform system for valuing public environmental products. For example, willingness to pay can be estimated in card, dichotomous, open-ended, and so on. There are gaps in their accuracy and stability. Therefore, it is important for policy makers. Focusing on the environmental value of environmental products (low carbon city strategies) helps them to better evaluate the economic value of the established strategies. It helps the implementation of the policy.

Increasing the publicity of low-carbon strategies can help increase public attention to the measures. In our study, respondents who were more aware of, and more concerned about, the construction of low-carbon cities The willingness to pay is higher. Therefore, we believe that policy makers should develop a reasonable evaluation system for public environmental products as soon as possible and strengthen the publicity of the measures. The importance of low-carbon city measures should be properly understood by respondents. So that individuals can actively participate in the construction of low-carbon cities.

2. Increase the transparency of the flow of funds

In our study, part of the group responding to the protest was prompted by questions about the transparency of the flow of funds. The contribution of public funds to urban environmental development has been demonstrated in previous studies. However, some researchers have argued that public funds can be risky in their use because of their opacity. Dinnie [2] argues that public participation is important for the construction of urban environments and that public funding is essential for sustainable urban development. Based on community initiatives, and pointing to technical and management issues, community programs may encounter receiving public funding, including how to balance the rights and obligations of recipients and funders. Some studies have also shown that the lack of supervision by relevant authorities such as the government in some public self-organized environmental projects can increase information asymmetry between the public and project implementers. The involvement of the government as the initiator of the project can play a good coordinating role. Therefore, the government should develop the project, monitor the project, and have the public fund the project, with a third-party company as the implementer of the strategy, and be open and transparent about the steps to implement the strategy. Reducing the information asymmetry caused by the game between two parties may be a feasible way to use public funds to build low carbon cities.

3. Increase publicity on the importance of low-carbon city strategies

In our study, many respondents indicated that they were not aware of urban low-carbon strategies such as vertical greening and the construction of switching stations. They expressed the need for policymakers to provide detailed information about the relevant measures and to make the data public. Therefore, we believe that it is important to increase the publicity of urban low-carbon strategies and to make the data open and transparent to increase public participation. And in the study of Hangzhou citizens on vertical greening. We discussed the effect of knowledge of vertical greening on willingness to pay as a variable. The results showed that it was statistically significant at the 1 percent level. This reinforces our suspicion. Therefore, through publicity, the public is made aware of the importance of low-carbon cities. And it is very important to actively participate

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in the construction of low carbon cities.

4. Increase the education of environmental protection measures

The importance of environmental knowledge for willingness to pay has been demonstrated in past studies. Environmental knowledge can greatly influence people's behavior in participating in environmental governance. In our study, both environmental knowledge and educational attainment were statistically significant with willingness to pay at the one percent level. Unfortunately, although education in China has made rapid progress in recent years, there are still some shortcomings, and Xiong et al [4] conducted an in-depth study on the availability of systematic education on environmental knowledge in China. It was found that nearly 20% of the sample did not have a reasonable environmental education system in place. Education on environmental protection was even more lacking in linguistics, arts, and sports than in forestry, agriculture, and related disciplines. In addition, provincial or local municipal universities performed less well compared to universities directly managed by the Ministry of Education. Therefore, we believe that firstly, it is necessary to increase the publicity of environmental protection knowledge on campus, and secondly, due to the rapid development of the Internet, the information carriers have been diversified so far. It is important to estimate the amount of information that can be disseminated through various information carriers, especially those that are of interest to or commonly used by students on campus.

5. Increase the publicity of environmental protection policies

In our study, individuals' policy perceptions are the dominant variable in predicting payment behavior. It is of great importance. In the long-standing top-down management model in China, the policies introduced by the government are often mandatory. And with the revision of the Environmental Protection Law of the People's Republic of China in 2015, public participation in environmental protection has been encouraged. However, the long-standing top-down management model has made individuals quite dependent on government policies. Therefore, while encouraging public participation in environmental protection activities, policies should be developed to support it. The public should be encouraged to participate in environmental protection activities. The public should be encouraged to participate in environmental protection activities. In addition, the government should monitor the implementation of environmental protection policies and their promotion. To ensure that the public can participate in environmental protection activities, and to protect the public's participation in environmental protection behavior. This will provide a good environmental foundation for public participation.

