博 士 論 文

中国における低炭素戦略のための新しい都市交通及び都市施設の

導入に関する市民行動の評価

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Evaluation of citizen behavior on introducing new urban transportation and facilities for low carbon strategies in China

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Preface

China established the targets of carbon peaking by 2030 and carbon neutrality by 2060 with the signature of the Paris Climate Agreement in 2021. Researchers who are interested in the development of low-carbon cities have taken notice of this. However, up until now, city building has been more about technical innovation, and there hasn't been much study on how low-carbon city building practices affect the environment. This makes it difficult for politicians to promote new low-carbon city initiatives and improve current ones.

For these reasons, Beijing, Weihai, and Shandong Province were chosen as the study's target cities. To determine willingness to pay, assess the environmental value of four low-carbon strategies using conditional value. Aspects influencing government payments are also discussed. and the factors that influence each variable of pay-willingness. Contribute to the development of low-carbon cities in China, as well as the formulation of related policies.

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This work would not have been possible without the support, guidance and assistance of the many people and institutions who provide data and insights, for which I am very grateful.

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IV

Evaluation of citizen behavior on introducing new urban transportation and facilities for low carbon strategies in China

ABSTRACT

Air pollution, climate warming and other environmental problems are affecting people's normal production and living activities, these environmental problems brought haze, glacier melting, and other negative effects have threatened the survival of people and other species, the main reason for these environmental problems is that the sharp increase in carbon emissions continues to strengthen the greenhouse effect, resulting in a rise in global average temperature. With the advancement of globalization, environmental problems such as air pollution and ecological environment damage have become practical problems faced by all countries in the world. How to effectively promote low pollution and low emissions and embark on the road of low-carbon development is an important topic for joint research by all countries in the world. In 2020, China repeatedly pointed out at the UN Biodiversity Summit and other meetings: "As the world's largest developing country, China will strive to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060 in order to implement the Paris Agreement." The construction of low-carbon cities is a key project for the Chinese government. The construction of low-carbon cities is of great significance to achieving the set goals of the Chinese government. Unfortunately, however, most current research on low-carbon cities is focused on technology. Research on the environmental value assessment of established low-carbon city construction and development strategies is still limited.

In view of the lack of environmental value assessment of established low-carbon city strategies, this study adopts more commonly used non-market value assessment methods to evaluate the environmental value of low-carbon city strategies, including the use of hydrogen energy buses, intelligent waste sorting systems, and shared battery vehicles for low-carbon travel to reduce urban carbon dioxide emissions.

Based on the "arteries" and "veins" in the urban vein system, this study evaluates the payment willingness and environmental value of "shared battery cars", "hydrogen energy buses" and low-carbon urban vein "smart garbage recycling cabinets" contained in low-carbon urban arteries using the conditional value method, contributing to China's strategy to achieve carbon neutrality.

This study first discusses the theoretical basis of economic evaluation of low-carbon city related measures, explains the reasons for the economic value of positive externalities of low-carbon

urban environment, defines the connotation of economic value, and discusses the theoretical connotation of its economic value evaluation method. Then, the main trends of CVM research design on the environmental value of urban low-carbon measures are sorted out, the possible deviations and their remedial measures are summarized, and the main determinants affecting residents' willingness to pay are discussed. Finally, the public's willingness to pay for environmental protection and carbon emission reduction in the promotion of hydrogen energy buses, the use of smart garbage recycling cabinets, and the green travel of shared battery cars in Beijing, Shandong Province and Weihai City, Shandong Province were analyzed, and the relevant determinants affecting residents' willingness to pay were discussed. Emphasizing that zero response should not be overlooked when assessing willingness to pay, planning behavior theory can adequately explain payment behavior.

As a data collection method, we chose web-based questionnaires. Questionnaires are a valuable tool for understanding public attitudes towards environmentally friendly products. Face-to-face surveys, telephone interviews, and web-based questionnaires are three types of questionnaires. Due to cost and length constraints, telephone interviews are not commonly used. Face-to-face interviews are an effective way to collect questionnaires, help respondents understand the details of questionnaires, and answer questions in real time. However, given the epidemic prevention situation in our country during the new crown period, it is unlikely that face-to-face interviews will be implemented on a large scale. Moreover, with the growth of the number of Internet terminal devices in China, the number of mobile Internet users in China has reached 1.007 billion. This is very convenient for online surveys. It ensures the smooth implementation of the web questionnaire. Considering the cost and situation of epidemic prevention in China. We used a peak model combined with the double-boundary dichotomy in the conditional value method to handle zero responses, as respondents who refused payment accounted for about thirty percent of the total respondents in our study. We also demonstrate the ability of the peak model to handle zero responses. We also discuss the effect on willingness to pay if the influencing variable in planning behavior theory is not demographic and socioeconomic. Finally, we discuss the predictability of planning behavior theory in explaining payment behavior.

The results show that residents in Beijing, Weihai and Shandong provinces are willing to pay 29.15 million yuan, 2.21 million yuan and 204 million yuan for the three low-carbon city strategies, respectively. Thus, we proved the viability of these plans. Among the factors influencing payments, there is a statistically significant relationship between public income, education level and willingness to pay. Among the variables in planned behavior theory, attitudes, subjective norms, and emotional behavior 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.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

RESEARCH BACKGROUND AND PURPOSE

1.1 Research background

1.1.1 The carbon emissions

Since the outbreak of the Industrial Revolution, the world economy has shown an exponential growth trend, and people's living standards and the degree of social modernization have markedly improved. At the same time, as a by-product of the consumption of fossil energy in industrial development, the total emission of carbon dioxide has jumped sharply compared with before the industrial revolution, resulting in large-scale greenhouse gas emissions, which is the main cause of global warming, and has a series of adverse effects on the ecological environment and global climate. Therefore, a series of social and environmental problems caused by global warming have become a hot spot in the world [1]. By 2020, global carbon emissions reached 38 billion tons, a threefold increase from the second half of the 19th century. The International Energy Organization IEA (2019) pointed out that the content of carbon dioxide in the atmosphere is increasing at a rate of 2.0ppm per year, and has exceeded 400ppm by 2019, much higher than the level maintained before the industrial revolution of 280ppm [2], and the growth of carbon emissions caused using various fossil energy sources in the past three decades has not slowed down. In 2020, the global average surface temperature warmed by more than 1.2°C compared with before the industrial revolution, and there is a further upward trend, causing many risks to terrestrial and marine ecosystems, human health, food and water security, economic and social development, etc. The IPCC pointed out that 1983-2012 was the warmest 30 years in the past 1400 years [3]. As the world's second largest economy, the largest developing country, and the largest country in total carbon emissions, China plays a decisive role in the process of controlling global climate change. Therefore, the implementation of low-carbon emission reduction policies is the only way to dissolve international pressure and improve the quality of economic development.

On May 7, 2021, the BBC published a report that a study by the Rhodium Group pointed out that China accounted for 27% of global carbon emissions in 2019, the United States ranked second with 11% emissions, and India occupied third with 6.6%, as shown in Figure1-1.

In 2019, global carbon emissions were about 10.285 billion tons. China emitted 2777 billion tons, accounting for 27%. The United States emitted 1.442 billion tons, accounting for 11% of emissions (11% on Rhodium Group's chart, but it should be 14%). According to the Rhodium Group, China's emissions are as high as those of all developed countries combined.

Greenhouse gas emissions (%)

Country	Value
China	27
US	11
India	6.6
EU-27	6.4
Indonesia	3.4
Russia	3.1
Brazil	2.8
Japan	2.2
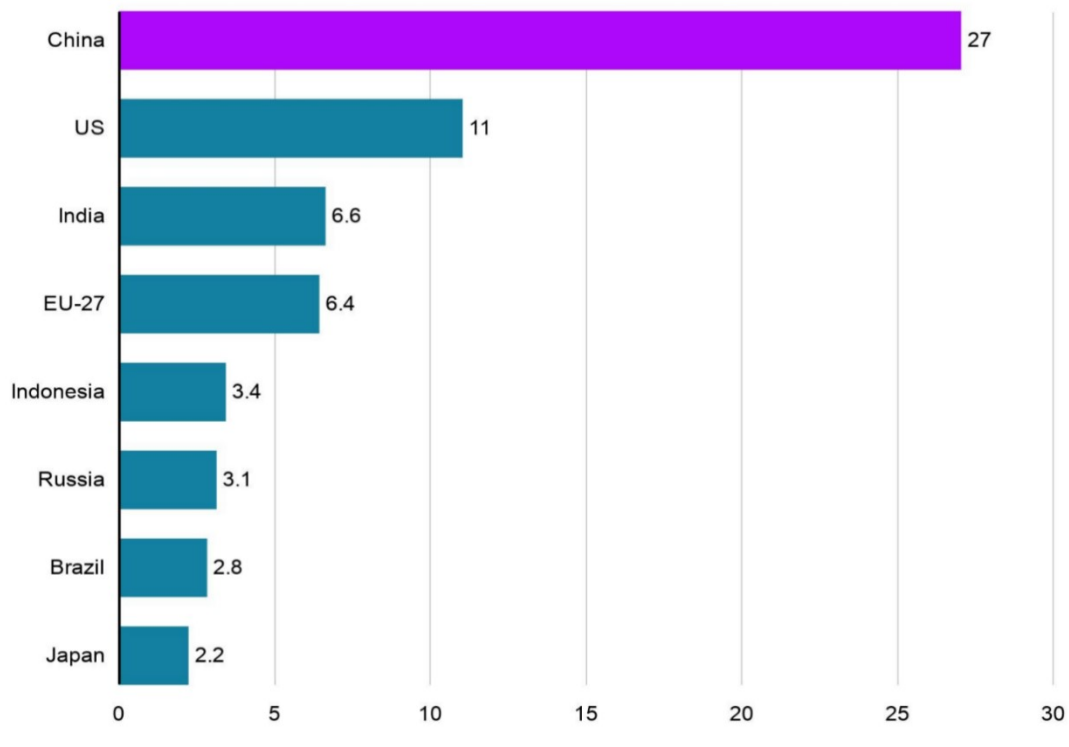
Figure1- 1.Greenhouse gas emissions

As can be seen from Figure 1, carbon dioxide has the highest emission and the most significant impact on climate. Therefore, it is recognized as the most important greenhouse gas and the main cause of climate warming. The consequences of global warming will lead to global precipitation redistribution, melting of glaciers and permafrost, and rising sea levels, which will not only endanger the balance of natural ecosystems, but also threaten human food supply and living environment [4].

1. The climate will become warmer, glaciers will melt, and sea levels will rise, causing the loss of ecological groups such as coastal tidal wetlands, mangroves and coral reefs, coastal erosion, seawater intrusion into coastal underground freshwater layers, salinization of coastal land, etc., resulting in an imbalance of the natural ecological environment of coasts, estuaries, and bays.

2. Many small islands will disappear if the water evaporates more, the rainy season is prolonged, the chance of flooding increases, the degree and severity of the storm impact increases.

3. The ice and snow of the Antarctic Peninsula and the Arctic Ocean will melt, and polar bears and walruses will gradually become extinct.

4. The increase of temperature will affect human fertility, and the activity of sperm decreases with the increase of temperature.

5. The change of the original ecosystem has an impact on agriculture, forestry, animal husbandry

and fishery and other production fields.

6. The risk of contracting infectious diseases and other diseases increases, and germs expand the epidemic through extreme weather and climate events (El Niño, drought, flood, heat wave, etc.), endangering human health. Wait a minute.

To control carbon dioxide emissions and delay the trend of global warming, countries around the world have reached and signed the United Nations Framework Convention on Climate Change (1992), the Kyoto Protocol (1997), the Cancun Agreement (2010), and the Paris Agreement (2016). China has pledged to reach carbon neutrality before 2060, basically aiming for emissions to peak around 2030-2040.

Figure 1-2 shows China's carbon emissions over the years. The surge in CO2 emissions reflects China's rebound from the coronavirus lockdown in early 2020 and economic recovery, mainly reflected in growth in construction, steel and cement. About 70% of the increase in emissions in the first quarter of 2021 was due to increased coal use, with oil demand growth contributing 20% and fossil gas demand increasing by 10%. About 60% of the increase in coal use came from the power sector, followed by the metals industry (15%) and the building materials industry (10%, including cement and glass). In contrast, while emissions from China's steel industry have been growing rapidly in recent years, the steel industry has set ambitious emission reduction targets, peaking by 2025 and falling by 30% from peak by 2030. These targets are the steel industry's response to central government calls for emissions from major energy-consuming sectors to peak by 2025, achieve "stable" emissions reductions by 2030 and "substantial" reductions by 2035. The steel industry's emissions reduction targets are mainly based on the substantial growth of scrap metal electro steelmaking, which could reach nearly 40% of steel production by 2030. In contrast, the current share of electric steelmaking is only 10%. If steel production is flat and scrap supply is used exclusively for steel production, this alone would be enough to reduce emissions from the steel industry by almost 30% [5].
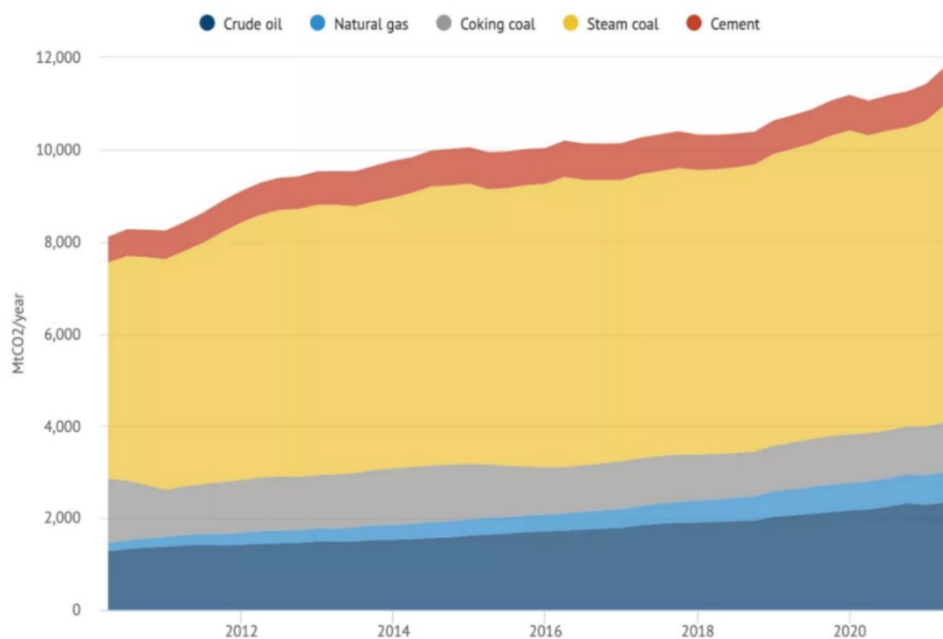
Figure1- 2. China's carbon emissions over the years

To sum up, the rapid growth of Chinese economy also caused the sharp increase of carbon emission. Under the dual pressure of domestic economic development demand and international carbon emission reduction situation, how to promote urbanization and control carbon emission at the same time is a key issue urgently needed to be solved by the Chinese government. To effectively solve this problem, the Chinese government regards urban low-carbon economic development as an important strategy and has formulated a series of measures.

1.1.2 Strategies to mitigate carbon emissions

China strives to peak carbon dioxide emissions before 2030 and strive to achieve carbon neutrality before 2060. After this goal was proposed, relevant ministries, industry associations, and regions successively issued policies of "carbon peaking and carbon neutrality", and relevant work was rapidly advanced. These measures to mitigate carbon emissions can be mainly divided into the following aspects.

First, hydrogen will become a low-carbon solution in the global energy transition of oil giants. The reason why hydrogen energy is favored is not only because of the zero carbon emissions in its release process, but also because hydrogen can be used as an energy storage carrier to make up for the shortcomings of renewable energy fluctuations and intermittencies and promote the large-scale development of the latter. In recent years, countries around the world are promoting the development of hydrogen energy industry at an unprecedented speed. According to a report jointly released by the International Hydrogen Council and McKinsey, more than 30 countries and regions have issued hydrogen energy development roadmaps, and by 2030, global investment in hydrogen energy projects will reach 300 billion US dollars. Globally, 228 large-scale projects have been announced, 85% of which are in Europe, Asia and Australia. Hydrogen could be the most competitive low-carbon solution in more than 20 applications, including long-haul trucks,

shipping, and steel.

Second, vigorously develop clean energy projects. 57% of China's electricity comes from fossil fuels. In recent years, many clean energy projects are being carried out, such as China's dominance in the field of solar energy（Figure 1-3）. The latest power report released by the IEA pointed out that the global energy transition process is accelerating, the proportion of traditional fossil energy power generation has been greatly reduced, and the proportion of renewable energy electricity has increased rapidly, becoming one of the most important sources of electricity in the world.

Figure1- 3.solar energy

The third is to promote green transportation, advocate green travel, and vigorously promote electric vehicles. China's new energy vehicle sales reached 1.367 million units in 2020, a year-on-year increase of 10.9%, accounting for 40.7% of global new energy vehicle sales. China's model has shifted from the "factory of the world" to a clean, green local manufacturer of high-tech products and the world's largest market for electric vehicles. Figure 1-4 shows NEV sales in China from 2014 to 2020 (units: 10,000 units).
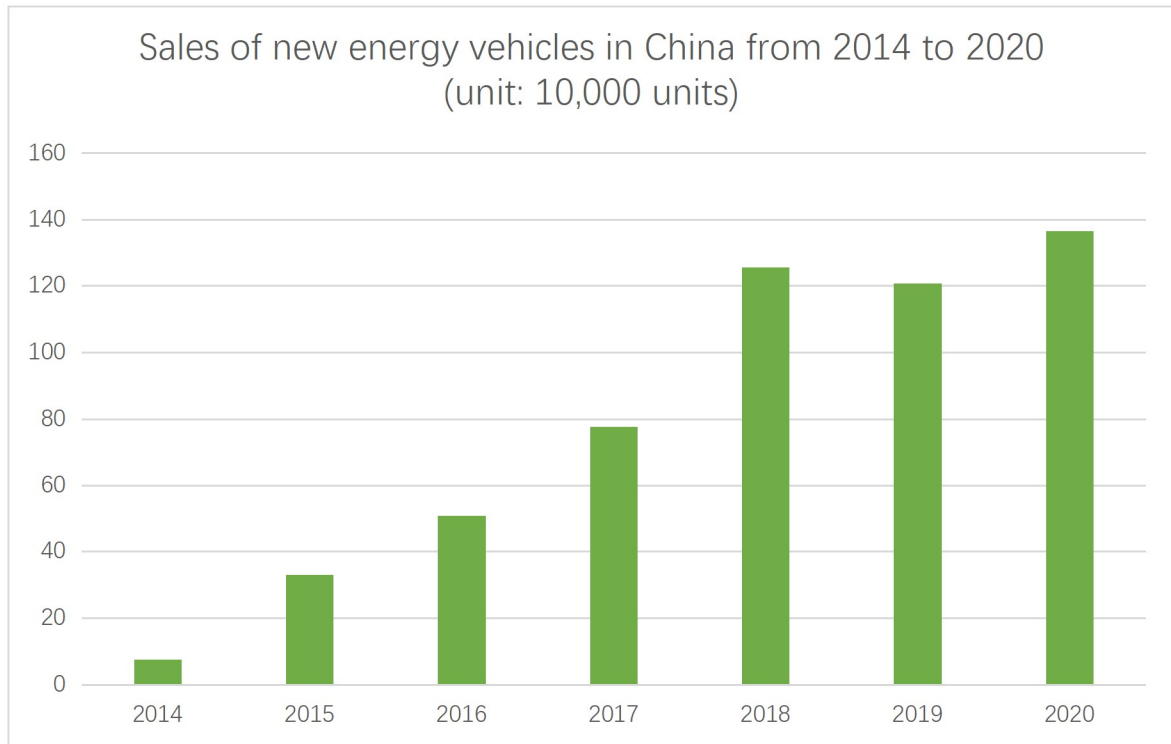
Figure1- 4.Sales of new energy vehicles in China from 2014 to 2020 (unit: 10,000 units)

Fourth, through the development of circular economy, waste utilization, etc. to reduce the discharge of urban garbage and sewage, while protecting the environment to achieve the purpose of reducing carbon emissions. In the circular economy (CE), resources and products are divided, leased, reused, repaired, refurbished, and recycled, thereby extending product lifecycles, reducing waste and generating added value [6]. For example, promote the resource utilization of urban sewage and the construction of corresponding supporting facilities. To promote the development of circular economy, the country has issued a series of measures. In December 2021, China's National Development and Reform Commission (NDRC) issued the Pilot Plan for the Allocation of Reclaimed Water in Typical Areas, requiring local governments to strengthen the construction of wastewater recycling infrastructure, ensure the profitability of relevant market players, and give play to the government's guiding role in the market. It also requires the formulation of reasonable and effective policy measures. Carbon emission reduction is achieved through measures such as the utilization of sewage resources and the upgrading of existing sewage treatment plants.

Fifth, improve the low-carbon development policy system. Increase support for low-carbon development from central and local budgets. Introduce comprehensive supporting policies, improve climate investment and financing mechanisms, better play the role of China's Clean Development Mechanism Fund, and actively use public-private partnership (PPP) models and green bonds to support climate change and low-carbon development. Give play to the guiding role of the government, improve the government green procurement system covering energy conservation, environmental protection, low-carbon and other requirements, and carry out activities to create low-carbon institutions, low-carbon campuses, low-carbon hospitals, etc. Study tax policies conducive to low-carbon development. Accelerate the reform of the energy price formation mechanism, standardize, and gradually eliminate fossil energy subsidies that are not

conducive to energy conservation and carbon reduction. Improve regional low-carbon development coordination and linkage mechanisms.

Low-carbon urban vein system, divided into urban arterial system and venous system. The arterial system refers to transportation, energy, etc. Venous systems refer to garbage collection, wastewater treatment, energy-efficient buildings, and more.

In this study, the value of citizens' value for urban transportation and garbage recycling is mainly explored.

1.1.3 city low carbon relevant measures of environmental economic value assessment

The ultimate purpose of low-carbon city related research is to provide data support and decision-making reference for the formulation and optimization of urban low-carbon development implementation strategies and measures, so how to formulate urban low-carbon construction paths and promote cities to shift from traditional development paths to low-carbon development paths has become a key topic of academic attention scientifically and effectively.

A large number of literature focuses on the implementation path of overall low-carbon construction of cities, for example, Fu Yun et al. proposed a low-carbon urban development path of low-carbon basic (low-carbon energy development), low-carbon structure (low-carbon economic development), low-carbon mode (low-carbon social development) and low-carbon support (low-carbon technology development) on the basis of the theoretical connotation of low-carbon cities and the development status of typical low-carbon cities at home and abroad [7]. Based on a review of international low-carbon city development practices and relevant explorations of domestic cities, Liu Wenling and Wang Can summarized the development models followed by low-carbon city practices, including the comprehensive "low-carbon society" model, the low-carbon industry pull model, the low-carbon supporting industry model and the demonstration "point-to-point" model [8]. Zhang et al. conducted a series of path simulations on energy consumption and carbon emissions in Beijing from 2007 to 2030 based on the long-term energy substitution planning model, and the results show that policy supervision and technological improvement will alleviate Beijing's greenhouse gas emission pressure to a certain extent, but greater energy conservation and emission reduction depend on the change of the city's economic and social development model [9]. Guan and Barker examined the future low-carbon development space and path of Guangyuan City, Sichuan Province through scenario analysis, and the results showed that technological progress and changes in production structure are interdependent and may become key determinants of carbon intensity and carbon dioxide emissions in the future, and the policy level should be based on the decarbonization of production structure to avoid the misunderstanding of "pollution first and treatment later" in many Western countries and coastal areas of China in the process of emissions-intensive industrialization[10].

Song and Zhang Ji combined the types and characteristics of Chinese cities with their choice of low-carbon development models, and divided Chinese cities from the perspectives of population size, location, resource endowment and industrialization stage, and believed that the low-carbon development of any type of city must choose an appropriate development model according to its own characteristics, and combined with the case study of Wuhan, they pointed out that the

selection of a comprehensive low-carbon development model of heavy chemical agglomeration and a large city in central China according to local conditions is an inevitable choice for Wuhan to achieve low-carbon transformation[11]. DeJong et al. pointed out that low-carbon knowledge, professional knowledge, and scientific and technological cooperation with developed countries is a favorable way to achieve low-carbon development of cities and proposed three effective ways of low-carbon cooperation between China and foreign countries according to the closeness of cooperation [12]. Suet al. reviewed the practice of urban low-carbon development from the formulation of China's urban low-carbon development plan, the construction of low-carbon demonstration zones, sustainable energy system, ecological industry, green transportation, green building and other specific fields, and put forward issues and related policy suggestions in the process of low-carbon development [13]. Based on the actual situation of Chinese cities and the national low-carbon development strategy, Zhuang and Zhou comprehensively described the strategic goals of achieving urban low-carbon development transformation from six aspects: urban greenhouse gas emission inventory accounting, future emission scenario analysis, low-carbon development goal setting, key sector action plan setting, low-carbon technology project emission reduction potential assessment and low-carbon policy implementation measures. path [14]. Based on the four perspectives of economy, management, technology and public information, Geng investigated the public acceptance of 22 low-carbon economic policies in five cities in eastern China, and the results of 197 7 questionnaires showed that administrative policies to promote public transport had the highest degree of response, followed by public information, technology and economic policies, and proposed implementation strategies to guide urban residents to low-carbon and green travel [15] . Liu noted Although since 2010, the Chinese government has successively carried out several batches of low-carbon city pilots, and has guided many relative measures, such as increasing urban vegetation, promoting renewable energy, environmental protection, and waste resource utilization. However, the improvement of relevant policies and norms still needs to be strengthened, especially in established urban areas [16].

The environmental value of low-carbon city development measures is often overlooked. An important reason for this is that decision-makers or experts responsible for public resources (local municipalities) tend to be more concerned with the economic consequences (real value) of a city's renewal. The environmental value of green city construction is difficult to estimate because it is a non-priced product. Given the limited amount of public resources available for low-carbon cities, failure to quantify the environmental value of these measures will lead to a lack of effective investment evidence among policymakers. This leaves a missing link between low-carbon research and economic consequences in cities [17]. incentives that are detrimental to sustainable development can be reduced.

The value of the various positive environmental externalities of urban low-carbon measures cannot be easily quantified through market-based means, and the only way these environmentally friendly behaviors need to be priced is non-market valuation.

Some researchers have begun to explore the non-market value of positive environmental externalities brought about by low carbon in cities, or the factors that influence payments. He et al.

(2021) investigated the willingness of Beijing residents to purchase smart waste recycling cabinets (IGSS) and the conditions that affect WTP. Using the framework of Planned Behavior Theory (TPB) and introducing the concept of environmental protection, the average annual price of reducing municipal solid waste in Beijing is estimated to be 319.2 yuan (US$49.43) per household. O'Garra et al. (2007) conducted comparative studies of public preferences for hydrogen buses in Berlin, London, Luxembourg, and Perth. Respondents in all four cities were willing to pay extra for each bus, and the values were similar: V0.29 to V0.35 (V for euro). Lin and Tan (2017) used the conditional value method to study the willingness of people to pay for new energy vehicles in four developed cities: Beijing, Shanghai, Guangzhou, and Shenzhen.