6. Study on the Value of Increasing Conditions Method for Low Carbon City Construction Assessment

Although the slogan of reducing urban carbon emissions dates to the mid to late twentieth century, it really caught the attention of people around the world at the Paris Climate Conference in 2015, where countries around the world set different targets to mitigate urban carbon emissions. This drew widespread attention from the scientific community to environmental issues such as carbon emissions. And it is ongoing. The Chinese government has set a goal of achieving carbon peaking by 2030 and carbon neutrality by 2060. Chinese researchers have begun to conduct a lot of

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research on the topic of low carbon. Although some progress has been made in urban low carbon research over the past year, it has been more in the area of technology, and research on the economic value evaluation of related measures has been more limited.

In this study we used the conditional value approach to assess the environmental value of these measures to inform policy development. Unfortunately, however, our study is also only a preliminary exploration. It has many limitations. Such as geographical limitations, strategy limitations (we only evaluated several strategies for low carbon city construction). Therefore, we believe that we should increase the research for the low-carbon city condition value method to conduct a comprehensive and effective environmental value assessment of low-carbon strategies.

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APPENDIX 1.

Questionnaire survey of Hangzhou electrical changing Station

Table A1

The questionnaire (pre-survey)

Category	Questions
Maximum amount of annual payment	What is the maximum amount your household can accept to support BSS construction (per year)?
Means of payment	Which of the following means of payment do you expect to adopt for payment for BSS construction? <input type="radio"/> Stamp duty <input type="radio"/> Income tax <input type="radio"/> <input type="radio"/> Consumption tax <input type="radio"/> Daily bills

Table A2

The questionnaire (initial survey)

Category	Questions
Respondent Screening	The state has formulated relevant policies to support construction of battery swapping stations for battery electric vehicles. We need to collect the public feedback. Could you answer the following questions on behalf of your family? (If yes, please continue to answer the following questions. If no, you cannot answer these questions. All your answers will be kept confidential and used for scientific study only). <input type="radio"/> Yes <input type="radio"/> No
Respondents' residence statistics	Which district of Hangzhou do you live in now? <input type="radio"/> Shang Cheng District <input type="radio"/> Xia Cheng District <input type="radio"/> Gan Jiang District <input type="radio"/> Gong Shu District <input type="radio"/> Xi Hu District <input type="radio"/> Bin Jiang District <input type="radio"/> Xiao Shan District <input type="radio"/> Yu Hang District <input type="radio"/> Fu Yang District <input type="radio"/> Lin An District <input type="radio"/> Others District (Hangzhou) <input type="radio"/> Not a local person in Hangzhou (If this option is selected, You cannot answer the following questions)

Table A3

The questionnaire (formal survey)

Category	Questions
<i>I. Demographic variables</i>	
1. Gender	Are you a male or a female? <input type="radio"/> Male <input type="radio"/> Female
2. Age	How old are you? <input type="radio"/> 18 ≤ Age < 25 <input type="radio"/> 25 ≤ Age ≤ 55 <input type="radio"/> 55 < Age ≤ 65
3. Family income	Is the monthly income of your family greater than the average family income of Hangzhou? (The reference average family income of Hangzhou was 15389CNY in 2020) <input type="radio"/> Yes <input type="radio"/> No
4. Final education	What is your final education? <input type="radio"/> University degree or above <input type="radio"/> others
5. Employment	Do you have a job currently? <input type="radio"/> Yes <input type="radio"/> No
6. BEVs cars	Does your family have a BEV? <input type="radio"/> Yes <input type="radio"/> No
<i>II. Policy attention</i>	
7. The influence of policy concern to payment	Does your family have concern about relevant BSS policies released by the government? <input type="radio"/> Yes <input type="radio"/> No
<i>III. Relevant experience</i>	
8. Relevant BEV experience	Have you or a family member ever test driven a BEV or ridden in a BEV? <input type="radio"/> Yes <input type="radio"/> No
9. Relevant BSS experience	Do you or your family members ever use a BSS or attend relevant experimental activities?
<i>IV. Relevant knowledge</i>	
10. Relevant BEV knowledge	Have you learned about relevant BEV information? <input type="radio"/> Yes <input type="radio"/> No
11. Relevant BSS knowledge	Have you learned about relevant BSS information? (If yes, please answer question 12) <input type="radio"/> Yes <input type="radio"/> No
12. BSS information access	By what means have you obtained relevant BSS information? <input type="radio"/> Book <input type="radio"/> Internet <input type="radio"/> Television <input type="radio"/> Newspaper <input type="radio"/> Community propaganda <input type="radio"/> others
13. Environmental awareness	Do you think BSS is beneficial to environment? <input type="radio"/> Yes <input type="radio"/> No
<i>V. Psychological factors (TPB)</i>	