The interval regression model was used to analyze the influencing factors of people's willingness to pay, and the exact amount paid for each sheet was estimated. The results show that about 80% of respondents in the four cities are willing to pay extra to support the adoption of new energy vehicles, and the specific amount of all respondents is 0.653 yuan per fare. Yan and Zhao (2022) studied the influencing factors of people's adoption trend and willingness to pay for hydrogen fuel cell heavy-duty vehicles and analyzed customers' willingness to pay. The results show that customers are less willing to buy hydrogen fuel cell heavy-duty trucks, but the purchase price, fuel cost, environmental awareness, and the number of heavy-duty trucks purchased have a significant impact on the selection of participants. People are willing to pay $116,099-131,579 for hydrogen energy trucks, more than 50% more than they are willing to pay for diesel heavy-duty trucks, and they are willing to pay no more than $1548 per year for repairs. As far as we know, in this series of studies, the scope of subjects studied is generally large, and there is no specific measure of social acceptance and WTP.

1.2 Urban metabolism system

Rapid economic growth, accompanied by health problems in cities and regions and other global environmental issues, has driven the popularity of the topic of "urban metabolic systems" among academics and policymakers. Currently, 56.2% of the world's population lives in cities, accounting for 80% of global GDP. It is expected that current trends in world economic growth, together with population growth and migration, will continue to affect resource production and consumption in cities and have an impact on other urban areas.

The concept of urban metabolism was first proposed in 1965, and by analogy with natural metabolic processes, it can be defined as the complete process of entering the city and products and waste exporting to the city, to indicate the basic way of material and energy flow, and reveal the impact of the city on the external environment. Since then, based on the perspective of metabolic analogy, the connotation of urban metabolism has been continuously enriched. Cities can convert raw materials, fuels and water into the internal environment, human biomass and waste, and cities are self-regulating systems that facilitate human survival and can be seen as a superlife. Here, the city is compared to biological individuals, and it is regarded as an organism that constantly exchanges materials and energy with the external environment, while urban metabolism describes the process and results of its consumption, storage and transformation, and then explores the impact and pressure of urban metabolism on the external environment that supports human life by analogizing the impact of biological individuals on their living

environment. Cities are a kind of social-economic-natural complex ecosystem dominated by human technology and social behavior, with ecological metabolic processes as meridians, and supported by natural life support systems.

Look at a city in terms of urban metabolism as if it had a metabolism, like a living biological system with inputs and outputs. A city's output is GDP, economic benefits, labor or labor, but also waste and pollution. The input may be energy or resources. Urban metabolism, therefore, looks at how resources are introduced into cities and used to produce useful outputs for economic growth. From this, we can measure the effectiveness of urban resource use in terms of total resource intake to assess the capacity of urban systems to maximize the use of all available resources with minimal waste.

The urban metabolic system is divided into urban arterial system and urban venous system. As the name suggests, the urban arterial system is dynamic, and the urban venous system is static. If we compare cities to human bodies, supply infrastructure is the artery. System, processing infrastructure, so to speak, venous system. The urban metabolic system is also a concept that compares the city to a living being. Food, water, oxygen, etc. are brought into the organism. Complete the city function and eventually discharge it as waste. This is the metabolic system. Urban metabolic systems are also concepts that compare cities to living organisms.The urban metabolic system is divided into urban arterial system and urban venous system (Figure 1-5).
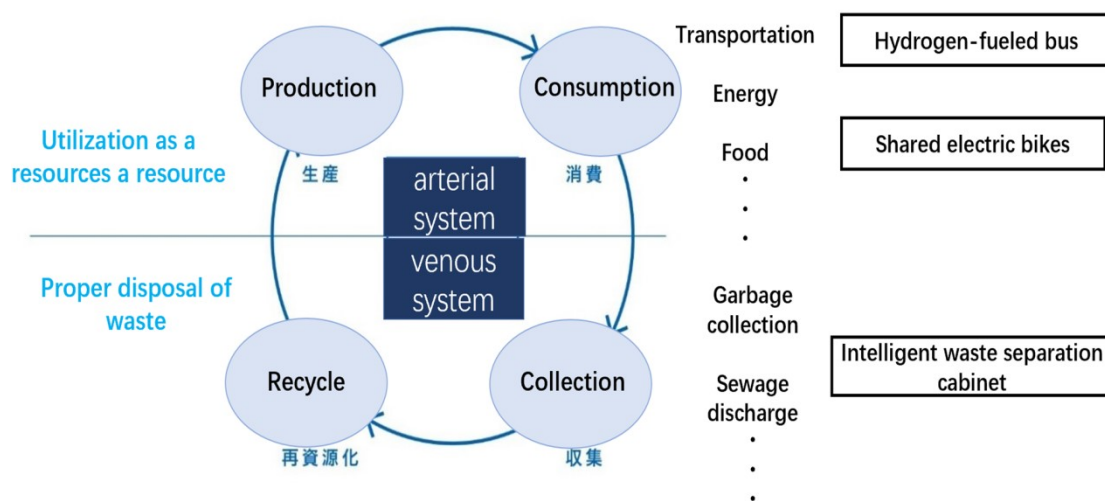
Figure1- 5.Urban metabolism system

In the urban metabolic system, the main industrial material flow is mainly divided into arterial system and venous system, of which arterial system refers to the process of mining, production, circulation and consumption of raw resources or raw materials, and venous system refers to the process of recycling, resource treatment, production and reuse of waste. Arterial industry mainly refers to the exploitation of natural resources and the use of natural resources for production and manufacturing. The vein industry is relative, that is, the waste generated in production or consumption activities is used to produce renewable resources.

The arterial system of a city sometimes includes production and consumption, for example, the transportation, energy, and food that people use. Hydrogen buses and shared battery buses will be considered part of the city's arterial system.

Urban venous systems are sometimes used to refer to public facilities and infrastructure, such as garbage collection and wastewater treatment.

A municipal waste collection system can be considered part of a municipal venous system. Garbage trucks traverse a network of roads, collecting waste from residential and commercial areas and transporting it to treatment facilities. Such a network of roads and vehicular routes becomes the venous system of the city.

Municipal wastewater treatment systems are also considered part of the urban venous system. Sewage networks and drainage channels are spread throughout the city, collecting wastewater and stormwater from residential and commercial facilities and discharging it into treatment facilities and rivers. This promotes the city's water cycle and environmental protection.

As a result, the city's venous system sometimes includes public services and infrastructure, such as garbage collection and wastewater treatment. These facilities and systems play an important role in maintaining the functioning and hygiene of cities and in providing a comfortable urban environment.

In the urban metabolic system, this study mainly studies the arterial system dominated by traffic and the venous system of garbage collection treatment. The introduction of the venous system and the arterial system is very important for the choice of citizens. We will discuss the willingness of citizens to pay for these systems introduced into the construction of a low-carbon society.In order for low-carbon measures to be recognized by citizens, low-carbon technologies are evaluated using the conditional value method.
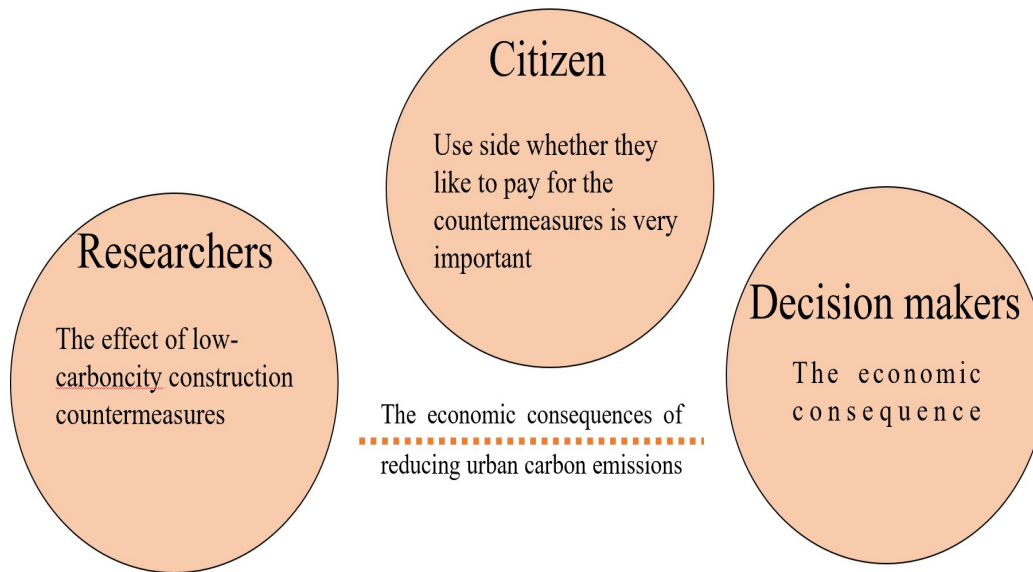
Figure1- 6.Economic evaluation of urban low carbon mitigation countermeasures

If the value of low-carbon urban construction measures cannot be quantified, then urban development policy makers lack effective investment evidence. There is a gap of connection between basic low-carbon city building research and economic consequences.

These three figures mainly represent the researcher's investigation, the choice of citizens, and the strategies of decision-makers.

In the urban metabolic system, the arterial system dominated by traffic and the venous system of garbage collection and treatment are mainly studied.

The choice of citizens is very important for the introduction of arterial and venous systems in a low-carbon society. This paper examines the willingness of citizens to pay for the introduction of these systems. This result can be fed back to decision makers. Contribute to their decision-making(Figure 1-6).
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1.3 Purpose of this study

1. This study discusses the theoretical basis of economic evaluation of measures related to low-carbon cities, explains the reasons for the economic value of positive externalities of low-carbon urban environment, defines the connotation of economic value, and discusses the theoretical connotation of its economic value evaluation method.

2. In this study, the literature review of the non-market value of low-carbon city related measures using conditional value method is reviewed, the main trends of CVM research design of urban

16

low-carbon measures environmental value are sorted out, the possible deviations and their remedies are summarized, and the main determinants affecting residents' willingness to pay are discussed.

3. This study analyzes the willingness of the public in Beijing, Shandong Province and Weihai City, Shandong Province, the capital of China to pay for environmental protection and carbon emission reduction in the promotion of hydrogen energy buses, the use of smart garbage recycling cabinets, and the green travel of shared battery cars through online questionnaires and discusses the relevant determinants affecting residents' willingness to pay.

4. Based on the theory of planned behavior, this study proposes an extended behavior prediction model based on the traditional theory of planned behavior and tests the model to predict the incentive mechanism that promotes the pro-environmental behavior of residents.

5.Provide a way to evaluate low-carbon technologies in order for low-carbon measures to be recognized by citizens.

1.4 Research structure

Based on the "arteries" and "veins" in the urban vein system, this study evaluates the payment willingness and environmental value of "shared battery cars", "hydrogen energy buses" and low-carbon urban vein "smart garbage recycling cabinets" contained in low-carbon urban arteries using the conditional value method, contributing to China's strategy to achieve carbon neutrality.

This study focuses on strategies for building low-carbon cities, and the content of the study is their economic value. In addition to the introductory part of the first chapter and the concluding part of the last chapter, the main part can be divided into three parts, following the research process of this paper. Research processes for theoretical research (Chapter 2), methodological research (Chapter 3), and experimental research (Chapters 4-8), See Figure 1-7 Research Process.

The first part is the theoretical part, which includes the second chapter. This section mainly sorts out and reviews the relevant measures, related theories, conditional value assessment methods and planning behavior theories of urban low-carbon environmental economic value evaluation. Regarding related theories, we explain the theory of public goods, the theory of utility value, the theory of willingness to pay, and the theory of externalities. For the conditional value method, we mainly explain its development history, research status, applicability analysis, and possible deviations in its remediation. For the theory of planned behavior, we elaborate the origin, development process and connotation of its theory, quantify, and discuss the application of this theory in related fields.

The second part is the methodological part. Based on the research on the existing valuation methods of conditional value method, the research design of conditional value method is further studied and discussed. First, this study analyzes the experimental subjects and experimental designs of previous conditional value method studies. Secondly, this study analyzes the main

academic controversies regarding the study of conditional value method, summarizes and discusses possible errors and their remedies. Finally, this study summarizes the main influencing factors influencing respondents' willingness to pay. This section will provide evidence for the experimental study design in Part III.

The third part is the experimental part, which mainly contains the strategy of low-carbon construction in cities (chapters 3-7).

Chapter 3 describes the way the questionnaire was asked and the basis for its preparation. The two-boundary dichotomous conditional value method is used to derive WTP, and SPSS24 and R language are used to process the data. To handle the large number of zero-response samples in this study, a peak model was used in this study. The study also explores the factors influencing residents' participation in supporting low-carbon cities.

Chapters 4, 5 and 6 focus on the willingness to pay for three strategies, analyze the willingness of the public in Beijing, Shandong Province and Weihai City, China's capital to pay for environmental protection and carbon emission reduction in the promotion of hydrogen energy buses, the use of smart waste recycling cabinets, the green travel of shared battery cars, and discuss the relevant determinants of residents' willingness to pay.

Chapter 7 summarizes the conclusions of previous research and puts forward suggestions on how to effectively promote the pro-environmental development of residents based on the research results.

CHAPTER ONE:Research Background and Objectives
I. Research background
2 Purpose of this study
3 Study structure
4 Innovation in this study

CHAPTERTWO :Theoretical Background
I Related theory
2 Research progress of conditional value method
3. Theory of planning behavior
4Conditional valuation Strategic value of low-carbon city

CHAPTER THREE: Research Methods

CHAPTER FOUR, FIVE,SIX
(Valuation oflow carbon city measures)
IUse hydrogen energy buses
2shared electric bikes for low-carbon travel
3intelligent waste sorting systems

CHAPTER SEVEN
Conclusion and policy implications

Figure1- 7.Research Process

1.5 Innovation of this study

1.This is the first time that environmental value has been evaluated in relation to low-carbon city measures. Also, the factors influencing residents' willingness to pay are thoroughly investigated through the theory of planned behavior and the theory of extension.

2.This paper outlines its substance and connotation and elaborates on the theoretical underpinnings of economic evaluation of urban low-carbon strategies.

3.From a methodological perspective, this article outlines the study design of pertinent CVM studies, the factors influencing respondents' WTP, potential biases, and countermeasures. Future CVM low-carbon city initiatives and the creation of related plans may benefit from this information.

4.This study, in contrast to earlier studies, introduces and evaluates the two-boundary dichotomous conditional value approach in conjunction with the peak model to address the zero response that

frequently arises in CVM research. This study enhances the classic TPB model's prediction power for the factors affecting respondents' WTP by incorporating variables like policy concerns, personal interest perception, and moral perception.

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Chapter 2

THEORETICAL BACKGROUND

2.1 Related theories

2.1.1 Theory of sustainable development

2.1.1.1 Implications of sustainable development theory

From the perspective of historical philosophy from the practical point of view, since the emergence and development of human beings, nature has always been the basis for human survival and life, and it is also a necessary prerequisite and condition for the existence of human society. In recent centuries, as human beings gradually enter the industrial society, large-scale exploitation and utilization of natural resources has deteriorated the ecological environment and led to the depletion of resources. Environmental pollution and ecological imbalance are becoming increasingly serious, and the harmonious relationship between man and nature has been broken. Faced with such a deteriorating situation, mankind, after a long period of conscious reflection, is striving to find a natural environment that can protect the natural environment on which we depend. It also makes the win-win way for long-term economic and social development. This theory of sustainable development has gradually entered people's field of vision and gradually become a category involving economic, social, cultural, technological and natural environment and other integrated concepts.

The theory of sustainable development has undergone half a century of iteration and replacement, and was recognized by participants at the United Nations Conference on Environment and Development in 1992. The 1987 United Nations Commission on World and Environmental Development, published a study entitled Our Common Future, defined sustainable development as "development that meets the needs of present generations without jeopardizing the ability of future generations to meet their needs." It is necessary not only to achieve the goal of economic development, but also to properly protect the atmosphere, fresh water, oceans, land, forests, and other natural resources and environment on which mankind depends, so that future generations can sustainably develop and live and work in peace and contentment."

The theoretical definition of sustainable development can be broken down into two key parts: "need" and "limit" on "need". There is no contradiction between the two, and reasonable needs can be met. But this need requires a certain degree of moderation, and if this need is endless, it must endanger the natural systems that support life on Earth. First, the core of sustainable development theory is development. The premise must be to control the number of people while improving the quality of the population, protect the ecological environment while achieving sustainable resource utilization, and ultimately achieve sustainable and long-term economic, ecological and social development. Second, the goal of sustainable development theory is to form a virtuous circle of economic and social development. The goal of sustainable development theory is to meet the various needs of human beings, strive to make the best use of human talents, materials, and interests, and pay attention to the ecological rationality of various economic activities under the condition of protecting ecological resources. It does not pose a threat to the survival and development of future generations. That is, to start with the needs of immediate development and to pay attention to the needs of future development. Let economic and social development enter a

virtuous circle. Third, the theory of sustainable development involves the three aspects of economy, ecology and society, organically combines environmental problems with development issues and penetrates into all corners of economy, ecology and society, and proposes that human beings must pay attention to economic efficiency in development, pursue social fairness and justice, and always pay attention to ecological harmony. Then we will eventually achieve all-round human development. Specifically, the content includes the sustainable development of ecosystems, and strives to achieve sustainable economic development in which man and nature live in harmony and perpetuation. On the premise of not harming the interdenominational rights of future generations, we should strive to achieve a rational allocation of social resources and ensure stable, healthy, sustained, coordinated, and rational economic growth. The sustainable development of society is based on the relationship between people. With natural development and economic development as the medium, we strive to realize the free and comprehensive development of human beings, ensure that the needs of the material and spiritual life of the current generation can be satisfied, and provide the necessary conditions for the survival and development of the next generation.

2.1.1.2 Marx and Engels' ideas on sustainable development

The theory of sustainable development provides a profound theoretical foundation for human beings to correctly understand the relationship between man and nature and seek a scientific and reasonable economic development model. Therefore, it is necessary to trace the origin of Marx, Engels, and the natural view of harmonious coexistence with nature to discuss the theory of sustainable development. The sustainability of development has attracted the attention of Marx and Engels very early, especially Marx's view of treating nature well, which has initially revealed the ideological implications of modern ecological ethics. Engels put forward with foresight that on the one hand, science and technology can promote the development of social productive forces, and on the other hand, human beings continue to conquer nature, and will eventually suffer the consequences of self-defeat and be punished by nature. Marx and Engels' ideas on sustainable development are mainly embodied in the following three aspects. First of all, Marx and Engels pointed out that man is a product of nature. As an organic part of the natural world, the way for man to realize his own survival and development must rely on the natural world. That is, nature is prior and objective relative to man. Therefore, human beings are exercising their subjective initiative. When acting on the natural world through practice, we must respect the nature and the objective laws of nature. Realize the organic unity of human subjective initiative and respect, and the objective laws of nature. Only then will humans enjoy the fruits of nature. Achieve harmony between man and nature, rather than destroying nature and causing human beings to suffer the consequences. Although Marx and Engels' view of nature on harmonious coexistence with nature has provided behavioral guidance and value orientation for human beings to deal with the relationship between man and nature, since the beginning of the century, along with the accelerating process of social industrialization, the level of science and technology has been continuously improved. By transforming and conquering the natural world, human society has greatly raised its own level of material development and spiritual needs. At the same time, human beings adopt an attitude of domination and conquest towards the natural world excessively, indiscriminately, and without following objective laws. This has further aggravated the ecological

crisis. Problems such as global warming, environmental pollution, resource shortage, and energy crisis have become increasingly prominent. The emergence of these problems has led human beings to re-examine the relationship between man and nature, and then explore what is a scientific and reasonable economic development model.

2.1.1.3 A low-carbon economy is an inevitable choice for sustainable development

As mentioned earlier, as the greenest and most environmentally friendly economic development model in history, the low-carbon economy has the basic characteristics of low energy consumption, low emissions and low pollution. These three basic characteristics inherently imply the importance of harmonious development of the relationship between man and nature, the importance of scientific development of the relationship between man and economy and society, and the importance of achieving free and comprehensive development of human beings themselves. The process of achieving a coordinated, balanced and continuous state of these three relationships is a useful manifestation of the connotation of sustainable development theory. As a low-energy economic development model, low-carbon economy advocates improving the technical system of traditional energy utilization and high consumption, reducing carbon emissions in the process of consumption and utilization of fossil energy, and achieving low-carbon energy consumption, which is often called "energy saving". At the same time, new energy will be developed and used, and the traditional energy demand mode with coal, oil and other fossil energy as the main energy consumption will be changed. The development of a low-carbon economy will put forward multi-level requirements for the energy structure, not only to achieve the diversification of the energy structure, but also to achieve low consumption of energy use. Developing a low-carbon economy can reduce the amount of carbon in the atmosphere. Effectively curb the current situation of global temperature rise, as well as improve the status quo of environmental pollution, resource shortage, energy crisis, etc.

"Low-carbon economy is an economic development model that transitions from high-carbon energy to low-carbon energy, and is a human self-help behavior aimed at repairing the carbon imbalance in the earth's ecosystem." It can be seen that the low-carbon economy starts from reducing carbon content and gradually improves the current situation of carbon imbalance in the earth's biosphere. As a low-emission economic development model, low-carbon economy proposes that economic development is not only the improvement and growth of economic indicators, but also people's contribution in the process of economic development. On the basis of improving production technology, the process and results of improving production level and enhancing economic development efficiency are highly organically unified. Its ultimate goal is to reduce carbon emissions in the atmosphere based on low energy consumption. This is often referred to as "emission reduction". This low-emission economic development model requires economic development, not at the expense of damaging the carrying capacity of nature and the ability to restore and regenerate resources, reflecting a high degree of coordination and integration between economic development and natural development. It is possible to correctly handle the relationship between economic development and environmental protection in the natural world. As a low-pollution economic development model, low-carbon economy requires the rational and efficient development and utilization of energy resources on the basis of optimizing the structure

of energy resources and reducing high-carbon emissions. And through technological innovation and scientific and technological progress, effectively recycle energy resources and minimize the index of pollutants emitted to the earth due to energy consumption. Of course, achieving the grand goal of low pollution still requires human beings to change their traditional ways of living and consuming. Achieve green living and rational consumption. Only in this way can we promote the sustainable development of the economy. In turn, it will promote the sustainable development of society and the sustainable development of all mankind. Therefore, the development model of low-carbon economy through "low consumption, low emissions, low pollution" is a good proof that it effectively adheres to the concept of sustainable development.

Low-carbon economy is a development model that takes into account both 'low-carbon' and 'economic'. Low-carbon means that economic development must minimize or stop relying on carbon-based fuels, and achieving energy use transition and economic transition means continuing to maintain the stability and sustainability of economic growth on the basis and process of energy use transition." The development of a low-carbon economy is, in essence, a process of organic integration between economic development and the development of human society in nature. Countries need to wean themselves off fossil fuels, reduce the pressure of high oil prices, and transform their economies, while maintaining moderate, rapid economic growth. Solve many problems in development". Developing a low-carbon economy is an inevitable choice for achieving sustainable development.

2.1.2 Public goods theory

From an economic point of view, goods are generally divided into two categories, one is private goods and the other is public goods. Public goods are not ordinary traditional goods, they are relative to private goods, and they have two unique attributes, one is "non-exclusive" and the other is "non-competitive". Public goods cannot be evaluated at traditional market prices, nor can they be provided by enterprises or individuals through the market system, and generally government departments are responsible for the supply of public goods. Non-exclusivity means that no person's consumption of a public good will reduce the total amount consumed, much less reduce the consumption of the public good by others; non-competition means that people do not interfere with each other's consumption of public goods, and no one will compete with others when enjoying the consumption of a certain public good, because the cost of people consuming public goods at a certain level of production is zero. From the perspective of the nature and characteristics of public goods, low-carbon cities belong to public goods, and the attributes of public goods determine that its total utility is the sum of the utility of all individuals to their consumption income, and the utility of personal consumption income can be obtained by asking about the willingness to pay, and so on, counting the willingness to pay and using the sum of each individual willing to consume can calculate the total utility. However, it should be noted that these two attributes are likely to lead to the phenomenon of "free rider", that is, some people believe that they can enjoy the fruits of co-payment by others without paying, so the willingness to pay will decrease, and the impact of the free-rider phenomenon needs to be fully considered when conducting value assessments.

Non-exclusiveness means that a specific consumer cannot easily prevent other consumers form benefiting from the goods or services. On-competitiveness means that once a public product is provided, any consumer's consumption of public goods will not affect the utility of other consumers, neither the utility of the whole society. Mitigation of urban carbon emissions is a pure public good with non-competitive and non-exclusive characteristic. Markets cannot provide services such as mitigating urban carbon emissions, which need to be provided by governments. Public goods theory can help us understand why we should value cities for the economic value of reducing urban carbon emissions. According to public environment theory, urban low-carbon measures can be defined as public environment products.

2.1.3 Utility Value Theory

Utility value theory is a theory in economics that believes that commodities can meet people's needs, and people's subjective judgment of commodity value makes value occur, which was first proposed in bourgeois economic writings around the 17th century. Utility value theory can be subdivided into two categories, one is general utility theory, the other is marginal utility theory, and the marginal utility theory is currently more mentioned. According to the theory of utility value, the value of commodities arises from satisfying certain needs of people, and there is no value if it cannot meet people's needs. When the quantity of value changes in the opposite direction with the increase or decrease of the quantity of goods, marginal utility can be considered as a criterion for judging the value of goods; Supply and demand determine the magnitude of utility, which means that value maps people's subjective understanding of goods and their opinions, preferences, and actions. According to the utility value theory, any resource with the characteristics of utility and scarcity is valuable. Utility is the source of project value. Measures to reduce urban carbon emissions can indirectly improve people's comfort in urban life, reduce air pollution caused by emissions, alleviate the summer high temperature and heat island effect caused by the greenhouse effect, and improve people's labor productivity, especially for outdoor workers. The indirect utility of reducing a city's carbon emissions has become a solid foundation for its economic value.

It is worth noting that utility can be divided into total utility and marginal utility. Total utility refers to the total satisfaction of consuming a certain amount of a certain item. The magnitude of the total utility depends on the level of individual consumption, i.e., the greater the amount of goods and labor consumed, the greater the total utility, and marginal utility refers to the additional effect of each additional unit of consumption. The willingness to pay for measures to mitigate a city's carbon emissions depends on the marginal utility of the city's carbon emission improvement.

2.1.4 Theory of willingness to pay

The willingness to pay, which represents the maximum price people are willing to pay for an item, is a key point in the Western paradigm of political economy and can be used as an appropriate criterion for evaluating the value of resources. In the absence of a real market, the willingness to pay can be used to measure the level of preference for an item. The greater the willingness to pay, the higher the level of this preference, and vice versa. There are many factors that affect people's

willingness to pay, such as age, marital status, disposable income level, degree of literacy and education, knowledge of goods or resources and preference level, among which the biggest factor is the level of disposable income, usually the higher the level of disposable income, the stronger the willingness to pay. Although the value of a commodity or resource evaluated by willingness to pay may differ from the actual situation, with appropriate methods, the assessment can be brought closer to the actual situation and even the hypothetical market situation can be realized.

2.1.5 Theory of externalities

The concept of externalities was first proposed by Henry Sitchwick and Alfred Marshall, also known as spillover effects, external influences, etc. The theory of externalities refers to the fact that the behavior and decisions of one person or group of people affect another person or group of people, but they are not directly reflected in the market price, and there are two kinds of externalities: positive and negative. Positive, that is, positive externality, refers to the phenomenon that the behavior decisions of a person or group of people bring benefits to others, and the beneficiaries do not have to pay for it, such as residents receiving the new crown pneumonia vaccine can not only reduce the risk of their own infection but also reduce the possibility of becoming a source of the virus and transmitting it to the people around them; Negative externality, that is, negative externality, refers to the phenomenon that the behavior and decision of a person or group of people bring losses to others, but the victim does not receive corresponding compensation, such as sewage discharged by enterprises with unqualified sewage equipment, which will have a bad impact on the entire downstream population. Positive or negative externalities can also be caused by production behavior or consumer behavior [1]. Therefore, externalities can be divided into the following four specific forms: one is the external production economy, that is, the producer takes certain economic actions that benefit others or society; The second is the external economic barrier to production, that is, the producer takes some economic behavior that harms others or society, but does not bear the corresponding compensation costs; The third is the external economy of consumption, that is, consumers take certain economic actions to benefit others or society, but the beneficiaries do not have to pay. The fourth is the external uneconomic nature of consumption, consumers take certain economic actions to harm others or society, and they do not bear the corresponding compensation costs [2].

The increase in carbon emissions due to the development of cities and the use of fossil fuels within cities is a factor in the negative externalities of urban development. This negative externality is affected by both external non-economic production and external non-economic consumption in urban expansion [3]. On the one hand, due to the early stage of urban development, policy makers paid more attention to the development dynamics brought by urbanization, and ignored the increase in carbon emissions caused by urbanization, which led to increased carbon emissions, greenhouse effect, etc. On the other hand, in order to promote the development of the city, the relevant supporting facilities are not implemented in accordance with the response low-carbon standards, such as large-scale heating facilities, various types of motor vehicles with no emission restrictions, and uncontrolled garbage disposal, resulting in carbon emissions generated in the process of emission or degradation. In urban life, the roles of producers and consumers are often interchangeable.

Because the low-carbon nature of urban low-carbon has the nature of public welfare, which leads to its inevitable externality properties. For the builders of early urban development, because the development of low-carbon cities has not attracted enough attention from decision-makers, developers do not have a clear understanding of urban low-carbon measures and related knowledge, so they only focus on economic benefits and do not analyze the economic benefits of low-carbon measures.

As for consumers of eco-friendly products. Due to the externalities of public goods and the existence of self-interested motives, each city dweller only considers marginal costs and marginal utility, and social costs are not burdened, which also leads to their lack of awareness of the importance of carbon emissions, which leads to an increase in carbon emissions and environmental degradation.

It is worth noting that in the process of urban development and expansion, externalities are more direct and dominant; The accumulation of external non-economy in the process of urban development is an intangible effect. The external economy has long been overshadowed by the external economy. If it is not controlled by external economic barriers such as urban carbon emissions caused by urban sprawl, the potential of urban development will continue to be lost [4]. The theory of externalities could explain the result of underestimation of the economic value of public goods. Externalities is defined as the impact of an economic institution to the welfare of others, the value of which is not reflected in market transactions. A large amount of urban carbon emission is the function of negative externalities in the process of urbanization. Positive or negative externality may also be caused by production behavior or consumer behavior.

Direct use value includes the direct utility provided by urban low-carbon construction initiatives; Indirect utilization value mainly includes environmental benefits brought by urban carbon emission mitigation. On-use value contains the benefit available for oneself or future generations. In environmental economic, the value of environmental goods can be divided into Use Value and Non-use Value, Urban carbon emission mitigation value mainly consists of direct use value and non-use value. The non-use value means environment value.

In our research we focus on non-use value.
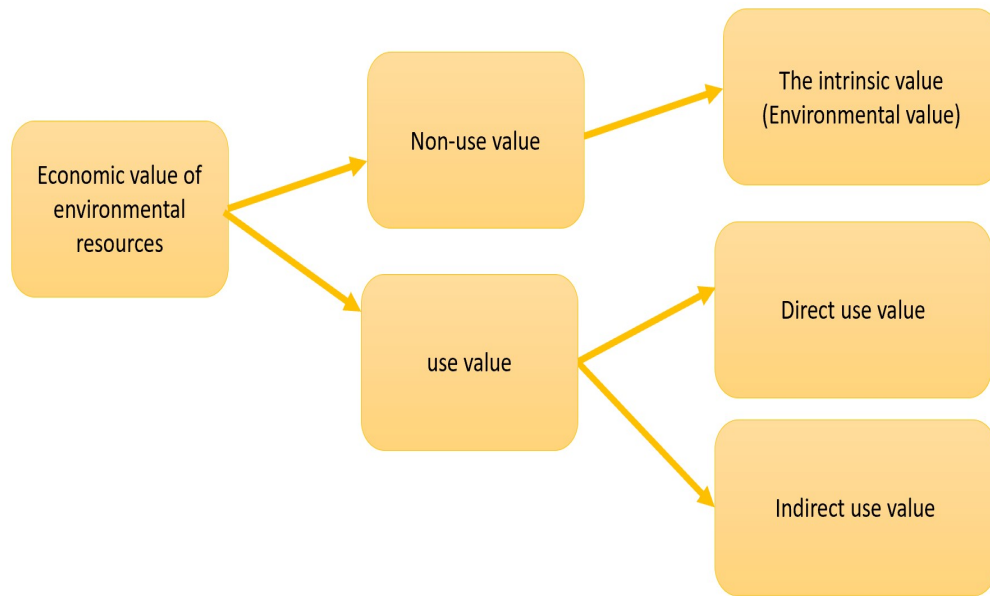
Figure2- 1.Economic value of environmental resources

2.2 Research progress of conditional value method

2.2.1 CVM conception

At this stage, in addition to the direct market price measurement of income, the main income evaluation methods for economic value measurement indicators are the following five other methods: travel cost method, alternative cost method, characteristic price method, intermediary goods method and conditional value assessment method. All five main methods are applied to value valuation without or without direct access to market prices.

1.Travel Cost Method: This method determines the value of a destination by estimating a traveler's travel expenditure. It considers the various expenses of travelers in tourism activities, including hotels, transportation, catering, tickets to tourist attractions, etc. This method is suitable for analyzing the economic value of tourist destinations.

2. Substitution Cost Method: The alternative cost method refers to assessing the value of a tourism project from the investor's point of view. The methodology determines the investment value of the tourism project by comparing other investment opportunities in the same region. When the expected rate of return of other investment opportunities is higher than the project, the value of the project decreases.

3. Characteristic price method: The characteristic price method determines the value of a tourist destination based on its characteristics. These characteristics can include climate, culture, natural landscapes, etc. This approach makes it possible to estimate the value of a tourist destination without considering the number of tourists and tourism spending.

5. Intermediary Goods Law: The Intermediary Goods Law is a method that uses intermediary goods (such as oil, food, airline services, etc.) as the basis for value calculation. This method converts the cost of tourism activities into the value of intermediary goods, thereby estimating the value of the tourist destination. This method is suitable for analyzing various consumption in tourism activities.

6. Conditional value assessment method: The conditional value assessment method is to determine the value of a tourist destination by analyzing its various conditions, such as climate, transportation, landscape, etc. This method is like the characteristic price method, but it is more concerned with the actual impact of tourism conditions than on the characteristics of tourist destinations alone.

Quantitative evaluation of ecological environmental goods or services under non-market conditions is a difficult field of ecological economics and environmental economics, and conditional value assessment (CVM) is generally considered by foreign researchers to be an authoritative method for evaluating resource and environmental goods [5]. Conditional value assessment method (CVM), also known as willingness to pay method, hypothetical evaluation method, willingness value assessment method, through direct investigation to ask people in the simulation market the maximum willingness to pay (WTP) for the improvement of a resource and environmental goods (WTP), or the minimum willingness to accept (WTA) for the loss of a resource and environmental goods (WTA), and finally the respondent's WTP or WTA to reveal the economic value of an environmental good, is a direct investigation method. Conditional Value Assessment (CVM) is widely used in environmental cost-benefit analysis and environmental impact assessment and is a typical declarative evaluation method [6].

The main techniques for assessing the economic value of environmental goods can be roughly divided into two categories: the revealing preference method and the statement preference method [7]. The revealing preference valuation method is to estimate the economic value of changes in environmental quality by indirectly inferring people's preferences for the environment by examining people's market-related behavior, especially the prices they pay or the benefits they receive in a market that is closely related to the environment. These also include the travel expense method, the hedonic price method, the market cost method and the revenue transfer method. The stated preference method refers to direct inquiries to elicit consumer preferences for goods or services in a particular environment [8]. The most used method of stating preferences is conditional value method, which obtains people's willingness to pay for benefits of environmental improvement or deterioration of environmental quality within a hypothetical market, thereby estimating the economic value of a particular environmental good or service. The conditional value method allows both use and non-use values to be estimated [4].

The Revealing Preferences method uses an individual's behavior in the actual market and the simulated market to derive the value of environmental goods or services. For example, the value of a nature reserve can be deduced from the travel expenses incurred by tourists who travel to the area. These methods are also known as indirect market approaches or surrogate market approaches.

Methods to reveal preferences include TCM, HPM, Market Cost Method, such as Replacement Cost Method, Defen sive-Expenditure Method, etc. Benefit Trans fer Method, BTM, etc. (Figure 2-1).

The stated preference method is a "direct method" that attempts to elicit environmental value directly from the respondent's response using survey techniques in the context of a hypothetical market. Methods for stating preferences include Conditional Value Assessment (CVM) and Choice Experiment (CE). Selection testing methods include Conjoint Analysis (CA) and Choice Modelling (CM). The joint analysis method can be further divided into Contingent Ranking (CR), Contingent Rating (CR), and Paired Compari son (PC) [4] (Figure 1). These methods are flexible and can be used to value a wider range of environmental goods or services than disclosure preferences. More importantly, the stated preference method can be used to value total economic value (i.e., use value and non-utilization value). The method of revealing preferences can only be used to assess use value.
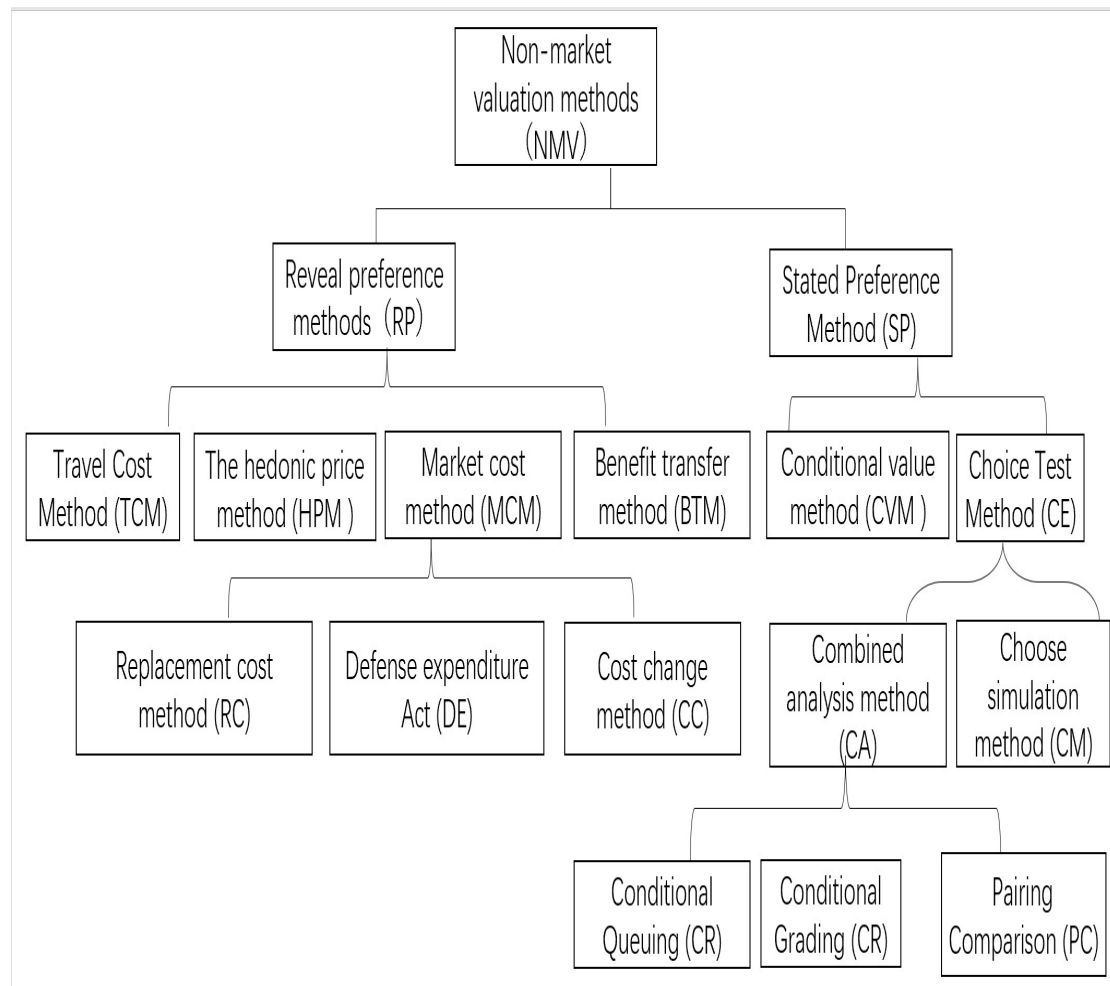
Figure2- 2.Classification of non-market valuation techniques

Conditional value method is the most effective method to evaluate the non-use value of public environmental products (market resources, such as environmental protection or pollution impact).

It is an economic technique based on research. While these environmental goods do bring benefits to the public, there is no clear market price for them because they are not sold directly - for example, clean air, beautiful environment, authentic atmosphere, etc., but it is difficult to obtain value using price-based models. Conditional value method is an evaluation technique used to measure these aspects. Conditional value method usually obtains relevant information needed for valuation through questionnaire. Since it uses the statement information of respondents for analysis, it is also called "stated preference" model rather than price-based revealing preference model. Both models are utility based. Typically, surveys ask how much people are willing to pay (or accept) to maintain (or be compensated for) an environmental feature, such as the environmental value of a low-carbon strategy. Usually, the conditional value method requires that in the context of a hypothetical market, respondents describe changes in the quantity or quality of environmental goods or services through a questionnaire and ask them to be willing to pay (WTP) or willing to accept the loss of improvement or environmental quality. Consumer preference for public environmental goods and services and their economic value can be estimated in this way. Researchers usually use WTP to assess the economic value of environmental public goods [8].

2.2.2 Review of the development of conditional value method

CVM was proposed by Davis in 1963 and first applied to the recreational value of camping and hunting in Maine woodlands [9]. Since the 70s of the 20th centuries, CVM has gradually been used to assess the economic value of natural resources for recreation, hunting, and aesthetic benefits [10.11]. In 1979, the U.S. Water Resources Commission (WRC) introduced principles and procedures for applying CVM to cost-benefit analysis in water resources planning, recommending CVM as one of two priority methods for assessing recreational benefits. (The other is the travel cost method). It has promoted the application of conditional value methods by water-related federal agencies such as the US Army Corps of Engineering and the US Bureau of Reclamation [12]. In 1986, the U.S. Department of the Interior recommended CVM as a fundamental method for measuring the value of natural resources and environmental resources and heritage [13].

In 1992, the National Oceanic and Atmospheric Administration (NOAA) appointed a senior commissioner led by two Nobel laureates in economics, Kenneth Arrow and Robert Solow，The applicability of CVM in measuring the non-use or existential value of natural resources was evaluated The Commission proposes some guidelines for the application of CVM to the assessment of the in-use or existential value of natural resources[14] For example, in order to make CVM research findings as reliable as possible, WTP questions should be formatted using voting rather than open-ended question formats; Surveys should be conducted face-to-face (or telephone) rather than mail-in questionnaires [15.16]. The promotion of the US government has played an important role in the widespread application and methodological development of CVM in the assessment of the economic value of environmental goods in the United States. In the 80s of the 20th centuries, CVM research was introduced to the United Kingdom, Norway, and Sweden, and in the 90s it was introduced to France and Denmark. Studies in European Union countries over the past 20 years have shown that CVM is a promising technology for aiding public decision-making [17]. Although European countries started many years later than the United States, their development is also very remarkable. According to statistics, by 1999, more than 650

cases of environmental value assessment research carried out by European countries using various environmental value assessment techniques had been carried out. These evaluation techniques include CVM and other stated preference techniques. Such as selection experiments, joint analysis, conditional queuing, condition grading, travel fee usage, hedonic price method. Among them, the application of CVM technology accounts for the main part.

In the past 40 years, CVM has been increasingly widely used in Western countries. The number of research cases has increased. Survey and statistical analysis methods are becoming more and more perfect. It has become one of the most used and useful tools for valuing the economic value of goods and resources in non-market environments. According to Mitchell and other statistics, in the more than 20 years from the early 60s of the 20th centuries when CVM was proposed to the end of the 80s of the 20th centuries, there were 120 CVM research cases published. Carson's statistics show that more than 2,000 CVM cases have been studied in more than 40 countries [18]. According to statistics from the Department of Economics of the University of California in 2001, since the 90s of the 20th centuries (mainly in recent years), there have been more than 500 literatures on the use of CVM to assess the value of non-market resources. While research methods are evolving, the scope of research is also expanding. From the beginning of research on the recreational value of environmental goods or services, to the current widespread application to assess the benefits of environmental improvement and the economic loss of environmental damage. Since Randall et al. applied CVM to research on environmental quality improvement for the first time in 1974, the research literature on condition valuation of environmental restoration and environmental improvement has increased year by year, and in recent years, the applied research on CVM has mainly evaluated the value of water quality improvement, wetland restoration, oil spills, natural area protection, health risk reduction, etc. The most representative studies include Loomis et al. [19] on the evaluation of the total economic value of restored watershed ecosystems, Jorgensen et al. [20] on the fairness of the valuation of environmental public goods conditions.

2.2.3 Guidance technology for maximum willingness to pay

A detailed description of the condition of the environmental goods or services to be evaluated in terms of quantity, quality, time and location, and the provision of sufficient and realistic and accurate information to the respondent, is the basis for the respondent's assessment of the questions raised in the conditional value assessment. The appropriate payment instrument should also be selected to guide the WTP or WTA. Possible means of payment include income tax, property tax, utilities, entrance fees, and payments to trust funds.

Willingness to pay can be obtained through face-to-face surveys, telephone surveys and postal letters. Although the most expensive face-to-face survey, it is the most important and commonly used survey method because it has obvious advantages in illustrating hypothetical markets, stating the goods and services to be evaluated, and answering respondents' concerns.

In conditional value assessment research, the guidance technology or questionnaire format used to derive the maximum willingness to pay is an important means in CVM research. the initial

technique used is that the bidding game is a continuous type of questionnaire format. A variety of question formats have been developed to guide respondents to their maximum willingness to pay. Existing guidance techniques for deriving WTP can be divided into continuous conditional value assessment and discrete conditional value assessment (two categories) (Figure2-2). Continuous conditional valuation can be divided into three categories: repeated bid game, open question format (i.e., bid game) and payment card format. In the double bid game, the investigator continuously raises and lowers the offer level until the maximum WTP of the respondent is identified. The repeat bid game is effective in telephone and face-to-face surveys, but due to the possible influence of the starting price on the maximum WTP, the repeat bid game technique is not often used in today's research. Open questions in the format respondents freely express your most big WTP. Respondents were asked to name the biggest direct WTP, so open questions format provides the most easily analyzed According to. Easy to open-ended question format of the questions, but there is certain difficulty on the respondents in answering questions, especially on their when a solution of the problem, or it is difficult to determine their own the greatest willingness to pay and leave blank on the questionnaire or answer does not represent the number of pay their greatest willingness to pay.

There are two kinds of payment cards: non-anchor type payment card and anchor type payment card. Unanchored payment cards require respondents to select their maximum amount of willingness to pay from a given set of value data.
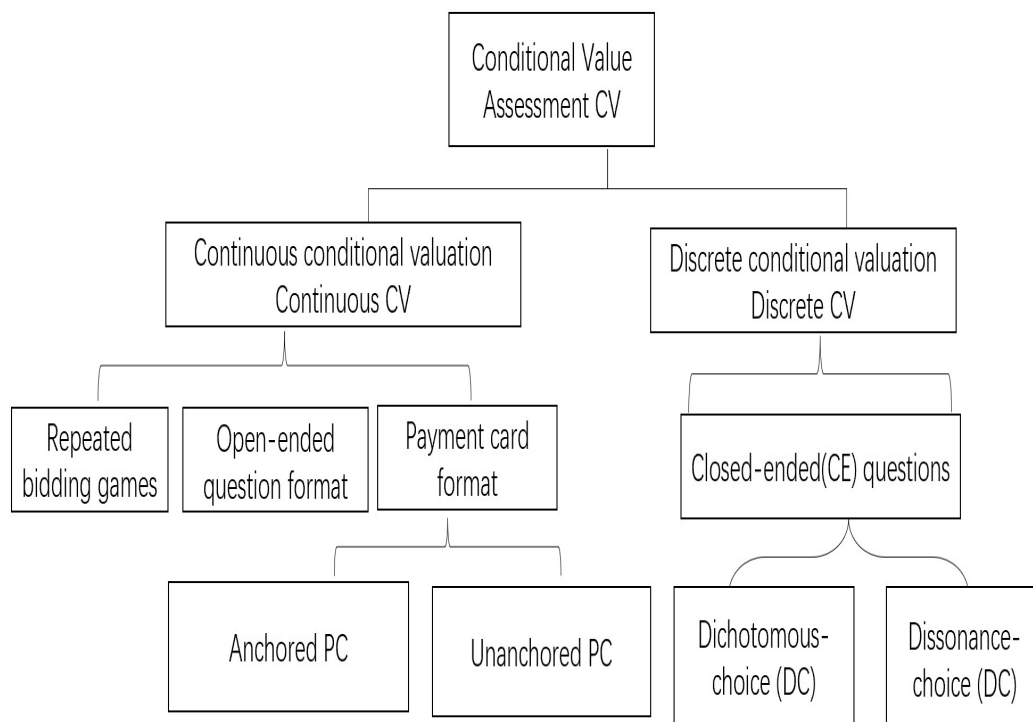
Figure2- 3.WIP-guided techniques for conditional value assessment studies

It is also possible to write their own maximum number of willingness to pay; Anchored payment cards provide investigators with some background information to ask them about their willingness to pay in other public items at the same time to provide some binding background data for ongoing surveys. While the payment card format can overcome some of the difficulties found in open-ended questionnaires, some researchers believe that the range of offers offered on the payment card and its midpoint may influence respondents' willingness to pay. The range of values on the payment card and its midpoint can be determined in the pre-survey using an open-ended question format. Discrete conditional valuation uses a closed-ended question format, which also includes a binary selection question format and an incongruity minimization question format. During the development of CVM, researchers were able to simulate the pricing behavior of the market more than asking respondents to answer "yes" or "no" than asking them to directly state their maximum willingness to pay. Instead, a closed-ended, binary choice question format was used in the study. In the binary choice questionnaire, respondents were asked to answer 'yes' or 'no' for a given maximum WTP, a question format that does not provide a direct estimate of the maximum WTP.

The closed-ended binary choice questionnaire format was introduced into CVM research by Bishop et al. in 1979 [21]. It was widely used after Hane Manne established the function relationship between binary choice and willingness to pay [22][23]. NOAA's CVM High Committee recommends the binary choice question format as a priority question format for CVM research. Since the 90s of the 20th centuries, the binary choice question format has become very popular in the study of CVM [24]. At present, the binary choice question format has developed a variety of question formats such as unilateral dichotomy (or referendum vote), two-boundary binary choice (or citizen referendum) [25], trilateral dichotomy choice [26.27].

Dual-border re-voting and tri-border binary selection are 2 newer variants of the binary choice question format. The closed-ended binary choice question format is currently considered to be the most advanced method in CVM research. The advantage of the binary choice question format is that it simulates the market pricing behavior familiar to consumers, and the respondent decides whether to buy or not buy for a given price of a hypothetical commodity; The questionnaire format can be designed as a "yes" and "no" question format. Moreover, Hoehn et al. [28] believe that dichotomy questionnaires provide motivation for people to tell the truth, and respondents evaluate the resources and services provided. If the number of offers is less, respondents will not answer "yes". At the same time, respondents can only answer "yes" or "no" without asking them to make a direct offer. The bipartite choice question format will reduce the likelihood that respondents will overstate their estimates. The main disadvantage of the binary choice question format is the difficulty of designing the range of tender quantities and calculating willingness to pay. Designing the number of bids requires determining the specific range of quotes asked and the interval at which the quotes change, as well as how many respondents will select a particular offer. The range of quotations should be determined so that the analyst can outline the probability of payment curve from the payer's quotation.

2.2.4 Research status of conditional value theory

The Contingent Valuation Method (CVM) is a method that can be used for non-use valuation and is a type of declarative preference. It does not rely on data in the real market, but by designing a virtual market environment, by using the method of questionnaire survey, asking respondents if the quantity or quality of the supply of environmental goods in the virtual market has changed to a certain extent, in response to this change, the respondent is willing to pay (WTP) or Willingness to Accept (WTA) change. Based on this, the economic value of environmental resources is evaluated [29].

This method was first applied to the assessment of negative effects from the 1989 oil spill in Valdez, USA [30]. Although there have been assessments of negative effects or non-use values before, most of the methods are only in the hands of scholars and are not well known to the public. However, in Valdez's lawsuit against the company that caused the oil spill, the conditional value theory began to attract widespread attention and aroused heated discussion. After that, the declarative preference research method represented by conditional value theory began to be widely recognized and began to be widely used in the evaluation of non-use value. O'Doherty [31] believes that a complete conditional value theory should not only select appropriate survey methods to investigate the respondent's willingness to pay, but also set a complete background for the questionee's question to enhance the respondent's understanding of the thing to be investigated. With the continuous improvement of conditional value theory, the measurement method of willingness to pay is also constantly improving. Holvad [32] has shown that different measures are used to obtain different willingness to pay. The survey method of payment willingness is divided into continuous type and discrete type, the continuous type mainly includes free answer (Open-ended), bidding game (Bidding Game), payment card (Payment Card), and discrete type only binary choice (Dichotomous Choices). Open-ended is the requirement for respondents to give directly and clearly what they think is the maximum amount or minimum amount of compensation they think should be paid for current improvements or regressions. Carlsson, Johansson Stenman, and Carlsson [33] argue that this approach eliminates starting point bias in the assessment process and bias caused by respondents' being too aggressive. However, Hoyos and Mariel's [42] research shows that this method is not suitable for the investigation of unfamiliar questions with the respondents, and there are often more shortcomings for unfamiliar questions, which is easy to produce many non-answers, and many "zero" payments or obvious too high or too low payments, which can easily lead to strategic behavior. Bidding game is to ask for an initial payment amount, based on this amount, if the consumer answers in the affirmative, continue to increase the payment amount, and vice versa, continue to reduce the amount until the respondent's willingness to pay. Huh, Lee and Shin [34] et al. argue that respondents' willingness to pay in such cases is easily influenced by the amount of the initial prompt.