14. Attitude Do you think BES is quite important for you and can provide convenience to BSV owners? Yes No
15. Subjective norm Do your family members or friends support your use of BSS? Yes No
16. Perceived behavioral control Do you have adequate resources to participate in BES construction? (Please give your answer based on your actual family income) Yes No

VI. CVM question

17. Willing or not whether your family is willing to pay extra consumption taxes if the Hangzhou Municipal Government intends to double the efforts to promote BSS construction in response to the Zhejiang Province's objective of building more than 5000 BSSs by the year 2025 (Please give your answer based on your actual family income)

Group Four (Select one of the eight bidding groups as an example)

18. Initial Bid Amount Is your household willing to pay 100 CHY annually for the next 5 years?
 Yes (If people chose this, then ask question 19)
 No (If people chose this, then ask question 20)
19. Higher bids Is your household willing to pay 200 CHY annually for the next 5 years?
 Yes (If people chose this, then ask question 23)
 No (If people chose this, then ask question 23)
20. Lower bids Is your household willing to pay 50 CHY annually for the next 5 years?
 Yes (If people chose this, then ask question 23)
 No (If people chose this, then ask question 21)
21. Spike model Is your household willing to pay a certain amount for the next 5 years?
 Yes (If people chose this, then ask question 23)
 No (If people chose this, then ask question 22)
22. Protest Response Determination Why do you refuse to pay for this project?
 Inability to make payment due to low income
 No benefit from BSS The government should assume the liabilities and pay for BSS construction.
 The project lacks reality. The new infrastructure has nothing to do with me.
23. Suggestions Suggestions for the government to promote BSS construction.
 Increase community BSS construction
 Enhanced promotion of the benefits of BSS and BEV for environmental improvement
 Increased subsidies for BSS use in the community
 Increased subsidies for BEV purchases
 Formulate relevant policies to realise the integration and unification of BSS in China

o others

Appendix 2.

Program code for calculating willingness-to-pay in R (some examples)

```

library(numDeriv)
data <- read.csv('data.csv',header = TRUE,sep = ',')
n = dim(data)[1]
lnL <- function(x){
result <- 0
x_alpha = x[1:??]
x_beta = x[??]
for(i in 1:n){
data_i <- c(1,as.numeric(data[i,1: ??]))
alpha <- x_alpha %*% data_i
Gc_u <- 1 / (1 + exp(alpha - x_beta * data[i, ??]))
Gc <- 1 / (1 + exp(alpha - x_beta * data[i, ??]))
Gc_0 <- 1 / (1 + exp(alpha))
YY <- data[i, ??]
YN <- data[i, ??]
NY <- data[i, ??]
NNY <- data[i, ??]
NNN <- data[i, ??]
lnl <- YY * log(max(1 - Gc_u,1e-323)) + YN * log(max(Gc_u - Gc,1e-323)) +
NY * log(max(Gc - Gc_d,1e-323)) + NNY * log(max(Gc_d - Gc_0,1e-323)) + NNN
log(Gc_0)
#lnl <- YY * log(1 - Gc_u) + YN * log(Gc_u - Gc) + NY * log(Gc - Gc_d) + NNY
* log(Gc_d - Gc_0) + NNN * log(Gc_0)
result <- result - lnl }
return(result)
par <- c(0.01,numeric(??),0.002)
s <- numeric(0)
cov <- solve(opt $ hessian)
for(i in 1: ??){
s[i] <- cov[i,i]
}
value <- opt $ par
t <- value / (sqrt(s))
p_value <- 2 * (1 - (pt(abs(t),n - 2)))
Likelihood <- -lnL(value)
spike_f <- function(x){
result <- 0
for(i in 1:n){
data_i <- c(1,as.numeric(data[i,1: ??]))