The payment card provides a series of amounts for the respondent within a range, and the respondent can choose his maximum willingness to pay. Cameron and Huppert [35], in their analysis of the value of non-market resources using payment card methods, found that payment card methods provide respondents with alternative payment prices, and while they can clearly reveal the scope of respondents' payments, the data on the payment card may influence the choice of respondents. As the only discrete method of payment willingness to pay, Dichotomous Choices is to ask the respondent whether he is willing to pay the currently given amount under the current

set situation, and further use statistical inference to determine the willingness to pay according to the relationship between the probability of the respondent's answer and the number of prompts [36]. In the above binary selection, because the prompt amount can be given randomly, but there is usually only one prompt amount, when the prompt amount is higher than the payment amount that the respondent is willing to accept, the respondent usually refuses to answer, resulting in a bias. Therefore, in order to reduce the above bias, Cooper and Hanemann [37] and others proposed a two-stage dichotomy selection method, also known as the improved dichotomy. The method is to add a question to the original binary choice to determine whether the respondent is willing to pay a higher or lower amount, which is very different from the bidding game in that it is only added once, rather than constantly asking questions. Chien, Huang and Shaw [38] and Bjornstad [39] believe that in addition to the need for prejudgment estimation for a given price, another disadvantage of the improved dichotomy is that a relatively large sample size is required to complete the evaluation of the whole process, which makes many "unexpected values" at the tail of the numerical distribution, and the corresponding statistical processing becomes very complex.

It is also used internationally. When Nomura and Akai [40] used conditional value theory to analyze the willingness of Japanese residents to pay for clean electricity, they found that the design and distribution method of the questionnaire had an impact on the willingness to pay. Lera-López, Faulin and Sánchez [41] estimated the willingness of people near the Pyrenees to pay for the improvement of the transport environment, and analyzed the factors that influenced the willingness to pay, finding that pollution and environmental concern were important factors influencing the willingness to pay. China introduced the conditional value theory from abroad in the 80s, and the discussion and research of this method in recent years is in the process of continuous development. Chiu and Tzeng [42] used declarative preference analysis to assess market acceptance of electric vehicles in Taiwan. Guo, Liu, and Mao [43] used unilateral dichotomy to investigate Beijing's willingness to pay for renewable electricity. Xue [44] believes that although the popularization and application of the willingness survey method is difficult, it has shown a strong and seemingly omnipotent potential for measuring the economic value of goods without a market, so it still has a wide range of application prospects.

2.3 Applicability analysis of conditional value method

2.3.1 Characteristics and limitations of conditional value method

The conditional value method has obvious advantages in assessing the value of non-market goods, which can be easily operated by obtaining the willingness to pay for goods that are not marketable and can be used to estimate the correlation between other economic variables and willingness to pay. However, there may be some deviations that affect the evaluation conclusion in the actual application of the conditional value method, including hypothetical bias, information bias, strategy bias, embedding bias, induced technical bias, problem order deviation, survey method bias, scope problem, etc. Therefore, targeted countermeasures should be taken in all links of the assessment process to minimize deviations, so that the subjective influence of assessment conclusions is as small as possible, more accurate and reasonable.

1．Hypothetical bias

Instead of obtaining data in a publicly traded market, conditional value creates a hypothetical market in which respondents trade virtually in a simulated market. The willingness to pay collected in this way may be biased from the actual situation, but because there is no non-use value and there is no real trading market, the existing deviation cannot be verified, which is an imaginary deviation.

2．Payment deviation

When asking about willingness to pay, respondents may have different perceptions of the form of payment, which may affect the willingness to pay. For example, paying a portion of the tax paid does not result in additional expenditure, but handing it over to a specialized department requires additional expenditure in addition to the current living expenses, which will make respondents less willing to pay than the former. The resulting deviation in the willingness to pay is the payment deviation.

3．Deviation from tender value

When conducting a questionnaire survey, respondents choose from a set ordered willingness to pay value or range, which may affect the respondent's judgment of their willingness to pay, and the resulting deviation is the deviation of the bid value.

4．Policy deviation

Due to the subjective psychological effect, respondents may go against their true willingness to pay when choosing, which is mainly reflected in the fact that respondents who are unwilling to pay exaggerate their willingness to pay for the sake of "face" or are willing and able to pay out of caution or questioning the management level of the institution for the payment funds and reduce their willingness to pay or are unwilling to pay, this deviation is policy bias. This bias is also known as protest response, the former is protesting overestimation, i.e., the respondent's choice of willingness to pay is higher than the true will, and the latter is a defiant zero payment, i.e. the respondent actually has the willingness to pay but chooses to refuse.

5．Embedding bias

Embedding bias, also known as partial-global bias, embedding effect, etc., is the difference in willingness to pay when the same subject is evaluated as a separate object and when evaluated as part of a larger assessed object. Embedding bias may exist in both use and non-use value assessments, whereas in non-use value assessments, respondents lack value in the market in which they can be referenced, so the embedding bias may be greater than in use value assessments.

2.3.2 The necessity of conditional value method improvement

For non-use value, the evaluation through the conditional value method can obtain an appraisal value with a certain degree of accuracy. At present, with the diversification of tourist demand and the continuous enrichment of tourism resource asset types, the impact of various deviations in the conditional value method is also very different for different types of tourism resource assets and should be re-analyzed according to the type of assessed object. For hypothetical deviations,

payment deviations, and bid value deviations, when using the conditional value method to evaluate non-use value, you can still reduce the deviation by setting up a pre-survey. The specific method is: select a small sample size of respondents to do a pre-survey first, and deepen the interviewee's understanding of the assessed object by fully introducing the situation of the assessed, so as to achieve the purpose of simulating the market more realistically; Ask respondents about the willingness to pay directly, without providing an orderly willingness to pay value or range, learn as much as possible about the payment method from the respondent, collect information such as the willingness to pay value and payment method provided by the respondent themselves, and set the willingness to pay value or range, payment method, and part worth paying in the formal questionnaire based on this. At the same time, in the pre-survey process, problems that are unreasonable and not easy to understand can be found, and they can be adjusted to questions that are easier to convey to the interviewee, which is conducive to obtaining a more true and accurate willingness of the respondent to pay.

When collecting information using conditional value methods, complete information is essential. Respondents' willingness to pay can only reflect their preference if the information is complete [45]. Many researchers believe that the way information is collected plays an important role in the study of CVM [46]. The quality of CVM is largely influenced by the quality of the respondent's information.

In CVM's research, respondents were provided with information in the following ways: respondents' needs and budget constraints and the characteristics of relevant environmental products or services, information on environmental resources and alternatives or supplements to related services, and the WTP value of other products. Among them, the type or characteristics of environmental products or services, their own conditions (funds, time, etc.), and the influence of relatives and friends will affect the WTP value of the respondent [47].

2.4 Application of the conditional value method

In recent decades of research in the United States and European Union, the application of CVM can evaluate the economic value of environmental goods such as recreation value, environmental quality improvement, wetland restoration, and ecosystem services, so as to provide technical support for public decision-making on natural resources and environmental protection. However, due to the influence of economic development level, social system and public awareness, CVM has been poorly studied in developing countries. CVM was introduced to China in the 80s of the 20th centuries, but it has been stuck in the introduction and discussion of theory, and the earliest empirical study was Xue Da yuan in 1997 to use CVM to explore the non-use value of biodiversity in Chang bai Mountain [48].

The use of conditional value assessment method to assess the economic value of environmental quality improvement or deterioration is a research hotspot, and in 1974, Randal et al. first applied the conditional value assessment method to the evaluation of environmental quality improvement, and since then, the relevant research on environmental improvement and environmental pollution loss has gradually increased [49]. Carlsson et al. surveyed Swedish residents about their willingness to pay to reduce harmful substances in the air by 50%, and the results showed that

people are willing to pay 2000SEK/a, and WTP is positively affected by income, wealth, and education [50]. Istamto et al. listed three traffic air pollution scenarios and investigated the willingness of residents in many countries to pay, and the results showed that the WTP of residents in different countries was large, and it was significantly affected by the three factors of risk perception, attitude and environmental pollution perception in terms of water environment improvement [51]. Day, Swanson et al. studied and discussed the willingness to pay for the improvement of water quality of all rivers in Beijing and Dian chi Lake in Kunming, and the WTP was 186 yuan/year and 77 yuan/year, respectively [52-53].

There are more and more economic assessment studies on environmental quality improvement or environmental pollution loss in China. Yang et al. investigated the willingness of households in 8 districts of Beijing to pay for environmental quality improvement (reducing the concentration of pollutants in the air by 50% within 5 years), and the results showed that the average willingness to pay was 143 yuan/year, which tested the correlation between WTP and residents' socio-economic situation and verified the feasibility of CVM in China's environmental field [54-55]. Cai et al. studied the willingness of Beijing residents to pay for air quality improvement, and the results showed that WTP was 652.33 yuan/year, and WTP was positively correlated with household income and education level [56]. Yang et al. conducted two surveys in 2004 and 2007 respectively showed that the WTP of residents for air improvement increased over time, and that demographic variables (income, age and education level) and environmental media exposure had a significant impact on WTP [57]. Zeng et al. used the conditional value assessment method to investigate the average willingness of Beijing residents to reduce the annual average concentration of PM2.5 by 30%, 45% and 60%, which were 71.60 yuan/month, 85.66 yuan/month and 94.31 yuan/month, respectively, and constructed a structural equation model between risk perception and willingness to pay, and the fitting results showed a significant positive correlation between the two [58]. Through literature research, it is found that there are only a few economic assessments of water environment improvement in China, and the earliest was Du Ya ping's assessment of the economic value of improving East Lake, and the results showed that the degree of water quality improvement increased, and residents' willingness to pay also increased [59]. Xu et al. evaluated the non-market value of water environment improvement in the Xi jiang River Basin and analyzed its influencing factors, and the results showed that the average monthly willingness of households to pay for environmental improvement was 132.6 yuan, and the total value of water environment improvement in the entire river basin was about 4.31 billion yuan/month, and the respondents' confidence in the successful realization of the virtual water environment improvement project goals, willingness to participate in environmental protection volunteer activities, local water environment quality and household monthly income had a significant positive impact on the willingness to pay for water environment improvement[60].The results of Liang Yong et al. on the urban water environment in Yinchuan showed that the average willingness of residents to pay was 175.55 yuan per year, which was significantly related to education level, income, satisfaction with the current water environment and trust in the service department [61].

2.5 Possible biases in CVM studies and their resolution

As a typical statement preference valuation technique, conditional valuation has obvious advantages. It

is a relatively straightforward way to guide individuals to value goods or services in non-market environments. The most significant advantage over the revealing preference method is that it is easy to apply and does not require any theoretical assumptions. The only assumption implicit in CVM applications is that respondents are aware of their personal preferences and are therefore capable of valuing environmental goods or services. And be willing to honestly state his/her willingness to pay. Moreover, the choice simulation (CM) method of the current CVM and stated preference methods is the only method that can be used to value non-utilization value or passive utilization value. It may be precisely because of the relative simplicity of its theoretical premises that the correctness and reliability of the value assessment results obtained with CVM will be questioned by its inherent biases. Summarized, the possible deviations affecting the accuracy of the results of the evaluation of conditions and value evaluation studies mainly include: hypothetical bias, payment method deviation, bid starting point deviation, strategic deviation, information bias, non-reflection deviation, affirmative response deviation, protest reflection bias, partial-global deviation, embedding bias, question order deviation, residence time length deviation, investigator bias, survey method deviation, etc. [62]. Most of these biases are related to the CVM method itself, and another method of stating preference- the selection simulation (CM) method, is less prone to bias. These biases become possible factors affecting the validity of the results of conditional valuation studies. Based on international research experience, in the process of questionnaire design and survey implementation, corresponding methods can be adopted to effectively reduce and reduce the possible impact of most deviations in conditional value assessment. Table 2-1 summarizes the various biases proposed in international CVM studies and how to deal with them [63].

Table2- 1.Possible biases in contingent valuation study and their solutions

The type of deviation	Description of deviation	Simultaneous volume design and implementation methods to reduce deviations
Hypothetical bias	Respondents' responses to hypothetical market questions differ from responses to real markets, and the hypothetical nature of the survey leads to deviations from the real results	The illustrated questionnaire was designed and refined, with at least 30 participants. questionnaires to fully simulate the market; Anonymous surveys; To the respondent. Appropriate remuneration reflects the value of its valuation information to simulate the market
Payment method deviations	Because the hypothetical payment method (the way people are charged for the currency) is inappropriate resulting deviations	Design WTP questions with various payment methods for pre-survey selection" sex" payment methods; Or

		provide a variety of appropriate payment methods by the respondent. Choose the way that suits your heart
Starting point bias	**The bid format for some CVM studies suggests the bid recommended for the bid starting point.** **The starting point will be misinterpreted by the respondent as the "appropriate" WTP range.**	**The starting point and value interval of this tender format can be determined through pre-surveys range to reduce the starting point deviation**
Strategic bias	**Respondents try to influence the survey results and the actual decision-making process while bidding.** **When you deliberately say high or low your true willingness to pay, the strategy arises.** **Sexual deviations**	**Outlying bids are excluded before the results of the survey are analyzed Bids that exceed 5%~10% of revenue) to obtain the core bid value**
Information bias	**The quantity, quality, and order of information provided affect the quantity of information on bids This can make it difficult for uninformed respondents to give appropriate willingness to pay**	**The information provided to the respondent and the scenario described are as relevant as possible to the assessment to be assessed The true state of the environmental goods or services**

Non-response bias	It was not possible to involve some people who were not interested in the subject matter of the survey in the response. The CVM questionnaire biases the demographic representation of the sample (and is subject to Question)	The design of the questions is concise and easy to answer (the response rate of more than 70% in the CV survey is ideal, and the response rate of 40%~60% is also common)
yes-saying bias	When answering discrete CV questions, respondents tend to answer yes. Biases to express their motives rather than give their true preferences	Give respondents the possibility to express their support for the survey plan without it. Tube prices can avoid this deviation
Protest response bias	Respondents tend to oppose hypothetical markets and payment instruments. difference	Design a question specifically in the questionnaire to identify the reason for 0 payment; Exclude the protest bid sample from the data analysis (no more than 15% of the total sample)
Part-whole bias	When the respondent fails to correctly distinguish between an overall environment and its components Deviations generated	Remind respondents to clarify and pay attention to their income and expenditure limits, and value the entire item and not the part of the item
Embedding effect	To a good or service as a more inclusive good or service Some of them have a lower WTP than when they were valued independently. phenomenon	Provide a full background description or supplementary text and charts and their relative measurements of the different improvements in the environmental goods or services to be assessed

Order effects	**In questionnaires with multiple valuation questions, each related question differs.** **The possible effect of the current order on the results**	**Respondents are reminded to refer to the questions before and after and revise the previously made estimates.** **Judgment to reduce the impact of question order**
Length of stay bias	**Long stays in surveys were inconvenient and annoying for respondents.** **Sensation and influence on survey results**	**A sample was randomly selected in the relevant population area from the presentation to the end of the respondent Component 1 questionnaire for no more than 30 minutes**
Interviewer bias	**In face-to-face surveys attended by multiple investigators,differentinvestigatorswere evaluated.** **The possible impact of the value result**	**Strictly train and manage investigators or use professional investigators**
Survey mode bias	**Mailing letters, telephones, face-to-face interviews and other different investigation methods to the results Effect. Face-to-face interviews are the most accurate form of investigation but the costliest.** **Letter and telephone surveys are low in cost but also in response rates**	**In correspondence surveys, the following methods were used to increase the response rate: the first letter should be followed by the second and third letters (or telephones), respectively; A fee ($1) is attached to the first letter; Stimulate respondents' motivation to reflect with beautifully printed charts**

2.6 Statistical analysis of data on maximum willingness to pay

In recent years, the statistical aspects of conditional valuation questionnaire design and data analysis have become a hot topic in CVM research as the research shifts from the open-ended question format of the largest WTP of direct survey respondents to the closed-ended question format [64]. The survey results of the questionnaire using the open-ended question format, because the survey data provide a direct measurement of the maximum WTP of the respondent without further analysis itself, so the statistical technique is not high, and the average maximum WTP of the sample can be obtained directly by nonparametric methods. Survey data in the payment card question format, the average maximum WTP of the sample can be obtained using parametric and non-parametric methods (Figure2-3). The total economic value of the environmental good or service is equal to the average maximum WTP of the sample multiplied by the total number of households associated (if the sample is in "households").

In welfare economics, an effective way to measure welfare levels in monetary terms is willingness to pay (WTP) and willingness to accept (WTA). WTP and WTA are direct measurement of contingent valuation method refers to the maximum amount of income a person is willing to pay for a change or avoiding a change. WTA refers to the minimum income compensation that a person is willing to accept for an unfavorable change, or the minimum monetary compensation for giving up specific favorable condition.

In the survey results of the questionnaire in the closed-ended question format, the respondent's answer is not directly a certain amount of money, but answers "yes" or "no" for some given amount of money, so it is necessary to use certain statistical techniques to link a certain amount of money faced by respondents with their "yes" or "no" answers to derive the maximum willingness to pay, so the statistical technology requirements are high. Since the "yes" or "no" response in the closed-ended question format is a discrete variable, appropriate economic statistical models are needed to quantify such questions. The Probit and Logit models are two models that are increasingly widely used in discretely reflected data analysis of conditional value assessment [65] (Figure 2-3).
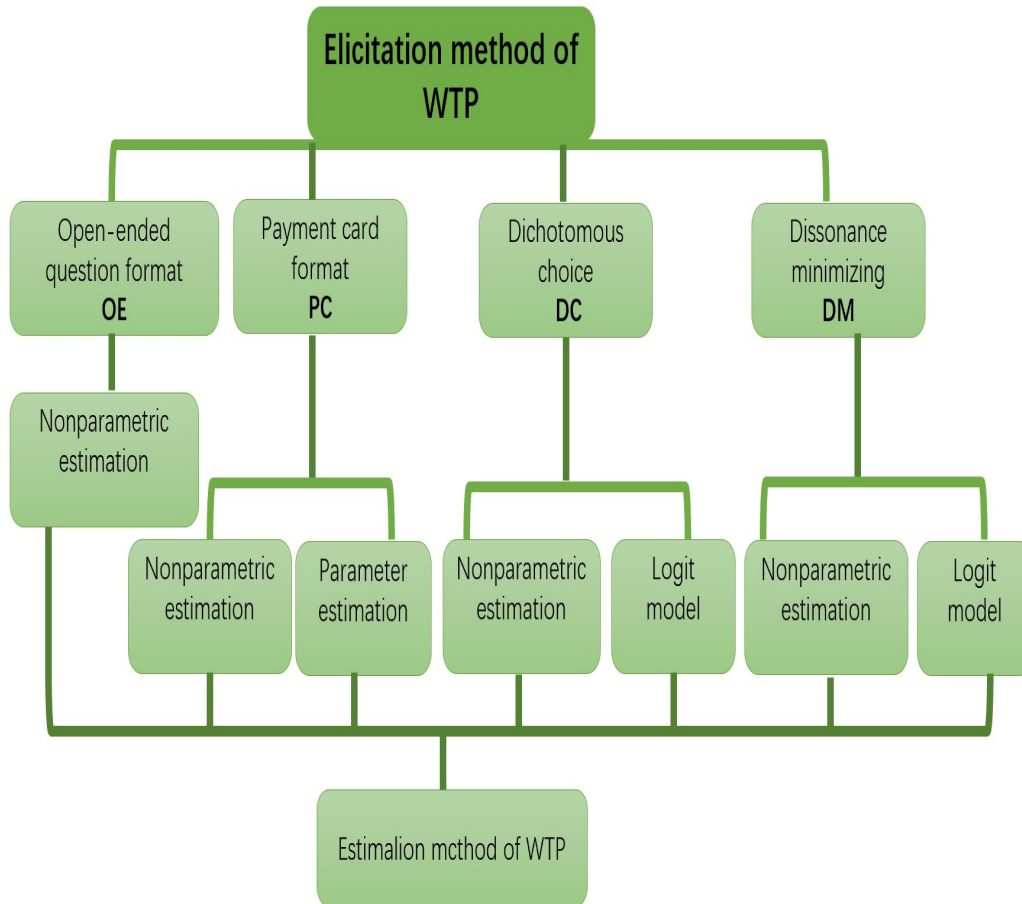
Figure2- 4.Data analysis method of WTP-guided method for conditional value assessment research

In a survey with a binary choice question format, respondents answered "yes" or "no" to a given amount of money. Hanemann points out that the likelihood that respondents are willing to pay for a given amount of money can be statistically estimated using Probit or Logit models [64]. The basic relationship is as follows:

$$\text{Prob (yes)} = 1 - \{1 + \exp[B0 - B1(X)]\}^{-1} \quad (1)$$

In this equation (1), B0, B1 are the coefficients for regression using the logit or Probit function, and X is the quantity of a certain bid that the respondent is asked to pay. Other factors may also include responses to attitudinal questions or statistical information about respondents such as age, education, membership in environmental organizations, etc. When WTP is greater than or equal to zero, Hanemann [65] gives the formula for calculating the expected value of WTP from equation (1):

$$E(\text{WTP}) = (1 / B1) \times \ln(1 + \exp B0) \quad (2)$$

In this equation (2), B1 is the coefficient of influence of the estimated maximum amount of money paid on the "yes" estimate. If there are no other independent variables in the regression equation, B0 is the constant term in the estimation equation; If there are other independent variables, B0 is the sum of the constant term and the product of the regression estimation coefficient of the other independent variable and its mean. The confidence intervals for the average WTP can be calculated using the variance: covariance matrix and the simulation method proposed by Park et al. [66].

2.7Theory of planned behavior

2.7.1 Origins of the theory of planned behavior

In 1975, American scholars Fishbein and Ajzen proposed the Theory of Reasoned Action (TRA), also known as the Fishbein model, which was originally proposed by Fishbein in 1967 and extensively analyzed and refined by Fishbein and Ajzen, aiming to explore the role of attitudes in individual selection, and focusing on the formation of cognition and the impact on attitudes. The Fishbyne model provides a detailed analysis of major theories, such as expected value theory, consistency theory, and attribution theory [67], and is structurally like other major motivation theories. The theory of rational behavior assumes that humans generally act in a sensible manner, the rational person hypothesis, that they consider the implications of their actions, implicitly or explicitly, considering the information available. This theory is consistent with its focus on volitional behavior, which assumes that a person's intention to perform (or not perform) an action is the direct determinant of that action. Unless something unforeseen happens, people should do what they want. According to rational behavior theory, a person's intentions are a function of two fundamental determinants; One is a personal factor, and the other reflects social influence.

Attitude refers to the degree of influence of an individual's evaluation of the target behavior, and a person's attitude towards a specific behavior is a function of the perceived outcome.

Subjective norm refers to "a person who thinks that the majority of people who are important to him think that he should or should not perform the relevant act" and is a function of "the perceived expectations of a particular reference individual or group, and the individual's motivation to comply with these expectations". While it is thought that normative beliefs may be included as part of the components of expected value attitudes, Fishbein argues that it is useful to maintain a distinction between beliefs about the consequences of actions and beliefs about expectations of relevant comparators.

The theory of rational behavior can be simply described as follows:

$$B{\sim}I \propto [\mu1ATB + \mu2SN]$$

B is a certain behavior, I am the intention of the person to perform the behavior B, ATB is the attitude of someone to perform the behavior B, SN is the subjective norm, $\mu1$ and $\mu2$ are weighted parameters, reflecting the relative importance of ATB and SN. The wavy line ~ indicates that an intent can predict a behavior only if the intent has not changed before the act is executed B: $\propto$ indicates that the intention is proportional to the weighted sum of attitudes and subjective norms.
Fishbein and Ajzen discuss two other conditions in which the ability of the intent variable to predict behavior will decrease. First, as the time between measuring a person's intent and observing their behavior increases, the likelihood that their intentions may change increases, reducing the overall predictability of the original intent. Second, where standards of conduct are not controlled by the will of the actors, a decrease in their ability to carry out their intentions

translates into a decrease in their ability to predict behavior. A lack of volitional control may occur when an individual lacks the ability or resources to perform the intended behavior. The rational behavior theory model asserts that external variables (including all variables not explicitly represented in the model), such as the characteristics of behavioral goals, indirectly influence behavioral intent only by influencing an individual's beliefs, evaluations, normative beliefs, motivation for compliance, or the importance weights of attitudes and subjective normative components.

2.7.2 Development of planned behavior theory

Because rational behavior theory has limitations in dealing with people's behavior that is not completely controlled by their will, Ajzen further proposed the Theory of Planned Behavior (TPB), which is the inheritance and development of rational behavior theory. As with rational behavior theory, a central element in planned behavior theory is the individual's intention or willingness to perform a given action, which is thought to be a motivation to capture the behavior, indicating that people are willing to try to put in the effort and how much effort people plan to put in to perform a certain behavior. In general, the stronger the intention to engage in an act, the more likely it is that the act will manifest. However, the performance of most behaviors depends to some extent on some unmotivated factors, that is, some external factors, such as access to necessary opportunities, time and resources (such as money, skills, cooperation of others), such as a person's inability to find the time required to plan and execute an action in a particular situation, then he may be able to perform the behavior in another situation without changing attitudes and subjective norms, and this external factor may force people to change the behavior plan. So planned behavior theory is a theory that expands the theory of rational behavior and aims to predict and explain human behavior in a specific context. The difference between the theory of planned behavior and the theory of rational behavior is the addition of perceptual behavior control, the concept of which refers to: the perception of ease or difficulty in performing an action of interest. In general, positive attitudes, support from significant others, and accurate perceptual behavior control should have a positive impact on behavioral willingness. The resources and opportunities available to a person must determine in some way the likelihood of behavioral success. However, greater psychological interest than actual control is the perception of behavioral control, as well as the influence on intention and behavior [68]. Perceptual behavior control plays an important role in planned behavior theory.

Ajzen argues that perceptual behavioral control not only has an impact on behavioral willingness but may also have a direct impact on target behavior, and that perceived behavioral control and behavioral intent can be used directly to predict behavioral achievement for two reasons: first, to keep the intention constant, the effort expended to make a behavioral process come to a successful conclusion is likely to increase with perceived behavioral control. For example, even if two people have the same strong desire to learn to ski, and both try to do so, those who believe they can master the activity are more likely to stick with it than those who doubt their abilities. The second reason is that perceptual behavioral control can often be used as an alternative to actual control, but this depends on the accuracy of perception, and if a person has less information about behavior, perceptual behavioral control may not increase the accuracy of behavior prediction, but it is

realistic to some extent, it can be used to predict the probability of a successful behavioral attempt.

The specific framework of the Theory of Planning Behavior (TPB) model is shown in Figure 2-4：
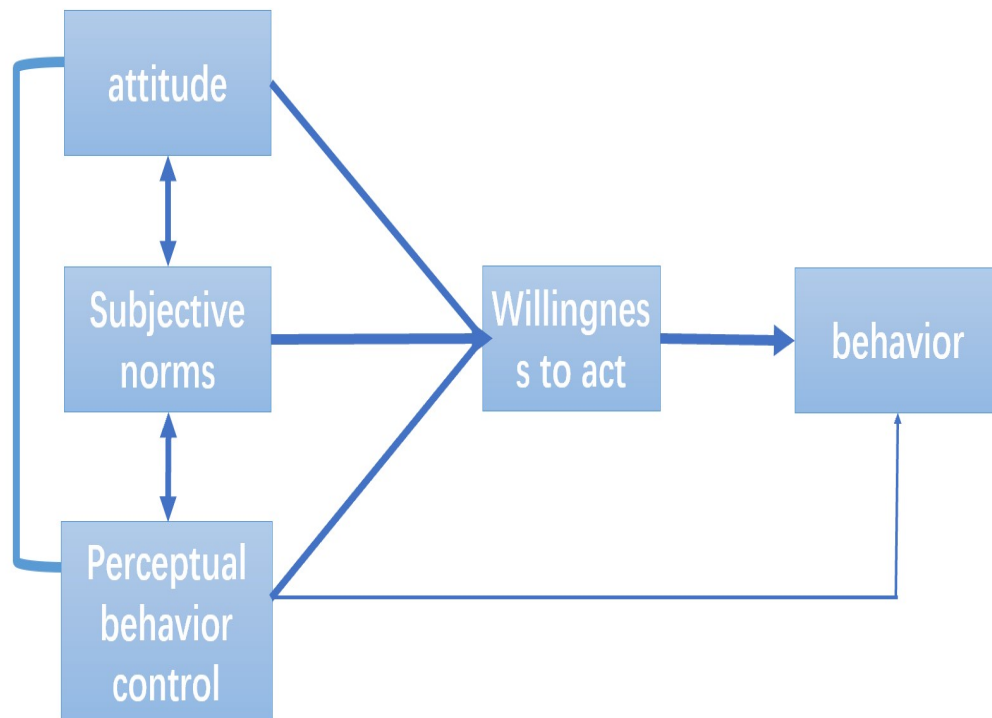
Figure2- 5.Theoretical model of planning behavior

Ajzen [69] 1991 years to perfect the theory of rational behavior, puts forward the theory of planned behavior. The theory of planned behavior adds three control variables to behavioral intentions. These are attitudes, regulatory norms, and perceived behavioral control. So far, planned behavior theory has been widely used. Used to explore the various factors affecting behavior.

Using literature meta-analysis methods, Sutton found that planned behavior theory and rational behavior theory can explain the variation index of behavioral intention by 40%~50% on average, and the coefficient of variation of explanatory behavior is 19%~38%. Based on 185 published literature, Armitage and Conner found that behavioral attitudes, subjective norms, and perceptual behavioral control explained 39 percent of the variation in behavioral intention, and perceptual behavioral control and behavioral intention together explained 27 percent of the variation in actual behavior. Compared with perceptual behavior control, behavioral intention is more explanatory to actual behavior.

2.7.3The connotation of the theory of planned behavior

Planned behavior theory is a well-known theory in social psychology that links behavior to attitude. This theory is based on the expected value theory and explains the theory of the general individual decision-making process from the perspective of information processing. It includes five elements: behavioral attitude, subjective norms, perceptual behavior control, behavioral intention, and behavior.

1.Attitude refers to the positive or negative feelings that an individual has about the behavior, that is, the attitude formed by the individual's evaluation of this behavior after conceptualization, so the component of the attitude is often regarded as a function of the individual's significant belief in the outcome of the behavior.

2.Subjective norm refers to the social pressure that individuals feel about whether to take a particular behavior, that is, when predicting the behavior of others, those individuals or groups that have influence on the individual's behavior decisions (salient individuals or groups) play a role in whether the individual takes a specific behavior.

3.Perceived Behavioral Control (Perceived Behavioral Control) refers to the obstacles that reflect the individual's experience and expectations, and when the individual believes that he has more resources and opportunities, and fewer expected obstacles, the stronger the perceptual behavioral control over behavior. There are two ways to influence it, one is to have a motivational implication of behavioral intention; Second, it can also directly predict behavior.

4. Behavior intention refers to an individual's subjective probability of taking a specific behavior, which reflects the individual's willingness to adopt a specific behavior.

5.Behavior refers to the behavior that an individual acts.

Planned behavior theory holds that human behavior is planned and the result of deliberation. Behavior here refers to specific actions taken by individuals, and such actions depend on the intention of the actor to act. Behavioral intention refers to the subjective possibility of an individual's judgment of whether to take a specific behavior and is the individual's willingness to implement a specific behavior. Early findings suggest that behavioral intent can often predict the implementation of that specific behavior more accurately. is the most direct and important factor influencing behavior. A person's actions are not entirely controlled by their personal will. It is also influenced by behavioral intent, as well as other physical control conditions, such as an individual's abilities, perceived resources, and opportunities. The results of a meta-analysis suggest that behavioral intention can explain 22% of the corresponding behavioral variation [69]. Ajzen believes that all factors that may influence behavior are indirectly affecting the performance of behavior through behavioral intention. The intention to act is affected by three related factors, one of which is the "attitude" derived from the individual's own "attitude", that is, the "attitude" to adopt a specific behavior; The second is derived from external "subjective norms", that is,

"subjective norms" that affect individuals to take a specific behavior; Finally, it comes from "perceived behavioral control."

The more positive an individual's attitude towards a certain behavior, the stronger the individual's intention to act; The more positive the subjective norms of a certain behavior, the stronger the individual's intention to act; When attitudes and subjective norms are more positive and perceptual behavior control is stronger, the individual's intention to act will also be stronger. Contrary to the basic assumptions of rational action theory, Ajzen argues that the individual's volitional control over behavior is seen as a continuum, with actions at one end that are completely under volitional control and actions that are completely out of volitional control at the other. Most of human behavior falls somewhere between these two extremes. Therefore, to predict behavior that is not completely under volitional control, it is necessary to add the variable of behavioral perception control. However, when the individual's control over behavior is closer to the strongest degree, or when the control problem is not a factor for the individual, the predictive effect of planned behavior theory is like that of rational behavior theory.

The theory of planned behavior has the following main ideas:

(1) The behavior that is not completely controlled by the personal will is not only affected by the intention of the act, but also by the actual control conditions such as the personal ability, opportunity, and resources to perform the act, and the intention of the act directly determines the behavior when the actual control conditions are sufficient.

(2) Accurate perceptual behavior control reflects the condition of actual control conditions, so it can be used as an alternative measurement index for actual control conditions, directly predicting the likelihood of behavior occurrence (as shown by the dotted line in the figure below), and the accuracy of prediction depends on the true degree of perceptual behavior control.

(3) Behavioral attitude, subjective norm and perceptual behavior control are the three main variables that determine behavior intention, the more positive the attitude, the greater the support of important others, the stronger the perceptual behavior control, the greater the behavior intention, and vice versa.

(4) Individuals have many beliefs about behavior, but only a relatively small number of behavioral beliefs can be acquired in a specific time and environment, and these accessible beliefs are also called highlight beliefs, which are the cognitive and emotional basis of behavioral attitudes, subjective norms and perceptual behavior control.

(5) Personal and sociocultural factors (such as personality, intelligence, experience, age, gender, cultural background, etc.) indirectly affect behavioral attitudes, subjective norms and perceptual behavior control by influencing behavioral beliefs, and ultimately affect behavioral intentions and behaviors.

(6) Behavioral attitudes, subjective norms, and perceptual behavioral control are conceptually

completely distinguishable, but sometimes they may share a common belief base, so they are both independent and related to each other.

While the TPB theory has been affirmed and supported, it has also been questioned a lot. Bagozzi et al. have pointed out that TPB theory only emphasizes the instrumental component of attitude and ignores its emotional component [70].Many researchers agree with this view and measure both attitudes at the same time in their studies, Chan et al. showed that the relationship between affective attitude and intention is stronger than that of instrumental attitude [71], while Paisley et al. showed that there was no significant difference in the relationship between the two attitudes and behavioral intention [72]. For the variable of subjective norms, Sheeran and Orbel believe that its conceptual definition does not reflect the influence of society on individual behavior well, resulting in a weak relationship between this variable and intention in many behavioral analyses, and propose that subjective normative definitions should be improved [73]. These doubts have led to the development and improvement of TPB theory.

2.7.4 Quantification of planning behavior theory

When applying the theory of planning behavior to practical projects, scholars mostly adopt the measurement theory proposed by Ajzen: the principle of consistency must be followed when measuring; The criterion for comparison is a two-step process, the first is to derive the prominent beliefs, and the second is to generate a formal questionnaire.

2.7.4.1 Principle of conformity

The principle of consistency means that the survey of all study variables must contain the same action elements, i.e., the measured attitudes, intentions, subjective norms and perceptual behavior controls should be intentions, attitudes, subjective norms and perceptual controls over specific actions, and the actions investigated should be consistent with the actions that occurred under its realistic conditions. Ajzen argues that failure to follow the principle of consistency leads to errors in inconsistent assessments, and it is easy to confuse or underestimate the relationship between variables [74]. Because of the importance of the principle of consistency to research results, planning behavior theory requires researchers to strictly describe and define the behaviors studied before the survey. In the theory of planned behavior, behavior refers to the exposed and significant observable response of an individual to a specific goal at a specific moment and environmental situation, so the definition of each factor in the study of action should include four factors: target, action, environment and time, referred to as the TACT element of behavior [74]. Definitions of TACT elements vary from researcher to investigator, who can change each factor for the purpose of the study or combine individual or many factors to reflect the generality of behavior. Whether defined in detail or universally, researchers must ensure that behavioral intentions, attitudes, subjective norms and perceptual behavior control have the same behavioral factors to ensure the consistency of the research.

2.7.4.2 Eliciting prominent beliefs

The most important part of the whole research is to elicit prominent beliefs, which occupy such an important place in the theory of planned behavior. Planned behavior theory argues that highlighting beliefs is the cognitive and emotional basis for behavioral attitudes, subjective norms, and perceptual behavioral control. Highlighting beliefs not only explains why different individual's different behavioral attitudes, subjective norms and perceptual behavioral controls have, but can even provide valuable information for designing behavioral interventions.

Many researchers use planned behavior theory for research, unconsciously use or choose questionnaire items from previous studies, although this practice also finds and produces relatively novel results, but the reliability and validity of research measurements are relatively poor, often underestimating the relationship between variables, and reducing the explanatory power of the theory [75]. Therefore, to obtain accurate and credible research results, it is necessary to elicit strong beliefs. The specific method is to select representative research samples, through three types of open-ended survey questions: what are the benefits and disadvantages of target behavior, which individuals or groups will affect the occurrence of target behavior, and which elements will promote or prevent the occurrence of target behavior, respectively, obtain concepts of behavioral outcomes, norms and controls, and then conduct specific analysis of the beliefs collected in the study, and highlight the belief patterns (modal salient beliefs) with items that appear more frequently. Highlighting belief patterns is an important source of information for generating survey items.

2.7.4.3 Preparation of formal measurement questionnaires

To help researchers better apply planning behavior theory, Ajzen has designed a general questionnaire model for planning behavior theory research for researchers' reference [76]. General questionnaires contain both overall direct measures and belief-based measures, and the Likert grading method is applied to all measurement items, where direct measures of attitudes use semantic differentiation. When developing specific items for questionnaires, care must be taken to draw on lessons learned from previous generations, and this component of attitudes should include instrumental and emotional attitudes; The project content of subjective norms includes prescriptive norms and descriptive norms; Perceptual behavioral control items include self-efficacy and control. There is an "optimal scaling" problem in the development of belief-based questionnaires [77]. Outline items are survey items that use a single-level or bipolar grading model when developing a belief-based questionnaire item. Adding or subtracting a constant value enables a transition between unipolar and bipolar scoring modes, which is linear and does not change the characteristics of the measurement questionnaire. However, the variable representative value based on belief measurement is the sum of products, and the linear conversion of unipolar and bipolar will lead to the nonlinear transformation of the variable representative value, so the choice of unipolar or bipolar scoring mode will directly lead to the difference in the final research results. There is no reasonable standard for choosing between unipolar and bipolar, and to solve this problem, Holbrook proposed a relatively easy method [78].

2.7.5 Application of TPB theory

Planned behavior theory has long been favored as a tool to explain and predict people's behavior. Planning behavior theory is applied to management, education, environmental protection, finance, health, medical treatment, leisure, tourism and many other fields, which is of great significance for predicting and designing behavioral intervention plans. In addition, the TPB theoretical framework is used to analyze the relationship between behavioral attitude, subjective norms, perceptual behavior control, and intention and behavior, and is expected to predict behavior. The theoretical application areas and results of domestic and foreign programmed is shown in Table 2-2 and Table 2-3.

Many empirical studies have proved that the plan is a good explanation and prediction power for theory. Conner and Armitage [76] found through meta-analysis that the explanatory power of behavioral attitude subjective norms and perceived behavior control on behavioral intention is between 39% and 50%, while behavioral intention and perceived behavior control have an explanatory power of 20% to 40% on actual behavior. Zhu Yuan Fei [79] showed that behavioral attitudes, subjective norms, and perceptual behavior control explained persistent intentions in a study of online shopping consumers' sustained purchase intentions. Wu Lin [80] took Hefei City as an example, and the explanation degree of low-carbon tourism by applying planning behavior theory to tourists was 58.287%.

Table2- 2.Foreign programs are theoretical application areas and achievements

Research literature	Application areas
Schifter, et al. (1985)	Weight loss intention
Doil, et al. (1990)	Play video games.
Parker, et al. (1990)	Violation of traffic intent
Ryn, et al. (1990)	Work intention
Beale, et al (1991)	Limit sugar intake
Hansen. (2004) (2008)	Online shopping intentions
Zikic J, et al. (2009)	Work intention
Ketal Y V, ct al (2009)	Food safety
Han H, et al. (2010)	Green hotel selection
Pakpour A H, et al. (2013)	Garbage collection behavior
Burton N, et al. (1990)	Election intent
Godin, et al. (1990)	Exercise intention
Schlcgel, et al. (1990)	Drinking intentions
Beck, ct al. (1991)	Fraudulent intent
Beedell J D C, et al. (1999)	Soil and water conservation behavior
Fielding K S (2008)	Environmental movement
Detal LG A, et al. (2010)	Learning intent
Stone T H, et al. (2010)	Intent on academic misconduct
Yeong Gug Kim (2014)	GM food consumption

Table2- 3.Domestic planning is the field of theoretical application and results

Research literature	Application areas
Li Hua Min (2007)	Rural tourism behavior intention
Zhang Hai wei (2008)	College students' sexual intentions
Huang Hua zhi (2010)	Hotel employee intention to leave
Zou Qing ru(2011)	Traffic behavior
Wang Da hai (2011)	Credit card intent
Tao Rui (2011)	Eco-friendly product purchases
Du xin(2012)	Green clothing consumption behavior
Shi xiao ning(2013)	Low-carbon tourism behavior intention
Qu Ying (2007)	Household waste sorting behavior
Lei Juan juan (2009)	Employee intent to leave
Fan Song (2011)	Leisure tourism behavior intention
Wu Wen zhen (2011)	Socially responsible consumption behavior

In the TPB model, attitudes, subjective norms, and perceptual behavior control have different effects on different behaviors. Wang [81] found in the study of low-carbon tourism intention that subjective norms have the most significant impact on behavioral intention, followed by perceived behavior control and attitude. Du Xin [82] proposed in the study of the influencing factors of green clothing consumption behavior that consumers' attitudes have the greatest impact on behavioral intentions, followed by perceptual behavior control, and subjective norms have the least impact. Tao [83] research on the purchasing behavior of environmentally friendly products showed that attitude had the most significant impact on consumer behavior, followed by subjective norms, while perceptual behavior control had no significant impact on consumer behavior. Xu, Chen, and Peng (2016) use planning behavior theory to study students' willingness and actual behavior towards environmental behavior and explore the influence of different factors

on willingness and behavior [84]. Planned behavior theory is also used to predict and explain an individual's willingness and behavior to participate in physical activity behavior. Asci et al. (2017) used the theory of planned behavior to study the positive effects of sitting behavior on physical activity and explored the influence of different factors on exercise willingness and behavior. Planning behavior theory can also be used to explain and predict an individual's willingness and behavior to decide to engage in healthy behaviors. Gozde (2015) applied the theory of planned behavior to study the factors influencing smokers' willingness and behavior to quit. Planning behavior theory can also be used to study an individual's willingness and behavior to shop online. Wang, Sun, and Liang (2016) use planning behavior theory to study the influencing factors of online shopping behavior and the decision-making process of individual shopping behavior.

As the research progresses, although the TPB model has good explanatory power for behavior, a large part of the behavior and behavioral intent cannot be explained by the main variables. In this regard, many scholars have added variables related to specific behaviors to the traditional TPB model and added other influencing factors to the theory of planned behavior to expand the research.

Ajzen, the proponent of the theory, also believes that in addition to the original 3 variables, other additional variables related to specific behaviors are needed to provide more explanations for the model. To increase the explanatory ability of the theory of planned behavior that tried to improve and achieved good results. For example, in the study of low-carbon strategies, Pakpour et al. [85] added variables such as moral obligations, self-assessments, action plans, and past recycling experiences to study domestic waste recycling behavior in the TPB model. Mans t e ad will add personal norms to the study of driving behavior, discovering the role of perceptual behavior control and emotional beliefs in shaping behavior [86]. GHANI et al. added a contextual variable to the food waste source model in Malaysia, indicating that there are other factors that influence the classification intention. Research found good morals and facilities The higher the public interest in segregating living garbage [87] when good moral values and facilities are available. In their study of household collection and waste management practices in Korea, Lee and Paik found that mandatory laws play a crucial role in controlling household waste segregation, and that government environmental policies can achieve a certain level of management. Among them, older and wealthy people are more involved in waste sorting [88]. Tan [89] conducted a study on public interaction in urban electric vehicle swap stations to reduce urban carbon emissions, and the results showed that policy perception can increase the explanatory power of planned behavior theory. Shangyu Chen added green usefulness perception, green value perception, and green comfort perception to the framework of extended plan behavior theory, studied the influencing factors of loyalty in the public bicycle system, and found that subjective norms and green comfort perception had the greatest impact on user loyalty [90]. Donald used a structural equation model, combined with extended planning behavior theory, to investigate more than 800 samples to explore the factors affecting individual private car travel and bus travel, and concluded that the use of private cars is determined by individual travel habits and travel intentions, and is not affected by perceptual behavior control, while bus travel is only affected by travel intentions [91].

Zeidi et al. [92] added moral obligation self-assessment, action plan and past recycling behavior

variables to the TPB model, and randomly selected 2000 households from eight medical coverage areas in Qazvin City, Iran as research subjects, and found that past behaviors had a significant impact on domestic waste recycling behavior by conducting questionnaire surveys on the same research subjects at two time points with an interval of one year, and finally expanded TPB The variance explanation rate of the model for the recycling behavior of domestic waste reached 47%. Li [93] added past behavior variables to study the behavior of rural tourism customers, showing that behavioral attitudes, subjective norms, perceptual behavior control and past behavior variables were significantly positively correlated with the overall intention of urban residents' sports and leisure behavior. Tang Jiayang [94] applied the TPB model to 55% of the behavioral intention of C2C online shopping, but after adding the variables of perceived online shopping usefulness, perceived ease of use of online shopping, perceived entertainment and concentration, the explanatory power of the model on behavioral intention increased to 79.746%.

2.7.6 Research progress on the combination of CVM and TPB

The combined application of CVM and TPB has been developed in recent years, and S pas ha and Uramab have used the CVM model to value environmental goods through a sociopsychological approach, the TP B model, when exploring the factors behind people's willingness to pay for improving the biodiversity of aquatic ecosystems, to explain the motivation behind the economy through a sociopsychological approach, the TPB model [95]. The study pointed out that the CVM model can be used as a standard economic model to exclude psychological and ethical factors, so the framework constructed by the TPB model can explore the influence mechanism under economic behavior, and the study shows that the willingness to pay is closely related to behavioral attitudes, in addition, subjective norms and perceptual behavior control also play a non-negligible role in paying intentions.

Anthony and Spasha used TPB and CVM to conduct an empirical study of the relationship between willingness to pay and attitude. In the questionnaire survey, a case study scenario is presented, and the TPB variable item is proposed to be proposed to increase the injection of funds, and people's willingness to pay for environmental protection is obtained, assuming that people's environmental protection behavior is driven by two attitudes, namely belief and political action, rather than driven by economic interests, and the relationship between willingness to pay and attitude is obtained through data analysis, so as to determine whether the willingness to pay can be used as a reflection of attitude in scenario 1 without adding TPB variables, so as to compare, after adding non-attitude variables , Logistic regression model fitting results show better, using least squares model fitting shows that attitude cannot fully explain residents' willingness to pay. The entire study shows that the factors influencing the willingness to pay are not only attitudes, but also influenced by subjective norms and perceptual behavior control [96].

Lopez-Mosquera and Garcia et al. explored visitors' motivations for maintaining public goods based on their willingness to pay for urban parks. The researchers chose an extended TPB model that added ethical factors, and at the same time used conditional valuation to elicit willingness to pay when compiling the questionnaire, that is, before asking valuation questions, they created an valuation scenario for respondents in as much detail as possible, emphasized the public facilities

provided to the public and the diversity of plants and animals, and then proposed the obligation to maintain the park's payment costs. In data processing, CVM is used to estimate the average of willingness to pay, and structural equation models are selected to explore the direct or indirect influence of psychological factors on willingness to pay. The study ultimately showed that determinants of attitudes, subjective norms, personal norms, and perceptual behavioral controls accounted for 40 percent of the willingness to pay variables [97].

There are few empirical studies on the combined application of CVM and TPB in China. In Wuhan, Hubei Province and Yangzhou City, Jiangsu Province, respectively, He [98] and Zhang [99] used conditional value assessment (CVM) to assess the non-market value of agricultural pollution prevention and control and introduced the planned behavior theory (TPB) model to analyze the influencing factors affecting farmers' willingness to pay for agricultural pollution prevention and control. The results showed that farmers had a low degree of awareness of the ecological environment, but their attitude towards agricultural pollution prevention and control was positive. Moreover, attitude, subjective norms, perceptual behavior control and annual net household income are the main determinants affecting farmers' willingness to pay for agricultural pollution prevention and control.

2.8 Conditional valuation Strategic value of low-carbon city

2.8.1 Introduction

With the intensification of global climate change, the development of low-carbon cities has become the focus of global attention. To cope with climate change, many countries and regions are trying to promote the development of low-carbon cities to reduce greenhouse gas emissions, improve urban environmental quality and enhance the ability of urban sustainable development. The development of low-carbon cities can not only reduce carbon emissions, but also improve the quality of the city's environment and enhance the city's sustainable development ability. By 2050, up to 78% of the world's population could live in urban areas [100]. As a result, more and more cities are trying to achieve low-carbon development.

The construction of low-carbon cities requires cities to take effective measures in terms of energy conservation and emission reduction, green development, environmental quality, residents' quality of life, economic development, social structure, management level, cultural atmosphere, brand image, infrastructure, and sustainable development ability to achieve low-carbon development. Specifically, cities are required to adopt a greener, more energy-saving and more environmentally friendly development mode, promote energy conservation and emission reduction, improve air quality, improve the quality of life of residents, enhance the level of economic development, improve the social structure, and improve the level of management.

The development of low-carbon cities requires the joint efforts of governments, enterprises and the public. Governments need to develop strong policies to promote the development of low-carbon cities; Enterprises should take effective technical measures to reduce greenhouse gas emissions; The public needs to change their lifestyles, reduce energy consumption and improve

the quality of the urban environment.

Nowadays, the development of low-carbon cities has become an important topic in today's world. Realizing low-carbon urban development is the leading direction of urban development in the future. The essence of urban low-carbon is to reduce carbon dioxide emissions and improve the city's carbon curing and neutralization capacity. It is an important strategy to change travel habits and develop low-carbon transportation system to realize green and low-carbon city. Low-carbon transportation system construction should adopt low-carbon fuel, actively develop tram, hydrogen and other new energy transportation, to achieve low carbon emissions. At the same time, residents should be actively guided to develop environmentally friendly travel habits. Residents should be encouraged to walk in close distance, ride shared battery cars, and take hydrogen energy public transportation for long distances. As a means of green travel, hydrogen bus plays an important role in urban low-carbon construction. To build a low-carbon city, it is clearly mentioned in important documents such as the Outline of the National Innovation-driven Development Strategy issued by the State in 2022 to vigorously develop hydrogen vehicles. According to the Beijing Hydrogen Fuel Cell Vehicle Industry Development Plan (2020-2025) released by Beijing Municipal Bureau of Economy and Information Technology at the Service Trade Fair, in order to accelerate the innovation and development of hydrogen fuel cell vehicle industry in Beijing and support the construction of the national science and technology innovation center, Beijing will focus on creating the innovation highland of hydrogen fuel cell vehicle industry. From 2016 to 2021, the number of hydrogen fuel cell vehicles in China has increased year by year, reaching 8,922 in 2021, accounting for 18% of the total number of major countries in the world. According to the Medium and Long-term Plan for the Development of Hydrogen Energy Industry (2021-2035), By 2025, the number of hydrogen fuel cell vehicles will reach 50,000 and be widely used in urban public transport. Although the country has formulated a series of policies to promote the development of hydrogen fuel cell vehicles, the relevant research on the public acceptance of hydrogen fuel vehicles (especially hydrogen fuel buses) is still limited.

Smart waste recycling cabinets are conducive to the construction of low-carbon cities. They can arrange reasonable treatment methods for different types of garbage, increase recycling efficiency, and contribute to the sustainable development of cities and reduce carbon emissions. As an important policy of waste management, garbage sorting and recycling plays an important role in emission reduction and environmental protection, but it has received limited attention.

There are also many government strategies for low-carbon cities, including vertical greening, rooftop solar, beach waste removal, sewage treatment plant renovation and so on. However, it is a pity that the implementation of these policies mostly carried out income assessment and lack of environmental value and non-use value assessment. This is bad for the implementation of the strategy, and bad for investors to invest in environmental products. Therefore, it is very necessary to evaluate the environmental value of urban low-carbon strategy (public environmental products). Before conducting the subsequent research, we tried to study the literature review on the one-time use of the conditional value method to evaluate low-carbon city construction measures, especially for China. Still, unfortunately, we did not find relevant research. Therefore, we reviewed and analyzed the literature related to low-carbon city construction strategies in the past ten years,

aiming to select a more stable assessment method and data collection method from the conditional value method for the next step in our research.

2.8.2 Method

Due to the non-market-oriented nature of low-carbon city measures, traditional market valuation methods are difficult to accurately assess their economic value [101.102].

The conditional value method is currently an important method used internationally to assess the economic value of non-market-based environmental goods [103-109]. In recent years, the carbon emissions of cities in various countries due to urbanization have increased, and the value of evaluating low-carbon urban strategies through conditional value methods has also increased. However, there is a lack of studies summarizing this willingness to pay and literature reviews. We summarize research on conditional value methods and low-carbon city strategies. It also provides the countries of relevant research, data collection methods, specific low-carbon strategies, induction methods of willingness to pay, and valuation results of willingness to pay, etc., which contribute to the research and valuation of low-carbon city strategies in the future. In addition, we discuss the influencing factors on willingness to pay, and explore the influence of behavior on willingness to pay through various theoretical frameworks that affect behavior. We also discuss the effectiveness of different payment instruments and data elicitation techniques and highlight the corresponding reliability and validity tests in future studies. This chapter focuses on the evaluation of conditional valuation studies of low-carbon city strategies. It focuses on the payment for the use of hydrogen energy buses, the promotion of the use of smart waste recycling cabinets, and the willingness to pay for low-carbon travel of shared battery vehicles, and their environmental values. At the same time, the factors affecting payments were evaluated.