```

```
alpha <- x %*% data_i
spike <- 1 / (1 + exp(alpha))
result <- result + spike
}
spike <- result / n
return(spike)
}
WTP_f <- function(x){
result <- 0
for(i in 1:n){
xxv
```

Appendix 3.

```

data_i <- c(1,as.numeric(data[i,1:???]))
alpha <- x_alpha %*% data_i
WTP <- log(1 + exp(alpha)) / beta
result <- result + WTP
}
WTP <- result / n
return(WTP)
}
beta <- value[??]
spike <- spike_f(alpha)
s_spike <- t(grad(spike_f,alpha)) %*% cov[1:??,1:??] %*% grad(spike_f,alpha)
t_spike <- spike / sqrt(s_spike)
p_spike <- 2 * (1 - (pt(abs(t_spike),n - 2)))
WTP <- WTP_f(val)
s_WTP <- t(grad(WTP_f,value)) %*% cov %*% grad(WTP_f,value)
t_WTP <- WTP / sqrt(s_WTP)
p_WTP <- 2 * (1 - (pt(abs(t_WTP),n - 2)))
mtcc <- rnorm(5000,WTP,sqrt(s_WTP))
interval_95 <- quantile(mtcc,prob = c(0.005,0.995))
wald <- t(value) %*% opt $ hessian %*% value
p_wald <- 1 - pchisq(wald,??)
result <- data.frame(matrix(0,??,4))
result[1:??,1] <- c('constant',colnames(data)[1:??],'beta')
result[??:??,1] <-
c('spike','MTP','MTP_interval_95','MTP_interval_99','wald_statics','Likelihood')
result[1:??,2] <- value
result[1:??,3] <- t
xxviAPPENDIX 3
result[1:??,4] <- p_value
result[??:??,2] <- c(spike,WTP,interval_95[1],interval_99[1],wald,Likelihood)
result[??:??,4] <- c(p_spike,p_WTP,"",p_wald,"")

colnames(result) <- c('Variables','values','t_values','p_values')

write.csv(result,'all_variables.csv')

```

APPENDIX.4 (Data)

gender	income	age<25	55>=age>=25	65>=age>=55	Employment	Final_education	Policy_attention	BSS_experience	BEV_experience	BSS_knowledge	BEV_knowledge	AT	S	PB	Au	A	Ad	YY	Y	N	N	N
0	1	0	0	3	1	1	0	0	1	0	0	0	1	1	3200	1600	800	0	0	0	0	1
1	0	0	0	3	0	0	0	0	1	0	0	0	1	1	3200	1600	800	0	0	0	0	1
0	0	0	0	3	1	1	0	0	0	0	0	1	1	1	3200	1600	800	0	0	0	0	1
1	1	1	0	0	1	1	1	1	0	1	0	1	1	1	3200	1600	800	0	0	1	0	0
0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	3200	1600	800	0	0	0	1	0
1	1	0	0	3	1	0	1	0	0	0	0	1	0	0	3200	1600	800	0	0	0	0	1
0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	3200	1600	800	0	0	0	1	0
0	1	0	2	0	1	0	0	0	1	0	1	1	1	1	3200	1600	800	0	0	0	0	1
1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	3200	1600	800	0	0	0	1	0
1	1	1	0	0	1	1	1	1	1	0	1	1	0	1	3200	1600	800	0	0	1	0	0
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0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	3200	1600	800	0	1	0	0	0
1	1	0	0	3	1	1	0	0	0	1	0	0	0	0	3200	1600	800	0	0	0	0	1
0	1	0	0	3	1	1	0	0	0	1	1	1	1	1	3200	1600	800	0	0	0	0	1
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APPENDIX

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APPENDIX

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APPENDIX

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APPENDIX

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