In April 2023, we used the Scopus database to conduct relevant literature searches as follows: a total of 25326 articles were obtained in the primary search willingness to pay, a total of 6362 articles were obtained in the secondary search willingness to pay and conditional value method, a total of 233 articles were obtained in the third-level search on the basis of the first two levels of search, and a total of 98 related articles were retrieved in the low-carbon search for low-carbon cities, and the specific search process is as follows（Figure 2-6）.
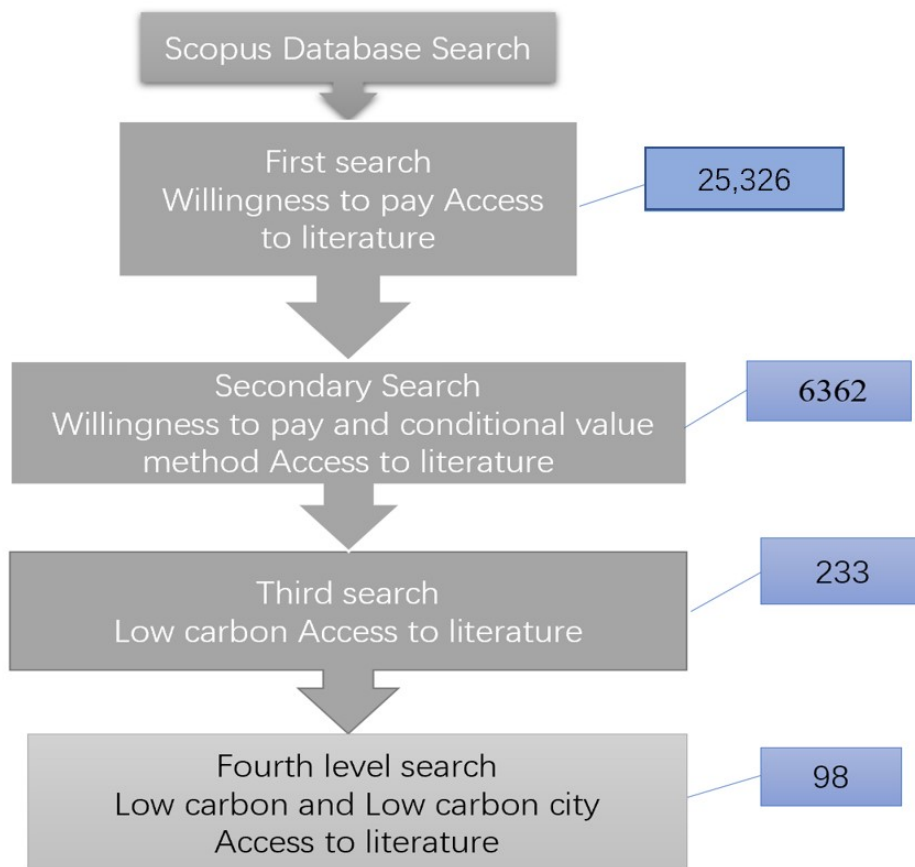
Figure2- 6.Flowchart of the systematic review process

In 98 articles, we provide a research summary of dedication. As shown in the following Figure 2-7. Literature from different countries, China, USA, Korea, UK, Australia, Netherlands, Germany, Italy, Mexico, South Africa, Nigeria. Except for China, Mexico, and South Africa, most of the research on the valuation of willingness to pay for low-carbon urban strategies has focused on developed countries. China is well ahead of other developing nations in their research on low-carbon strategies. The 2030 carbon peak and 2060 carbon neutrality targets have made China the world's top carbon emitter. China is increasingly focusing on reducing urban carbon emissions, but this is insufficient.
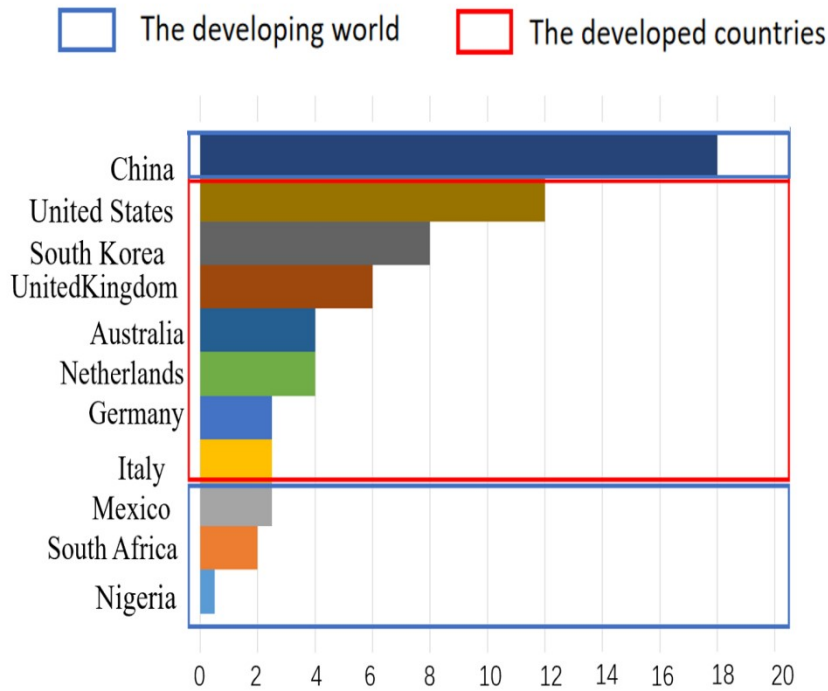
Figure2- 7.Literature from various countries

For the research of various literatures, we need to investigate the contents studied by various researchers from the following aspects. First, countries in the world have formulated different policies for the construction of low-carbon cities, and their strategies are different. Residents' willingness to pay for low-carbon cities is also influenced by government policies. If government policies support the development of low-carbon cities, the government will intensify its efforts to publicize them, and the higher the cognitive ability of residents, the more likely they are to pay for low-carbon cities. Knowing the strategies of countries for low-carbon construction, countries can learn from each other and communicate with each other. Secondly, residents' ability to pay will also affect their willingness to pay for low-carbon cities. Incomes in developed countries are higher than those in developing countries. Residents of rich countries should be more willing to pay. If residents have a low-income level, they are less likely to pay more for low-carbon cities. Finally, there is the willingness of countries to pay. Payment methods that assess willingness to pay. What is the data collection method and the estimation method of willingness to pay? This is helpful to provide reference for our research.

In these studies, we find that the selective experimental model method and the conditional value method are currently the two main methods used to assess the economic value of environmental goods. Since the selection test model method and the conditional value method are based on the theory of utility maximization, they belong to the statement bias method, and both estimate the willingness to pay in the form of questionnaires, which can provide an important decision-making basis for decision-makers. The difference is that.

1.in the contingent value method, the characteristics of the selected products are fixed, while in the choice experiment method, these characteristics are flexible.

2. In the conditional value method, the researcher collects information from the selected product, while in the selection experiment method, the researcher generates information from the unselected product. Discrete selection conditional value method can be regarded as a simplified version of selection experiment method to some extent.

3. The question format of the conditional value method is relatively simple, and the respondents are more likely to accept the question format like market transactions. However, the question format of the choice trial model method is more complex, which increases the perceived burden of the respondents and results in a lower proportion of valid questionnaires than the conditional value method.

4. The selection test model method is more complicated and technically difficult than the conditional value method in questionnaire design and model analysis, but the selection test model method can reveal more consumer preference information than the conditional value method and is suitable for evaluating the value of individual attributes of environmental goods [110].

2.8.3 Research result

About the document of city green low carbon policy, we are summarized. The results are as follows.

1. Tan applied the extended theory of planning behavior to predict the willingness to pay for the green and low-carbon energy transition, and the study investigated the willingness of rural households in Shandong Province to promote the development of the green and low-carbon energy transition, and to identify the drivers of the willingness to pay. To better predict the three variables of willingness to pay, moral perception, policy perception, and personal perception, interest was added to traditional theory of planned behavior. The results show that moral perception, policy perception and personal perception interest can predict the willingness to pay well, and personal perception is the most decisive predictor. Demographic variables, income, education and age also affect willingness to pay. The average willingness to pay is 133.55 RMB ($18.57) per month. Notably, the predictive power of the extended planned behavior theory model was 12% higher than that of the no planned behavior theory model. Therefore, the development of appropriate incentives to increase the personal perception of the public and improve the policy advocacy related to the green and low-carbon energy transition and its moral implications may help promote the green and low-carbon energy transition and sustainable social development [111].

2. Zhang investigated the willingness of Macao residents to buy and pay for electric vehicles through 406 questionnaires and determined the influencing factors. The results show that ease of use, actual cost and environmental benefits are considered factors for residents' investment, and it is found that 90.14% of respondents are willing to buy electric vehicles. The environmental benefits of electric vehicles, battery range, charging convenience and safety, as well as consumer income were positively correlated with respondents' willingness to pay. Potential pollution to their

willingness to pay comes from Fuel cars, frequency of travel and the environmental benefits of electric vehicles are more important. Using the conditional valuation method, the value of respondents' willingness to pay is estimated to be about 15,041.10 patacas (US $10.27), which is much lower than the market value gap: 5,000 yuan. To sum up, the Macao government should strengthen publicity, especially for young consumers, and give some privileges to electric vehicle owners [112].

3. Trifonova M analyzed the public acceptance of Bulgarian citizens towards all types of renewable energy technologies proliferating in the country. Based on data collected through nationally representative surveys in 2021, it assesses the willingness to pay for a higher proportion of low-carbon energy in the energy mix and its influencing factors. Despite their positive attitude towards renewable energy sources, Bulgarians lack knowledge of existing technologies to harness them. The potential contribution of renewable energy to the economic development of local communities has not been recognized and is not seen as an individual investment opportunity. Only one-third of survey participants expressed a willingness to participate in supportive actions to further expand renewable resources [113].

4. Gao assesses the impact of willingness to pay on Japan's achievement of future renewable energy resource targets. Renewable energy generation is an effective measure to mitigate climate change, environmental protection, and low carbon. The researchers developed a series of models simulating the willingness to pay under three renewable energy development scenarios and two economic growth cases to 2030. This would allow an assessment of the investment subsidies needed to adopt renewable energy to meet national targets for Japan's prefectures and prefectures. The median willingness to pay is estimated to increase from about 2,015 yen to 2,030 yen/ (household · month) over the 1000–2400-year period. As consumers' willingness to pay has increased, the investment needed to meet future renewable energy targets have fallen sharply. For prefectures with a high willingness to pay, such as Tokyo, the required investment can only be paid for by consumers' willingness to pay; No subsidies are needed. These results highlight the opportunity for willingness to pay assessments in the effective use of government subsidies to enable policymakers to shift towards greater use of renewable energy through flexible energy policies [114].

5. He investigated the willingness and impact of residents of Beijing, China, to pay for a smart waste sorting system. An online questionnaire was randomly sent to Beijing residents, and the average price paid was $49.43 per household per year, using the theoretical framework of planning. Perceptual behavior control and a concerned attitude towards environmental issues can also influence factors in willingness to pay. In the extended TPB model, Social Background, income, education level and willingness to pay were significantly positively correlated [115].
7. Yang et al. (2017) surveyed the willingness of the Korean public to support the policy of paying for hydrogen station expansion, and the results showed that the average annual willingness to pay was KRW 2258 (US$2.04) and was willing to bear a large part of the financial burden for the promotion of the policy [116].

I can find that most of the articles are closely related to green and low-carbon, such as green

energy transformation, green travel, low-carbon and environmentally friendly intelligent garbage recycling cabinets, green renewable resources, etc. Chinese households are more willing to pay for environmental protection, and we suspect that Chinese households are more willing to pay for environmental protection.

2.8.4 Summary

In the above literature analysis, the following conclusions are mainly drawn, in the current estimation method of willingness to pay, the treatment and solution of zero response is still relatively single, and it is necessary to further solve it. The peak model proposed by Kristom (1997) is an effective way to deal with zero response, and the effectiveness has been demonstrated, but the application of the peak model is still very limited. In our literature review study, there is no case of using the peak model for research related to low-carbon urban strategies, so in our study, in order to better estimate the results, the peak model is used to treat the zero response on the basis of the two-boundary dichotomous conditional value method, and the spike value is very close to the proportion of the true zero response in the sample. Valuation of willingness to pay fills a gap in research.

Through literature review research, we find that there is still limited research on the willingness of the public to pay for low-carbon urban strategies by using the theory of planned behavior. Planning behavior theory is a common method to explore individual behavior, which mainly includes three variables: attitude, subjective norm, and perceptual behavior control. China's top-down management model has been going on for many years, so the public's willingness to pay is very important. That is, when a policy maker formulates a policy, the degree of public support for that policy. However, it is very limited in literature reviews. This study explores the influencing factors of the public's willingness to pay and willingness to pay for the construction of low carbon cities and makes a strong contribution to the promotion of the government.

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Chapter 3

RESEARCH METHOD

3.1 Research design

3.1.1 Study site selection

There were three main sites in this study, Beijing, China, Shandong Province, China, and Weihai, Shandong Province, China. Specific locations such as Shown in the figure （Figure 3-1. Research Location）.

Figure3- 1. Research Location

3.1.2 Sample size

Conditional value studies generally require larger sample sizes to improve the accuracy of estimates, so it is important to determine the sample size in advance. Sample size is determined by the overall size, the accuracy and reliability of sampling, and the heterogeneity of the total sampling. At a certain level of heterogeneity of the total sample, the Schaefer equation can be used to determine the sample size [1][2].

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

where n is the sample size, N is the total, and ı is the acceptable sampling error. In 2022, the total population of Shandong Province, Weihai City, Shandong Province, and Beijing was 10.96 million, 2.92 million and 21.88 million respectively. This means that the N values of Shandong Province,

Weihai City, and Beijing are 10.96 million, 2.92 million and 21.88 million respectively. The sampling error δ is generally set to 0.05. Therefore, the statistical theory sample size of Beijing, the capital of China, Shandong Province, and Weihai, Shandong Province, China, is about 400 cases. Due to multiple biases in the survey, the minimum sample size should exceed 500 to reduce the deviation between the estimated and actual values to less than 15% [3]. Survey profitability is another important factor that affects the validity of survey results. In general, a 70% response rate is a benchmark for successful surveys, while a response rate of more than 75% is ideal [4].

3.1.3 Questionnaire design process

To ensure the reliability of the questionnaire, we supplemented and improved the questionnaire through a literature review, statistical researchers' revision and questionnaire pre-survey. The questionnaire design process is as follows（Figure 3-2. Questionnaire design）.
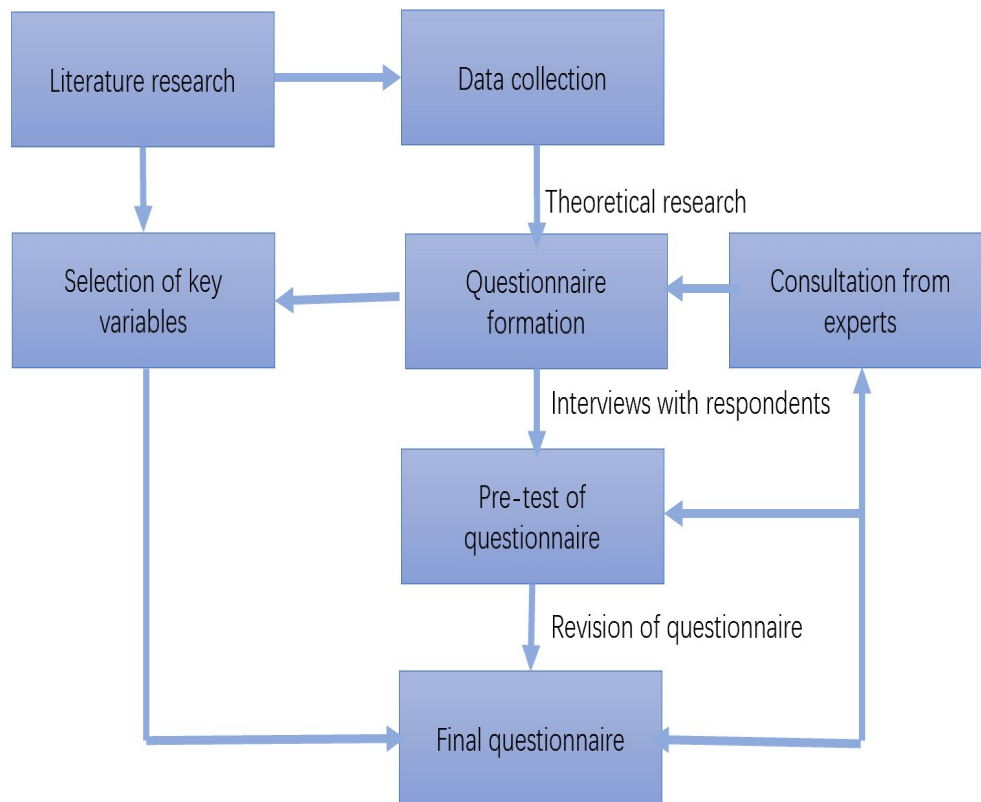
Figure3- 2.Questionnaire design

3.1.4 Access to information

The conditional value method mainly asks residents and other respondents about the willingness to pay for the target products through face-to-face interviews, online questionnaires, telephone interviews and other means, and measures the value of the target products. Each has different

characteristics. In our research, we mainly use the network questionnaire survey. Investigators often use face-to-face interviews to overcome the problems of low questionnaire recovery rate and long communication distance between researchers and respondents, to make the results of conditional valuation more credible and real.Time can be saved by using an online questionnaire. Face-to-face interviews are scarce in the setting of the global new coronavirus outbreak, therefore the advantages of online questionnaires can be most clearly seen. Information from interviews can be gathered without making contact.

The network survey, however, also has certain issues. The interview subjects are typically younger since, for instance, a bigger proportion of young people than older individuals use internet items. As a result, the respondents' age distribution will be imbalanced, which will skew the questionnaire's results in favor of respondents who are younger. Additionally, internet surveys frequently have a poor response rate [5]. As a result, compared to in-person interviews, the sample size for online interviews must be increased. More and more elderly folks are now online because to the growth of the Internet and smartphones. In the context of Internet popularity, Schaffner [6] contrasted online and offline questionnaires and found no appreciable differences. Therefore, in the current context where network popularity is considerably increasing, we may also claim that the effectiveness of network questionnaire is relatively good [7].

With the development of science and technology, the use of the network is more and more common, and the network has been greatly developed. Questionnaires were collected with the help of Wen juan xing, the largest online questionnaire platform in China with more than 190 million users. More than 15 billion questionnaires have been collected. So, we think the platform has great stability and reliability.

Therefore, the network questionnaire is mainly adopted in our research. Firstly, households in Beijing are investigated, and the willingness to pay for hydrogen buses in Beijing is the research object. The willingness of the public to pay for hydrogen buses and its influencing factors are discussed, and the environmental value of hydrogen buses is evaluated. Then the paper studies the public's willingness to pay for electric car sharing in Weihai City. Based on the theory of planned behavior, the factors that affect the public's willingness to pay are discussed. Finally, taking households' willingness to pay for smart waste recycling cabinets in Shandong Province as the research object, the paper discusses the public's willingness to pay for smart waste recycling cabinets and its influencing factors. And evaluated the environmental value of intelligent waste recovery cabinet.

3.1.5 Inducement of willingness to pay

In our study, we mainly used three inducements of willingness to pay.In the study of public willingness to pay for hydrogen buses, we explored the willingness to pay based on the double-boundary dichotic, peak model. In Chapter 2, we introduced the dichotomous as a highly effective valuation method recommended by NOAA [4]. Therefore, in our study, the dichotomous

is used as an estimate of willingness to pay. We chose the two-border dichotomous in the dichotomous, and Chen demonstrated in related studies that the two-border dichotomous has higher accuracy than the single-boundary dichotomous [8]. The data of the dichotomous questionnaire is characterized by the fact that the value of willingness to pay is not directly obtained, but the value of willingness to pay is estimated by the respondent's answer (yes or no). In China, the small number of hydrogen buses may lead to a lack of awareness among residents. Moreover, China is a developing country, the overall income level of the public is not high, environmental awareness is relatively weak, and CVM scenarios are relatively unfamiliar. Therefore, there will be respondents in the questionnaire who choose to refuse to pay (zero response). Therefore, we use the spike model proposed by Kristrom, (1997) and Benjamin et al, (1999) to process the zero response with a two-border dichotomous[9，10].

In the Weihai public's willingness to pay for shared battery cars, we used the payment card type as an estimate of the willingness to pay. In the payment willingness of households in Shandong Province for smart garbage recycling cabinets, the two-boundary dichotomy was used to study.

3.1.6 Research on Payment Methods

In our study, we chose two payment methods. One is the ticket as a payment tool. Buses are an important means of transportation for everyone's daily travel. Hydrogen energy buses are environmentally friendly and low carbon, so tickets will be more expensive than ordinary bus tickets. Payment instruments play a very important role in the research of conditional value method, because it provides a payment environment for the experimental study of conditional value method. To avoid payment, bias due to unfamiliarity with the payment instrument, the payment instrument must be well known to the respondent and the payment instrument should have a clear connection to the goods being valued [11]. Mandatory payment instruments make it easier to make results accurate, and we chose another payment instrument with mandatory characteristics, living contributions, to reduce the over-commitment behavior of respondents due to payment instruments [12]. Impact on estimates of the outcome of willingness to pay. The promotion of intelligent garbage collection cabinets and the promotion of shared battery cars belong to public welfare undertakings. In our pre-survey, the use of living expenses, which is a well-known payment method for the public, is widely accepted by respondents. This is also the reason why we choose living expenses as our payment method.

3.1.7 Bias of common methods

Most researchers agree that common method variance (variance that is attributable to the measurement method rather than to the constructs the measures represent) is a potential problem in behavioral research, the systematic error variance of which can have a serious confounding influence on empirical results, yielding potentially misleading conclusions [13]. The potential sources of common method biases in our research may be respondents' propensity to maintain consistency in their responses to questions and attribute socially desirable behavior. Before the onsite interview, all interviewers were trained about how to behave and answer the possible questions that respondents may raise, including informing that the respondents' anonymity will be

guaranteed. Each interviewer was followed by a supervisor to avoid interviewer bias. In addition, we separated WTP questions and variables about respondents' attitudes psychologically. Between WTP and TPB questions, there is a 5-10mins interview about respondents' social and economic characteristics, suggestions for the government, and answer to the respondents' question. Following the suggestion of Podsakoff et al. [14], Harman's single factor test and partial correlation coefficients are employed to estimate common method bias.

3.1.8 Determinants of willingness to pay

Since low carbon economy was formally proposed, governments of all countries have responded positively, and scholars have studied deeply. At present, more and more scholars begin to pay attention to how to realize the lifestyle of low-carbon consumption as well as individuals' attitudes towards public environmental products. More and more researchers begin to study individuals' behaviors towards the environment and put forward many valuable insights [15]. At first, socioeconomic parameters like age, income, and family size were the focus of study on the factors that influence pro-environment behavior. These studies have come under fire for only adequately describing the lowest levels of pro-environmental behavior factors. These factors are motivating academics to begin exploring more profound psychological levels. One of the most popular explanations in psychology is the hypothesis of planned conduct. An expansion of the theory of rational behavior is the theory of planned behavior [16]. The purpose of rational behavior theory is to explore the relationship between individual attitudes and behavior. However, the theory of rational behavior is studied on the assumption that behavior is completely controlled by the will and has certain limitations on the aspect of the will that does not control behavior well. The theory of planned behavior can deal well with this limitation. In the theory of planned behavior, behavioral intention is the direct factor in predicting behavior, and behavioral intention is supported by the positive and negative attitudes of the individual, the subjective norms of the individual or the support of relatives and friends, and perceptual behavior control (perception of resources). Therefore, we use the theory of planning behavior as the basic theory to study the influencing factors of public willingness to pay. We also add covariates to control behavior based on basic variables of planning theory, attitudes, supervisor norms, and perceptual behavior control to better explore the influencing factors on willingness to pay.
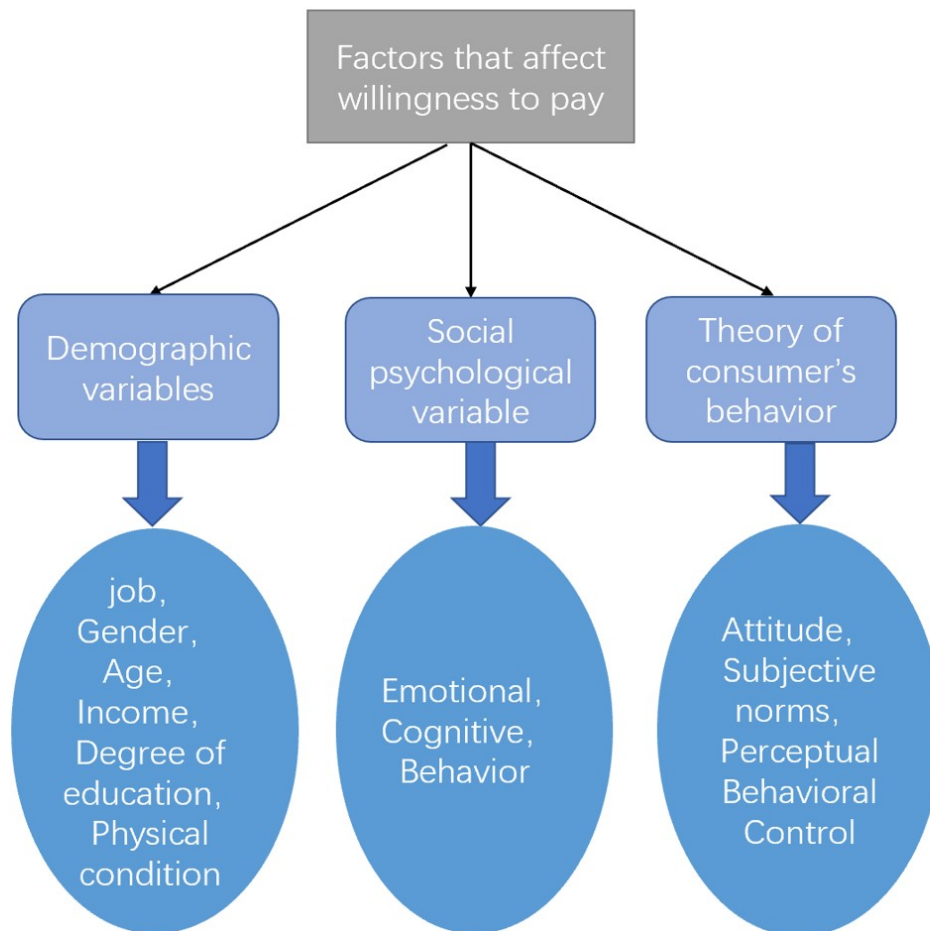
Figure3- 3.Determinants of willingness to pay

3.2 Data analysis

3.2.1 Valuation options for willingness to pay

There has been considerable debate in the data statistics of the CVM survey on the use of average or median value for value appraisal. On the one hand, the investigation of the theoretical underpinnings of the desire to pay that was done in the past is based on the idea of income compensation of the consumer surplus model of John R. Hicks, where the average value of the equivalence and compensation variables. But, as this survey's analysis demonstrates, people' willingness to pay is typically more discrete, making it more probable that extremes will affect the average value.

However, Bateman and Carson contend that averages have a strong theoretical and logical foundation, and that they should be used if the reasonability and effectiveness of decision-making are prioritized. However, from a fair standpoint, the median value is better suited for democratic decision-making because it represents the willingness of 50% of respondents to pay [17].

3.2.2 The basic WTP model

In the two-boundary dichotomous conditional value approach, we modelled the estimation of willingness to pay using the Johansson method. By maximizing the difference in the random utility model, the method is calculated by defining the difference in their utility. The model's expression is displayed below:

$$U = V（B,N;M）+ \varepsilon \qquad\qquad （1）$$

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

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

The result can be obtained by collating the formula.

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

The left half of Equation 3 represents the utility difference, which we define as $\Delta V(A)$, 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 $\varepsilon_0－\varepsilon_1$ is δ then $H_\delta(.)$ is the cumulative distribution functionδ. Then the probability that a respondent gets "yes" to a given bid can be expressed as Equation 4

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

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

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

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

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

When performing formula calculations we usually assume that $\Delta V＝R－TB,$ where $\gamma = (a, b)$ is the vector of parameters to be estimated.

3.2.3 The conventional DBDC-CVM model

In the conventional DBDC format, respondents would be asked whether they are willing to pay or accept the bidding value of a specific amount C_i (i=1, ..., n). The first answer of "Yes" or "No" would be regarded as a reference basis for the second inquiry to adjust the bidding amount. As for WTP, when the answer of the respondents is "Yes" for the first time, another higher bidding

amount C_i^H would be asked for the second time, otherwise they would be provided with another lower bidding amount C_i^L, i.e. $C_i^L < C_i < C_i^H$; The T denotes the response after a given amount C_i, willing to pay then $T = Y$ and refusal to pay then $T = N$. Therefore, there are four possible outcomes: unwilling-unwilling, unwilling-willing, willing-unwilling, and willing-willing. The binary-indicator variables would be A_i^{NN}, A_i^{NY}, A_i^{YN}, and A_i^{YY}, respectively. $G_c(C; X)$ represents the cumulative distribution function (CDF) of WTP, C represents the bidding value, Y represents an unknown parameter that needs to be valued, and the logarithmic likelihood function can be expressed as follows.

$$\ln L = \sum_{i=1}^{N} \left\{ A_i^{YY} \ln\left[1 - G_c\left((C_i^H; Y)\right)\right] + A_i^{YN} \ln\left[G_c(C_i^H; Y) - G_c(Ci; Y)\right] + A_i^{NY} \ln\left[G_c(C_i; Y) - G_c(C_i^L; Y)\right] + A_i^{NN} \ln G_c(C_i^L; Y) \right\} \qquad （7）$$

Formulating $1 - G_c(.)$ as logistic CDF and combining this with $Y = (\alpha, \beta)$ yields:

$$\Box \; (C_i; Y) = [1 + \exp(\alpha - \beta\Box)]^{-1} \qquad （8）$$

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

3.2.4 Spike model

We used *Spike model* to value our willingness to pay for hydrogen buses. Chinese residents may not know enough about the policies related to hydrogen fuel cell buses due to their small number. Besides, the overall income level of the public is not high in China, a developing country. Most Chinese residents have a weak environmental awareness, and they are unfamiliar with CVM scenarios. Hence, there would be respondents who choose to refuse to pay (zero response) in the questionnaire survey. As a result, the spike model proposed by Kristrom (1997) and Benjamin et al. (1999) combined with SBDC was employed to deal with zero response.

The spike model is established based on the modification of DBDC-CVM. In case the respondents are required to answer subsequent questions when the answer is No-No（A_i^{NN}）, they would be asked if they are willing to join the market again. If the answer is "Yes" （A_i^{NNY}）, they would be estimate by the spike model. The spike model allows the probability of 0 WTP to be a certain positive decimal. If the answer is "No"（A_i^{NNN}）, the reason why they are unwilling to join the market would be asked to judge whether the respondent belongs to a protest group. If it is judged as a protest response, the sample would be eliminated.

The formula can be expressed as follows,

$$\ln L = \sum_{i=1}^{N} \left\{ A_i^{YY} \ln\left[1 - G_c(C_i^H; Y)\right] + A_i^{YN} \ln\left[G_c(C_i^H; Y) - G_c(C_i; Y)\right] + A_i^{NY} \ln\left[G_c(C_i; Y) - G_c(C_i^L; Y)\right] + A_i^{NNY}\left[\ln G_c(C_i^L; Y) - G_c(0; Y)\right] + A_i^{NNN}\left[G_c(0; Y)\right] \right\}$$

In which

$$\Box \ (C_i; Y) = \begin{cases} 0 & if A < 0 \\ [1 \ + \ \exp{(\alpha \ )}]^{-1} & if A = 0 \\ [1 \ + \ \exp{(\alpha - \beta A)}]^{-1} & if A \ > 0 \end{cases}$$

The spike is defined by $[1 + \exp{(\alpha)}]^{-1}$. The average mean WTP can be computed as $\overline{C} =$ $(1/b) \ln[1 + \exp{(\alpha)}]$.

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Chapter 4

Willingness of Chinese households to pay extra for hydrogen-fueled buses: A survey based on willingness to pay

Chapter4 Willingness of Chinese households to pay extra for hydrogen-fueled buses: A survey based on willingness to pay

Hydrogen-fueled buses play an important role in the construction of low-carbon cities as a means of green travel. Beijing, as a pilot city of hydrogen-fueled buses in China, is very important in the promotion of hydrogen-fueled buses in China. But unfortunately, the public acceptance of hydrogen-fueled buses and their environmental positive externality value have not been studied. In this paper, we investigated the willingness of Beijing households to pay for the promotion of hydrogen-fueled buses and its influencing factors by means of a web-based questionnaire. The spike model was also used to estimate the willingness to pay for hydrogen buses. The results show that the willingness to pay of Beijing households is 3.19 CNY per trip. The value of a positive environmental externality is about 29.15 million CNY per trip. Household income level, environmental knowledge, individual environmental ethics, and perceived behavioral control are the main influencing factors of willingness to pay. Therefore, policymakers should strengthen publicity efforts to increase individuals' environmental awareness and environmental ethics and optimize the layout of hydrogen-fueled bus schedules and riding experiences to improve individuals' perceptual and behavioral control. Finally, the positive environmental externality value of hydrogen buses should be valued, which will help increase investor interest.

4.1 Background

With the United Nations Climate Conference in 2020, carbon emission mitigation has attracted widespread attention all over the world. the rapid economic growth is at the expense of the natural environment, resulting in great consequences. Environmental deterioration is one of them and poor air quality in some cities has aroused people's attention. "Haze" and "PM2.5" have become topics of public discussions and frequently appear in Chinese media. The capital city, Beijing, is troubled by heavy choking. It has been proven that automobile exhaust is closely related to the hazy weather. The main components of haze are sulfur dioxide, nitrogen oxides, inhalable particles and so on. Worse still, four kinds of substances in haze can lead to reduction in visibility: organic aerosols, sulfate, nitrate, and black carbon. Except sulfate automobile exhaust is directly related to the other three categories. The organic hydrocarbons in automobile exhaust is the main source of organic aerosols; the nitrate is produced by further oxidation of nitrogen oxides produced in automobile
exhaust and black carbon are emitted by the incomplete combustion of diesel and gasoline in the vehicle engines. Therefore, controlling the emissions of automobile exhaust is one of the key measures to prevent hazy weather. To reduce the emissions of vehicle exhaust, priority should be given to the development of public transport since the emissions of public transport per passenger are less than those of private cars. Public transport includes buses, tramcars, rail transport, taxis, ferries, and so on. It would be more effective if public transport uses clean fuels. With the promotion of the national "carbon neutral" and "carbon peaking" tasks, hydrogen energy, which is a green energy source, has received national attention and vigorous promotion. highlighting the importance of green energy for the construction of low-carbon cities [1].

China, as the world's largest emitter of carbon, has an urgent priority to reduce its carbon emissions. China has made a commitment to the Paris Agreement to achieve carbon neutrality by 2060. Hydrogen energy is an efficient and renewable clean energy source that plays an important role in the construction of low-carbon cities. With the promotion of the national "carbon neutral"

and "carbon peaking" tasks, hydrogen energy, a green energy source, has received national attention and vigorous promotion.

A hydrogen fuel vehicle (HFV) is an application of hydrogen energy, which works on the principle of producing electricity by an electrochemical reaction between hydrogen and oxygen without combustion. Hydrogen energy is a kind of secondary energy with rich sources, green and low carbon, and widely used. It is gradually becoming one of the important carriers of global energy transformation. Hydrogen cars mainly rely on the chemical reaction of hydrogen and oxygen in the air to produce electric energy, and then drive the motor to drive the car. The emission of the whole cycle process is generally only water, which can realize "zero carbon emission". Thus, its energy conversion efficiency is high, and the reaction emission is water. Compared with conventional fuel vehicles, HFV emissions are pollution-free. Compared with pure electric vehicles, HFV has obvious advantages such as short fuel refueling time and long driving range, which can effectively fill the inherent disadvantages of pure electric vehicles in medium and long-distance transportation, and is one of the important directions for the development of new energy vehicles in the future, as well as an important direction for the transformation and upgrading of global automotive power system and an important part of building low-carbon transportation system. In the construction of low-carbon cities, hydrogen-fueled vehicles are considered an important part of low-carbon cities as a new type of green transportation.

The use of hydrogen as fuel has many advantages: clean health, gas combustion emissions only water, without any environmental pollution components; Oxygen burns hotter than cars. Gas-fueled vehicles have strong endurance, long driving distance and long service life, and their greatest advantage is environmental protection. However, there are some difficulties in oxygen motor vehicles, such as the high cost of obtaining oxygen fuel, and the storage and transportation of pre-gas fuel is very difficult according to the current technical conditions.

Hydrogen fuel cell vehicles use "fuel cell + motor" as the power system, hydrogen as the fuel, produce "hydrogen + oxygen = water" reaction, during the driving process only generated water, while traditional internal combustion engine vehicles use "engine and fuel system", during the driving process to produce carbon dioxide, nitrogen oxides and other harmful gases, it can be seen that, Hydrogen fuel cell vehicles can realize "zero emission and no pollution" during driving, so hydrogen fuel cell vehicles have a greater advantage in energy saving and emission reduction compared with traditional internal combustion engine vehicles. Compared with pure electric vehicles, hydrogen fuel cell vehicles have two main advantages: first, they have a long driving range because of the high mass energy density of hydrogen: lithium ion has a mass energy density of 0.36-0.88MJ/Kg, while hydrogen has a mass energy density of 142MJ/Kg; Second, the hydrogenation time is very short, only 3-5 minutes can be filled with hydrogen, and the charging time of electric vehicles in the fast charging mode is also 2-3 hours. Hydrogen fuel cell vehicles are fueled by hydrogen, which, as a secondary energy source, has a wide range of sources. Hydrogen can be produced by coal gasification, natural gas steam reforming and water electrolysis. When large-scale renewable energy such as wind power generation and solar power generation can be used to produce hydrogen in the future, the production cost of hydrogen will be greatly reduced. Therefore, hydrogen fuel cell vehicles have broad prospects for development, and all

countries in the world are actively developing hydrogen fuel cell vehicles.

Hydrogen fuel cell vehicles use renewable energy -- hydrogen as fuel, which can effectively reduce energy consumption and pollution emissions during city and city transportation, so it is considered the most likely alternative to traditional fuel vehicles in the future.

Hydrogen fuel cell vehicle uses renewable energy. Hydrogen as fuel can effectively reduce energy consumption and pollution emissions in the process of urban traffic operation, so it is the most likely alternative to traditional fuel vehicles in the future. Beijing as a pilot city, it is very necessary to study it.

In China, hydrogen-fueled vehicles exist mainly in the form of hydrogen-fueled buses. Buses are widely used as an important tool for travel, but they have been criticized for a series of negative environmental externalities, such as the high carbon emissions of traditional buses. Hydrogen-fueled buses play a key role in the construction of low-carbon cities as a tool for green mobility. For the construction of a low-carbon city in 2022, the National Innovation-driven Development Strategy Outline and other important documents issued by the state clearly mention the vigorous development of hydrogen-fueled vehicles. According to the "Beijing Municipal Hydrogen Fuel Cell Vehicle Industry Development Plan (2020-2025)" released by the Beijing Municipal Bureau of Economy and Information Technology at the service meeting, in order to accelerate the innovative development of Beijing's hydrogen fuel cell vehicle industry and support the construction of the national science and technology innovation center, Beijing will focus on building a highland of innovation in the hydrogen fuel cell vehicle industry, and from 2016-2021 China's hydrogen fuel cell vehicle ownership is increasing year by year, and the ownership will reach 8922 vehicles in 2021, accounting for 18% of the ownership of major countries in the world. According to the Medium and Long-term Plan for Hydrogen Energy Industry Development (2021-2035), the ownership of hydrogen fuel cell vehicles in China will reach 50,000 vehicles in 2025 and be widely used in urban public transportation. By 2025, Beijing strives to build and put into operation 74 hydrogen refueling stations. With the help of the Beijing 2022 Winter Olympics and Paralympic Winter Games and the construction of the national fuel cell vehicle demonstration city cluster, Beijing is actively promoting the development of hydrogen energy industry. Beijing has put into application 1,528 hydrogen fuel cell vehicles, including large and medium-sized buses, ordinary logistics vehicles, cold chain logistics vehicles, sanitation vehicles, personal passenger cars, etc. In addition, in order to ensure the daily operation of hydrogen fuel cell vehicles, the city has built 11 hydrogen refueling stations, of which 10 hydrogen refueling stations have been put into operation.

Although a series of national policies have been formulated to promote the development of hydrogen fuel cell vehicles, studies on the public acceptance of hydrogen-fueled vehicles (especially hydrogen-fueled buses) are still limited. This is not conducive for policy makers to develop appropriate promotion policies. Assessing the public's willingness to pay is an important tool to measure public acceptance, which is of great social importance [2]. Assessing willingness to pay not only helps to understand public acceptance but also helps to assess the environmental value of public environmental products. It provides a reference value for policy formulation.

Respondents how much they would be willing to pay (Willingness to Pay (WTP)) for a certain change in the quantity or quality of environmental goods in the virtual market and evaluates the economic value of environmental resources based on this change. The economic value of a resource. It is a valid way to assess the non-use value of specific public goods and services [3]. This approach is also recommended by the National Oceanic and Atmospheric Administration (NOAA) and is currently used in many applications such as new energy product applications, urban green space protection, and environmental goods evaluation [4]. It has also been involved in the field of hydrogen energy [5].

Construction of low-carbon cities, with positive environmental externalities in terms of reducing urban carbon emissions and alleviating the use of fossil energy. In this respect, the use of hydrogen-fueled buses has the effect of protecting the environment and has an environmental value. Therefore, it can be considered a public environmental product, but its environmental value cannot be estimated by conventional methods. This is not conducive to the development and improvement of policies. It is also not conducive to the active participation of investors. Therefore, we use CVM to evaluate the willingness to pay for hydrogen buses and further understand the factors that affect the public willingness to pay, and finally calculate the environmental value of hydrogen buses.

Lin and Tan used a conditional value approach to study people's willingness to pay for the adoption of new energy vehicles in four developed cities, Beijing, Shanghai, Guangzhou, and Shenzhen [5].So far, many researchers have studied the public preference and willingness to pay for hydrogen buses, O'Garra et al. conducted a comparative study of the public preference for hydrogen buses in Berlin, London, Luxembourg, and Perth. Respondents in all four cities were willing to pay extra for each bus, and the values were similar: V0.29 to V0.35 (V for Euro) [6].

An interval regression model was used to analyze the factors influencing people's willingness to pay and to estimate the exact amount of each payment. The results showed that about 80% of respondents in the four cities were willing to pay extra to support the adoption of new energy vehicles, with a specific amount of RMB 0.653/fare for all respondents. Yan and Zhao studied the factors influencing people's adoption trends and willingness to pay for hydrogen fuel cell heavy-duty vehicles and analyzed customers' willingness to pay. The results showed that customers were less willing to purchase hydrogen fuel cell heavy-duty trucks, but purchase price, fuel cost, environmental awareness, and the number of heavy-duty trucks purchased had significant effects on participants' choices. People were willing to pay $116,099-131,579 for a hydrogen energy truck, with a willingness to pay more than 50% higher than that for a heavy-duty diesel truck, and they were willing to pay no more than $1,548 per year for maintenance [7]. Roche reviewed and summarized the findings of public attitudes toward HFVs. The results show that most people are not opposed to HFV, and some quantitative studies further prove that the public attitude is almost positive. From the above literature, we can find that the public acceptance and willingness to pay for hydrogen-fueled transportation has been widely studied worldwide, but there is a lack of research on public attitudes and willingness to pay for hydrogen-fueled buses in Beijing, the capital city of China [8].

Beijing, as one of the first pilot cities in China to carry out the application of hydrogen-fueled buses, it is of the reference signs in the promotion of hydrogen-fueled buses in China. Therefore, this paper is the first study to investigate the willingness to pay for hydrogen-fueled buses among Beijing households and the factors influencing the willingness to pay for hydrogen-fueled buses and to assess the environmental value of hydrogen-fueled buses. Specific research flow is as follows: in the second part, a review of the existing literature is presented. In the third part, the methodology is presented. In the fourth part, the main results are analyzed and discussed. In the fifth part, the conclusions are stated. In the sixth part, the policy implications are described.

4.2Literature review

4.2.1 Research on WTP for new energy and hydrogen fuel

Hydrogen cars are seen as promising clean-energy vehicles. To build a sustainable development society, the market scale of hydrogen energy vehicles will be further expanded in the future, accelerating the promotion of green environmental protection society. Therefore, it has been widely concerned by researchers.

Most studies on the willingness to pay (WTP) for hydrogen fuel cell motor vehicles (HFCVs) are generally conducted from the following two aspects.

4.2.1.1 Demography and Personal Behavior Preference

Liu et al. analyzed the factors influencing HFCV consumption of respondents in Jiangsu Province, Zhejiang Province, and Shanghai, three major regions in the Yangtze River Delta. The results indicated that gender, age, and income differences may not be the determinants of purchase, but the educational background was an important influencing factor. Consistent with social psychology research, personal environmental protection awareness and attitudes towards energy conservation are the key factors influencing HFCV consumption. Finally, they found that, in the Yangtze River Delta, the confidence of consumers in hydrogen products in China is also an important influencing factor [9]. Chen and Zhang constructed a structural equation model. The results indicated that the green purchasing behavior of consumers completely mediated the positive correlation between social value perception and purchasing intention of HFCVs. It was revealed through multi-group analysis that monthly income and gender could modulate the correlation between some study variables [10]. Du et al. examined psychosocial factors based on an extended TPB model and explained the "awareness-behavior" gap with the low-carbon awareness as a regulatory variable. Besides, they obtained three main findings through correlation analysis and hierarchical multiple regression analysis. Firstly, there was an "awareness-behavior gap", namely that low-carbon awareness had a slight regulatory effect on purchasing behavior through psychological factors. Secondly, subjective norms could exert a more significant impact on the WTP for new energy vehicles (NEVs) compared with other social and psychological factors. Thirdly, the acceptability of policies also had a positive and significant impact on the acceptance of NEVs. The low-carbon awareness can be regarded as a regulatory variable, which can enhance or weaken the WTP for NEVs[11]. Rosales et al. investigated the WTP of Spanish drivers for

HFCVs. They found that those individuals with higher education levels, higher income levels, thorough insights into HFCVs, and a higher awareness of the negative consequences of fossil fuels in transportation with respect to environmental pollution and economic dependence were prone to accept HFCVs at an earlier stage [12]. Huijts et al. explored the willingness of ordinary people to use hydrogen fuel facilities. The results indicated that personal moral perception would have a significant influence on the use of hydrogen fuel facilities [13].

4.2.1.2 Product Inherent Attributes and Social Level

Nie et al. discussed whether industrial agglomeration could affect the WTP of customers for HFCVs. The empirical analysis results revealed that the industrial structure height of a city was positively correlated with the acceptance of customers for HFCVs. This indicates that, in addition to economic and environmental factors, the agglomeration of industrial activities induced by industrial competition would increase the WTP of customers for HFCVs [14].

Li et al. explored the public's WTP for the performance improvement of two different HFCVs. They confirmed that the public was willing to pay for the improvement in range, refueling duration, fuel-saving amount, emission reduction and other aspects [15]. Hardman et al. conducted a questionnaire survey on HFV owners in the United States. They found that HFVs can attract customers who cannot charge up electric vehicles or install personal charging sets at home. They also maintained that the lack of charging or battery exchange stations is a major difficulty for the commercial success of HFVs [16].

Yang et al examined the public's willingness to support the policy of paying for the expansion of hydrogen stations in South Korea. They confirmed that the annual average WTP was KRW 2,258 (US $2.04), and the public was willing to bear a large part of the financial burden for the promotion of the policy [17].

Through the above analysis, it can be found that gender, age, income, and educational background could influence WTP. As per a previous study conducted by our group, family member composition and health status could also have an impact on WTP [18]. The above six variables can be classified into the demographic category. Moreover, it can also be validated that relevant environmental knowledge and experience would have an impact on WTP. Moral perception would also influence the use of hydrogen fuel facilities. Therefore, the relationship between the above variables and WTP was discussed in this section.

4.2.2 Theory of Planned Behavior

As one of the very important theories in the field of intentional behavior research, the main role of planning behavior theory is to explain how individual consumers plan their behavior to achieve their own goals, and most of the current research is mainly to find ways to predict the actual behavior of individual consumers through the impact on various dimensions of planning behavior theory.

The Planning Behavior Theory (TPB) is derived from the multi-attribute attitude theory of scholar Fishbein, who pointed out that behavioral intentions depend on behavioral attitudes, and the expected behavioral outcomes and outcome evaluations in turn determine behavioral attitudes. Based on the multi-attribute attitude theory, the two scholars Fishbein and Ajzen jointly proposed the rational behavior theory, which believes that behavioral intention is the direct factor determining the execution of behavior, and that behavioral attitudes and subjective norms affect its factors. The reason for the limited scope of use of rational behavior theory is because the mental will of individual consumers controls specific behavior, resulting in serious restrictions on its scope of use. In 1985, scholar Ajzen derived a new theory as the theory of planned behavior by adding the dimension of perceptual behavior control to the theory. And after "Planned Behavior Theory" was published by scholar Ajzen, it quickly reached maturity in the academic circle. In this theory, the intention of individual consumers is mainly influenced by planned behavior (behavioral attitude, subjective norm, and perceptual behavior control). The theory of planned behavior (TPB) is the most basic theory in the field of behavior. Planned behavior theory is the field of social psychology to explain and predict. A well-known theory of human behavior. The theory holds that the production of an action directly depends on the individual's intention to perform a particular act. The stronger the individual's intention, the greater the likelihood of action, vice versa. The behavioral intention is determined by the three elements of individual attitude, subjective norm and perceptual behavior control. The specific relationship is as follows: First, behavioral attitudes, subjective norms (support from significant others) and perceptual behavioral control (such as actual control conditions such as ability, opportunity, and resources) jointly determine behavioral intentions.

The basic assumption is that the more positive the actor's attitude towards a certain behavior, the stronger the intention to act. The more positive the subjective norm, that is, the greater the support of significant others, the stronger the intention to act. When the behavioral attitude and subjective norms are more positive and the perceived behavior control is stronger, the actor's willingness to act will be stronger, and vice versa. Second, behavior is not only affected by behavioral intention, but also constrained by perceptual behavior control, and in the case of sufficient actual control conditions, behavioral intention directly determines behavior. Third, accurate perceptual behavior control can reflect the condition of actual control conditions, so it can directly predict the likelihood of behavior occurring. Planned behavior theory synthesizes the various factors that influence individual behavior Element, behavioral attitude shows the internal factors of the individual and their associations, subjective norms reflect the role of the external environment, and perceptual behavior control represents the individual's perception of behavior.

Based on the same assumptions as the theory of reasoned action (TRA), it can be assumed based on TPB that individuals usually engage in behaviors wisely, consider available information, and implicitly or explicitly consider the meaning of their behaviors. In this theory, behavioral intention is the strongest determinant of behaviors. According to TPB, behavior is controlled by behavioral intentions. The theory is composed of three core components, namely, attitude, subjective norms, and perceived behavioral control (PBC). Specifically, (1) attitude is a psychological emotion that can be conceived as an assessment of the consequences of a specific behavior in rational choice, if a person has a positive attitude, he/she would present environmental behavior; 2) subjective norms

indicate that a person is subjected to social pressure from others, which may lead him/her to adhere to the beliefs of other people in some way; (3) PBC refers to an individual's belief that he or she overcomes obstacles and performs a given behavior. Hence, TPB is commonly used to explain various behavioral intentions. Of course, TPB has also been applied to the research on HFCVs or NEVs. Wang et al. utilized TPB to investigate the influence of Chinese consumers' attitudes, subjective norms, and PBC on their WTP for NEVs. The results indicated that the attitude towards NEV policy is the main variable affecting WTP [19]. Karuppiah and Ramayah explored the influence of TPB on the use of hybrid vehicles among the public in Malaysia. They found that the high sensitivity to price weakened the positive correlation between PBC and WTP for hybrid vehicles [20]. Huijts et al. adopted TPB to examine the Dutch public's intention to use hydrogenation facilities. The results showed that TPB can influence the public's intention to use hydrogenation facilities [21].

As per the above analyses, it can be validated that TPB has been extensively used in the investigation of public attitudes towards new energy and the influencing factors related to its use. Therefore, TPB would also be selected as a variable influencing WTP in this study.

4.2.3 Research on CVM

The Contingent Valuation Method (CVM) is a type of estimation that can be used for non-use The method of value is a type of declarative preference. This method was first applied in 1989, The negative effects of the oil spill in Valdez, USA, were assessed. Before that, although there have been negative effects or it is an assessment of non-use value, but most of the methods are only in the hands of scholars, and the public is not well known. It was in Valdez's lawsuit against the company that caused the oil spill that the conditional value theory began to attract widespread attention. And caused a heated discussion. After that, the declarative preference research method represented by the conditional value theory began to be obtained. It is generally recognized and has begun to be widely used in the assessment of non-use value. Doherty believes in the complete conditional value theory, it is necessary not only to select the appropriate survey method to investigate the respondent's willingness to pay, but also to set up the question for the respondent, establish a complete background to enhance the respondent's understanding of the matter to be investigated.

With the continuous improvement of conditional value theory, the measurement method of willingness to pay is also constantly improving. Depending on the measurement method, the willingness to pay is also different. There are three main ways to induce the contingent valuation method (CVM), including payment-card, open-ended, and dichotomous-choice mode. In terms of the payment-card mode, the interviewers can set multiple price options for the respondents to choose the most acceptable option. The payment-card mode tends to cause "rounding consumption", namely that the WTP of respondents will be concentrated on the integer bidding point provided by interviewers [22]. In terms of the open-ended mode, respondents directly bid for the highest acceptable WTP. However, the disadvantage of the open-ended mode is a lack of a reference point on the "maximum payment", which induces a low response rate for the questionnaire [23]. In terms of the dichotomous-choice mode, interviewers would randomly

question respondents within the determined bidding value range to observe whether they accept or reject the bid value. In contrast, the respondents under the dichotomous-choice mode only need to answer "Accept" or "Refuse" for a certain bidding value, without giving the specific value of their WTP, which contributes to preventing strategy bias in an incentive-compatible approach [24]. The dichotomous-choice mode can be subdivided into single-bounded dichotomous choice (SBDC) and double-bounded dichotomous choice (DBDC). Since DBDC is higher in the number of inquiries than SBDC, DBCD has higher accuracy [25]. Therefore, DBDC is recommended by the National Oceanic and Atmospheric Administration (NOAA).

In CVM, zero response with the WTP of 0 often appears, which would affect the estimation results [26]. Many researchers directly eliminated zero response in previous studies, which may induce bias in the results [27]. The spike model is an effective method to deal with zero response [28]. In this model, it can be assumed that the distribution function of WTP cannot be zero at zero, which eliminates the deficiency that the conventional model cannot deal with the WTP samples with the value being 0. Benjamin et al. extended the spike model by adding covariates to estimate the total WTP [29], thus exploring the factors influencing WTP. The effectiveness of the Spike model has been validated in some studies [30] [31].

4.3 Data Collection

4.3.1 Site of Data Collection

In this study, a questionnaire survey was conducted in Beijing, the capital of China (Shows in Figure 5-1). Beijing has experienced traffic congestion and environmental pollution in recent years.

Beijing has been one of the demonstration cities for hydrogen energy vehicles in China in recent years. The development and promotion of new energy vehicle industry in the region has achieved certain results, especially in the field of public transportation Outstanding performance. It is an inevitable choice for the city to vigorously develop NEVs. There is a favorable development environment for the hydrogen energy automobile industry in Beijing owing to many industrial support policies, famous universities, and powerful research institutions in this city. Beijing's vigorous development of new energy vehicles is a natural choice. To highlight the concept of humanistic Beijing, science and technology Beijing, green Beijing, continuously promote the research and development and application of energy-saving and hydrogen energy vehicles and strive to build Beijing into a resource-saving, environment-friendly and harmonious city, as early as the Olympic Games, Beijing was the first batch of hydrogen energy buses to show the operation. Beijing's new energy vehicle industry has a good development environment, based on China's hydrogen energy vehicle technology, infrastructure and other restrictions, Beijing is currently focusing on the development of hydrogen energy public vehicles, sanitation, rental cars, hydrogen energy public transport has always been the key application field of Beijing's new energy vehicles. The same situation exists in other new energy vehicle promotion cities in China, and hydrogen energy vehicles are the main products of the new energy vehicle market, and they are the vehicle models that the policy is vigorously promoting. Besides, during the 2022 Winter Olympics,

hydrogen fuel cell buses had been vigorously promoted as a vehicle for green travel. Based on these facts, Beijing was selected as the survey site.

Figure4- 1.Location map of the study area

4.3.2 Questionnaire Survey Method

（1）Data Sources

Questionnaire surveys have become a mainstream method to investigate the public's attitude towards environmental products [32]. This survey method can be divided into face-to-face interviews, telephone interviews, and online questionnaire surveys. The telephone interview is not a common method due to higher costs and longer duration. The face-to-face interview is considered an efficient way to collect questionnaires. It can help respondents understand the details of questionnaires and provide real-time answers to the questions of respondents. However, it is difficult to adopt face-to-face interviews on a large scale due to the current epidemic prevention restriction in China. The development of smart phones and the Internet can ensure the smooth conduct of online questionnaires, rather than in face-to-face surveys considering the high cost of questions and the sensitivity of interviewees' emotions. With the increased number of internet terminal devices in China, the number of mobile internet users in China has reached 1.007 billion. This provides great convenience for the implementation of online questionnaire surveys. This method can ensure the completion of this online questionnaire survey. In view of the cost and the epidemic prevention situation in China, the online questionnaire survey was selected as the data collection method.

In the past, online research was not feasible due to a lack of participation of older adults. However, with the increase in the number of Internet terminal devices in China, the size of China's mobile phone Internet users has reached 1.007 billion. China's WeChat users have reached 1.1 billion, and smartphone users account for 97.5% of Internet users. WeChat has developed into a comprehensive information platform including communication, information, entertainment, search, e-commerce, office collaboration, and enterprise customer service. It has the advantage of being efficient, collecting questionnaire answers and data in a short time, and specifying various sample attributes such as gender, age, region, occupation, industry, etc. identify target populations; Questionnaires can also set various filtering rules, filter pages, quota controls and other conditions to automatically filter out invalid responses, while supporting manual checks to ensure the validity of the final data. Users who seriously respond to the survey will be rewarded with a few dollars in red envelopes. With the development of the Internet, more and more people began to use the Internet, and the Internet has become an indispensable communication tool in everyone's daily life. If the person has a smartphone, he or she is a potential interviewee. Considering that the research object of this study is the Beijing area, we mainly invited teachers, classmates and friends working in the Beijing area to distribute this online questionnaire. The questionnaire was randomly sent to Beijing residents, and a valid sample was obtained.

These questionnaires were collected with the assistance of the Wen Juan Xing platform (https://www.wjx.cn/). This is the largest online questionnaire survey platform in China, and there are more than 190 million users and more than 15 billion questionnaires on the platform. Since this study was conducted in Beijing, the tutors, students, and friends in this city were invited to randomly distribute these online questionnaires to Beijing residents to obtain valid samples. This questionnaire survey was conducted on the respondents aged 18-65 years in Beijing. A total of 800 questionnaires were distributed, and 610 responses were obtained, including 565 valid questionnaires and 45 invalid questionnaires. These invalid questionnaires included protest responses and questionnaires with failures. For instance, the respondent contended that there was a lack of authenticity for the project, or that the government should pay for this project.

The Schaeffer equation is used in sample selection to determine sample size. The effectiveness of this method has been proven and is widely used in sample size confirmation [34].

$$U = T/(K-1)e^2 + 1$$

where U is the sample size, T is the total sample size, and e is the acceptable error. Given that Beijing has a population of 21.8 million, the ideal valid sample size should be no less than 400. Considering influencing factors such as invalid questionnaires in the questionnaire survey, the effective sample size should not be less than 500. The effective sample size of 564 in this study meets the requirements of the Scheaffer equation. Questionnaire Star allows the IP addresses of interviewees to be set within the range. We stipulated that the IP addresses be limited to the Beijing area and that all samples meet the set range. Therefore, it can be considered that our study conforms to the geographical setting and has applicability.

（2）Payment Instruments

The abrupt inclusion of WTP in online questionnaire surveys frequently left respondents perplexed,

and the payment method is helpful in disclosing the genuine payment purpose [35].Taxes, entry tickets, ticket payments, and other means are the principal payment instruments. According to Carson, adopting mandatory and widespread payment methods can significantly lessen payers' excessive commitment [36]. Relevant questions about income tax and consumption tax in the pre-survey had been clarified.

4.3.3 Data Collection Process

Before the formal questionnaire survey, a pre-survey was conducted based on a sample size of 50 respondents. The pre-survey was performed to determine the bidding value, bidding scope, and payment instruments.

Bus tickets were chosen as the payment method based on the findings of the pre-survey because they were both required and well-known to the respondents. Additionally, in this procedure, 3 sets of bidding values overall were established, and 6 bidding points, including 0.5, 1, 2, 3, and 4, were chosen. The selection of 0.5 and 4 was avoided in the first round of inquiry to prevent missing bidding points in the second round of inquiry. These three groups' bid values were sorted from little too large as CNY (0.5/1/2), (1/2/3), and (2/3/4).

The questionnaire was composed of four parts. The first part was involved in the demographic data of respondents, including gender, age, educational background, work, household income level, family member composition, and health status. The second part included 5 questions designed for obtaining the respondents' understanding of hydrogen energy or associated vehicles, the experience of hydrogen fuel cell buses, policy concerns, and environmental awareness. These questions are presented as follows. Do you know about hydrogen energy or related vehicles? Do you know about policies related to hydrogen energy? Have you ever taken hydrogen fuel cell buses? Do you know about policies related to hydrogen energy or HFVs? Do you think that using hydrogen fuel cell buses can help alleviate urban carbon emissions? The third part was related to TPB, including 3 questions. From the perspective of attitudes, in order to build a low-carbon city (improve the environment, purify the air, etc.), would you actively choose the hydrogen fuel cell bus as a means of travel? From the perspective of subjective norms, do your family members or friends support you to choose the hydrogen fuel cell bus as a means of travel? From the perspective of PBC, do you have enough resources to pay extra for hydrogen fuel cell buses? Although the government is actively promoting hydrogen fuel cell buses as a vehicle for green travel, there are certain financial burdens. Considering the positive environmental externalities of hydrogen fuel cell buses (zero emissions, improved air quality and other positive effects) and the financial pressure faced by the government, would you or your family members pay extra fees for the promotion of hydrogen fuel cell buses (the bus ticket is CNY 2) every time you take the bus under the premise that your status is fully considered? This is the core issue about the WTP for hydrogen fuel cell buses.

4.4 Methodology

4.4.1 The conventional DBDC-CVM model

In the conventional DBDC format, respondents would be asked whether they are willing to pay or accept the bidding value of a specific amount C_i (i=1, ..., n). The first answer of "Yes" or "No" would be regarded as a reference basis for the second inquiry to adjust the bidding amount. As for WTP, when the answer of the respondents is "Yes" for the first time, another higher bidding amount C_i^H would be asked for the second time, otherwise they would be provided with another lower bidding amount C_i^L, i.e. $C_i^L < C_i < C_i^H$; The T denotes the response after a given amount C_i, willing to pay then $T = Y$ and refusal to pay then $T = N$. Therefore, there are four possible outcomes: unwilling-unwilling, unwilling-willing , willing-unwilling, and willing-willing. The binary-indicator variables would be $A_i^{NN}, A_i^{NY}, A_i^{YN}$, and A_i^{YY}, respectively. $G_c(C; X)$ represents the cumulative distribution function (CDF) of WTP, C represents the bidding value, Y represents an unknown parameter that needs to be valued, and the logarithmic likelihood function can be expressed as follows.

$$\ln L = \sum_{i=1}^{N} \left\{ A_i^{YY} \ln\left[1 - G_c\left(\left(C_i^H; Y\right)\right)\right] + A_i^{YN} \ln\left[G_c\left(C_i^H; Y\right) - G_c(Ci; Y)\right] + A_i^{NY} \ln[G_c(C_i; Y) - G_c\left(C_i^L; Y\right)] + A_i^{NN} \ln G_c\left(C_i^L; Y\right) \right\}$$

Formulating $1 - G_c(.)$ as logistic CDF and combining this with Y = (α, β) yields:

$$\square \ (C_i; Y) = [1 + \exp(\alpha - \beta\square)]^{-1}$$

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

4.4.2 Spike model

Chinese residents may not know enough about the policies related to hydrogen fuel cell buses due to their small number. Besides, the overall income level of the public is not high in China, a developing country. Most Chinese residents have a weak environmental awareness, and they are unfamiliar with CVM scenarios. Hence, there would be respondents who choose to refuse to pay (zero response) in the questionnaire survey. As a result, the spike model proposed by Kristrom (1997), and Benjamin et al. (1999) combined with SBDC was employed to deal with zero response [28] [30].

The spike model is established based on the modification of DBDC-CVM. In case the respondents are required to answer subsequent questions when the answer is No-No（A_i^{NN}）, they would be asked if they are willing to join the market again. If the answer is "Yes"（A_i^{NNY}）, they would be estimate by the spike model. The spike model allows the probability of 0 WTP to be a certain positive decimal. If the answer is "No"（A_i^{NNN}）, the reason why they are unwilling to join the market would be asked to judge whether the respondent belongs to a protest group. If it is judged as a protest response, the sample would be eliminated.

The formula can be expressed as follows,

$$\ln L = \sum_{i=1}^{N} \{A_i^{YY}\ln[1 - G_c(C_i^H; Y)] + A_i^{YN}\ln[G_c(C_i^H; Y) - G_c(C_i; Y)] + A_i^{NY}\ln[G_c(C_i; Y) -$$

$$G_c(C_i^L; Y)] + A_i^{NNY}[\ln G_c(C_i^L; Y) - G_c(0; Y)] + A_i^{NNN}[G_c(0; Y)]\}$$

In which

$$\Box\ (C_i; Y) = \begin{cases} 0 & if\, A < 0 \\ [1 + \exp(\alpha)]^{-1} & if\, A = 0 \\ [1 + \exp(\alpha - \beta A)]^{-1} & if\, A > 0 \end{cases}$$

The spike is defined by $[1 + \exp(\alpha)]^{-1}$. The average mean WTP can be computed as $\overline{C} = (1/b)\ln[1 + \exp(\alpha)]$

4.5 Results and discussion

4.5.1 Data Statistics

In this study, Beijing was selected as the research site. Because children under 18 years old and the elderly over 65 years old may have incomplete cognition, a questionnaire survey was performed on respondents aged 18-65 years in this study. The online questionnaire survey was adopted to distribute 800 online questionnaires in total. Eventually, 610 responses were obtained, and 107 respondents withheld payment. Thus, the protest response judgment was performed on these 107 respondents according to the protest response judgment standard in some relevant articles [37[38]. During the judgment, a total of 5 questions are established, among which A and B represent the true zero response, and C, D, and E represent the protest response. After the judgment, there were 564 valid questionnaires and 46 protest response questionnaires.

A: Economic pressures
B: I am not interested in low-carbon urban construction
C: There is a lack of authenticity for the project
D: The government project has nothing to do with me
E: The use of hydrogen fuel cell buses has no contribution to the environment

Among them, there are 51 respondents in option A, 14 respondents in option B, 8 respondents in option C, 24 respondents in option D, and 10 respondents in option E. Therefore, there were 564 valid questionnaires and 46 protest response questionnaires. Due to the random distribution of protesters in the sample, they can be directly eliminated. These 564 questionnaires were analyzed, and the sample size was in line with that determined by the Scheaffer formula [39].

The distributed responses of respondents in each bidding group are listed in Table 4-1. It can be found that with the increase of the bidding value in the bidding group, the number of respondents who were willing to pay gradually decreased, while the number of respondents who refused to pay gradually increased. About 57% of respondents in the lowest bidding group agreed to pay the lowest bidding value (CNY 2), and 47% of respondents in the highest bidding group agreed to pay the highest bidding value (CNY 4). In addition, 89% of respondents had the WTP larger than 0,

and about 11% of these respondents were judged as zero response samples.

Table4- 1.Response distribution

Bid Amount	YY	YN	NY	NNY	NNN	SUM
(0.5/1/2) CNY	108 (57%)	50 (27%)	17 (9%)	4 (2%)	9 (5%)	188(100%)
(1/2/3) CNY	98 (52%)	45 (24%)	16 (9%)	10 (5%)	19 (10%)	188(100%)
(2/3/4) CNY	89 (47%)	40 (21%)	14 (7%)	12 (6%)	33 (19%)	188(100%)
sum	295 (52%)	135 (24%)	47 (8%)	26 (5%)	61 (11%)	564(100%)

The mean and standard deviation (SD) of each covariate in these statistical samples are listed in Table 4-2. The official data on gender, age, working status, educational background, and income can be obtained from Beijing Municipal Bureau of Statistics. By comparison, it can be observed that there was a significant difference in age and income between the obtained data and the official data; while there was no significant difference in gender, working status, and educational background between the obtained data and the official data. The deviation from the official data may be caused by that there were younger mobile phone users and fewer elderly mobile phone users. It may also be due to the number of samples, which induces some limitations in the spot check. Except for age, there was no significant difference in other variables. Therefore, it can be maintained that the sample in this study was suitable for estimating the WTP of the whole population.

Through population comparison, there were a relatively high proportion of respondents aged 26 to 45 years. Further, the respondents with jobs or households with elderly individuals or children accounted for the majority. Most respondents were in good health. About 60% of respondents had a household income exceeding the average level in Beijing. About 65% of respondents had a basic concept about hydrogen energy. More than 80% of respondents maintained that hydrogen fuel cell buses contributed to alleviating urban carbon emissions, and they were willing to choose these buses as green travel vehicles. In the answer to psychological covariate questions related to TPB, more than 60% of respondents provided positive responses.

Table4- 2.Sample statistics and definition of variables

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Demographic attributes						
Gender	Male =1	260	46.2	0.46	0.50	0.50
	Female=0	302	53.8			
Age	$18 \leq Age <25 =0$	152	26.9	0.85	0.60	1.21
	$26 \leq Age \leq 45=1$	344	61.6			
	$45< Age \leq 65=2$	65	11.5			
Education	University degree	310	55.3	0.55	0.49	0.41

	or above=1					
	others=0	252	44.7			
Job	Have job=1	404	72.0	0.72	0.45	0.51
	No=0	158	28.0			
Raising children or elder	Old or young=1	458	81.6	0.82	0.38	
	No=0	104	18.4			
Physical condition	Health=1	422	75.2	0.75	0.43	
	others=0	140	24.8			
Household Income	More than 35549	337	60.1	0.60	0.49	0.54
	CNY=1	225	39.9			
	others=0					
Relevant knowledge and experience						
Related environment knowledge	Have the knowledge =1	367	65.5	0.65	0.48	
		195	34.5			
	others=0					
Related experience	Have =1	264	46.9	0.47	0.50	
	others=0	298	53.1			
Related policy knowledge	Yes = 1	293	52.3	0.52	0.50	
	others=0	269	47.7			
Moral implications						
Cognition of environmental morality	Yes = 1	480	85.6	0.86	0.35	
	No = 0	82	14.4			
Moral	Yes = 1	473	84.3	0.84	0.36	
	No = 0	89	15.7			
Theory of planned behavior						
Attitude	Yes = 1	441	78.6	0.79	0.41	
	No = 0	121	21.4			
Subjective norm	Yes = 1	474	84.5	0.85	0.36	
	No = 0	88	15.5			
Perceived behavioral control	Yes = 1	355	63.3	0.63	0.48	
	No = 0	207	36.7			

4.5.2 Estimation Results

The maximum likelihood estimate (MLE) function was utilized to estimate the parameters, with the estimation results listed in Table 4-3. These variables were classified into four variable groups. Then, these variables in the four groups were estimated respectively (four estimation models 1-4 were established). Subsequently, the influence of these variables on WTP was discussed. The four

variable groups included the demographic variable group (Model 1), the demographic and environmental knowledge variable group (Model 2), the demographic, environmental knowledge, and moral perception variable group (Model 3), and the demographic, environmental knowledge, moral perception, and planned behavior variable group (Model 4).

In Model 1, there was a positive correlation between the income level and WTP at 1% of the statistical level. In Model 2, there was a positive correlation between the income level and WTP at 1% of the statistical level. Besides, there was a correlation between environmental knowledge and WTP at 5% of the statistical level. In Model 3, there was a positive correlation between the income level and WTP at 1% of the statistical level. Besides, there was a correlation between environmental knowledge and WTP at 5% of the statistical level. In addition, there was a positive correlation between the personal moral level and environmental moral cognition at 1% of the statistical level. In Model 4, there was a positive correlation between the income level and WTP at 1% of the statistical level. In addition, there was a positive correlation between the personal moral level and environmental moral cognition at 1% of the statistical level. Among the TPB-related variables, PBC was significant at 1% of the statistical level. Subjective norms were significant at 10% of the statistical level. There was no significant correlation between attitudes and WTP. Through the above four models, it can be found that there was a significant positive correlation between income level and WTP in the four models. This indicated that the higher the income of the interviewed households, the more willing they are to pay to support the use of hydrogen fuel cell buses as green travel vehicles. Knowledge and experience related to HEVs, moral perception, subjective norms, and PBC in TPB would also exert a significant positive impact on WTP.

Among the estimation results of the four models, the value of the peak model closest to the zero response of our samples can be observed in Model 4, and there was no significant difference (the zero response of the sample was 10.8%, while the peak value was 10.7%). Therefore, the estimation results of Model 4 were selected as those of WTP, and the average WTP was CNY 3.19. The 99% confidence interval (CI) was CNY [2.861, 3.469].

According to the data from the Seventh National Population Census in China, the number of households in Beijing is 9.138 million. If the WTP can be extended to all households in Beijing, the WTP of all households would be about CNY 29.15 million (namely the environmental positive externality value). It can also be considered that all households in Beijing were willing to provide CNY 29.15 million as the financial support to the government for the promotion of hydrogen fuel cell buses every time, they take these buses.

Table4- 3.Covariance estimation results

Variable	Model 1		Model 2		Model 3		Model 4	
	Coef	p values	Coef	p values	Coef	p values	Coef	p values
Constant	1.196	0.009	0.887	0.003	0.458	0.000	-0.019	0.000
Demographic attributes								

Gender	0.122	0.460	0.014	0.933	0.043	0.801	0.014	0.932
age	0.244	0.084*	0.152	0.291	0.153	0.291	0.161	0.271
education	0.319	0.056*	0.237	0.159	0.242	0.152	0.255	0.134
income	0.784	0.000***	0.661	0.000***	0.661	0.000***	0.615	0.000***
Job	0.185	0.321	0.122	0.514	0.092	0.625	0.076	0.690
family	0.185	0.382	0.168	0.430	0.136	0.528	0.131	0.548
health	0.239	0.195	0.257	0.166	0.285	0.125	0.219	0.244
Family members（ social psychology）								
Environment knowledge			0.468	0.032**	0.461	0.036**	0.457	0.037**
Experience			0.298	0.089*	0.308	0.086*	0.342	0.090*
Related policy knowledge			0.383	0.072*	0.351	0.092*	0.361	0.086*
Moral								
environment moral					0.619	0.004***	0.504	0.023**
moral					0.681	0.001***	0.657	0.002**
TPB								
Attitude							0.511	0.957
Subjective norm							0.393	0.084*
Perceived behavioral control							0.633	0.000***
Bid	0.731	0.000***	0.769	0.000***	0.777	0.000***	0.790	0.000***
spike	0.106	0.000***	0.105	0.000***	0.105	0.000***	0.107	0.000***
MTP	3.163	0.000***	3.149	0.000***	3.154	0.000***	3.191	0.000***
95% confidence interval	2.956 ～ 3.182		2.923 ～ 3.138		2.929 ～ 3.143		2.928 ～ 3.387 CNY	
99% confidence interval	2.947 ～ 3.183		2.915 ～ 3.140		2.920 ～ 3.144		2.861 ～ 3.469 CNY	

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

4.5.3 Descriptive Analysis

As the hydrogen fuel cell bus is still a relatively new concept, the public may still know less about it. Therefore, the respondents with the knowledge related to hydrogen energy were further asked to understand the approach to acquiring associated knowledge among them. This may contribute to providing reference for the publicity of hydrogen fuel cell buses. In this study, 367 respondents who had the knowledge related to hydrogen energy were further asked. Among them, 69 respondents obtained relevant knowledge through books, 95 respondents through the internet, 53 respondents through TV, 141 respondents through mobile phones, and 9 respondents through community publicity, as shown in Figure 4-2.
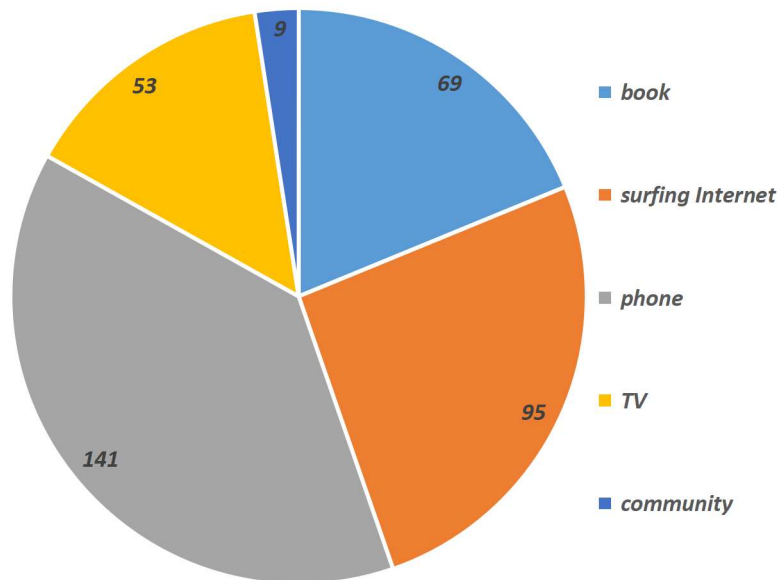
Figure4- 2.Feedback from residents participating in hydrogen energy buses

4.6 Discussion

Some interesting results can be found through this study, including the factors influencing the households' payment for hydrogen fuel cell buses in Beijing and their WTP. The formulation of relevant policies and the promotion of public participation have enlightening significance for the promotion of hydrogen fuel cell buses. Although some researchers have performed extensive studies on hydrogen energy vehicles, there is still a lack of an in-depth exploration into the public's WTP for hydrogen fuel cell buses in Beijing and relevant influencing factors. China is the

country with the largest carbon emissions in the world. The findings of this study based on Beijing are expected to promote the promotion of hydrogen fuel cell buses in China, which may provide reference for green travel in China.

Among demographic variables, there is a significant positive correlation between income level and WTP, which is consistent with the conclusion of Rosales et al. [12]. High-income respondents tend to be more active in environmental protection.

However, some researchers also contended that there is a positive correlation between income and educational background [32]. In this study, educational background is not significant in other models except that it is correlated with WTP at 10% of the statistical level in Model 1. This is different from the conclusions drawn by relevant researchers ([9] [32]) . This difference may be explained that some high-income respondents with a higher educational level would not choose buses as vehicles, and they often drive private cars. Therefore, these respondents were classified as protest responders and excluded from the sample in this study. Environmental knowledge, relevant experience, and policy-related knowledge all have a certain positive correlation with WTP, which is like some research results ([9] [12] [17] [32]). Those respondents who have environmental knowledge, understand relevant policies, and have riding experience are often interested in hydrogen fuel cell buses or take these buses as vehicles for green travel. For those respondents without relevant knowledge, increasing their experience opportunities or strengthening the publicity of relevant knowledge or policies may have a dramatic effect on the acceptance of hydrogen fuel cell buses. The moral factor has always been considered an important factor influencing WTP, and its effectiveness has been widely proved in studies on WTP ([4] [13]). It can be found through this study that environmental moral factors and moral factors have a significant correlation with WTP. This is consistent with the research results of Huijts et al. [13]. The personal perception of moral factors often urges them to actively participate in related activities beneficial to the public, including paying for hydrogen energy, paying for heat island mitigation and so forth. Therefore, it is necessary to increase moral education for policymakers and make individuals actively participate in environmental protection.

The theory of planned behavior (TPB) has become the most important theory in exploring individual behaviors in recent decades ([2] [4]). This theory is mainly composed of three variables, namely attitudes, subjective norms, and perceived behavior control (PBC). It can be demonstrated that there is no significant correlation between attitudes and WTP, which is like the conclusions of some researchers ([4] [35]). Subjective norms are significant at 10% of the statistical level, and PBC is significant at 1% of the statistical level. As a dominant variable affecting WTP in TPB, PBC could also exert an impact on WTP. This is different from the opinion of Ajzen, who believes that attitudes, subjective norms, and PBC can all exert an impact on individual behaviors [22]. This difference may be explained that WTP is not a payment behavior but occurs before the behavior. It may also be explained that although attitude is the driving factor of behaviors, it could be affected by subjective norms and perceived behaviors. When an individual has a positive attitude, but people who have a close relationship with him/her (subjective norms) would prevent this individual from engaging in a certain behavior or his/her resources (PBC) do not support him/her to engage in a certain behavior, the driving force (attitude) may be inhibited. PBC is the

variable that has the most significant influence on WTP in TPB. When respondents think that they have enough resources, they would support the promotion of hydrogen fuel cell buses. In this study, both the income level and PBC could exert a significant impact on WTP. Zhang et al. also proposed that income level was a part of PBC [35]. Due to the influence of COVID-19 in China, a certain economic recession has been induced. Therefore, the approach to improve the income and PBC of residents is a consideration that shall be addressed by policymakers.

We found a strong positive correlation between WTP, and knowledge and experience related to hydrogen-fueled buses; thus, it is essential to increase the dissemination of relevant knowledge to increase WTP for them. Cell phones are currently a widely used communication tool. More than 38% of respondents said that they obtain information is through their cell phone. Surfing online and watching TV are also important ways to obtain information. This is like the findings of Tan et al. (2022) and Zhang et al. (2019) [32] [35]; thus, these three information dissemination channels should be used as the primary means by which to increase knowledge dissemination and increase free hydrogen bus trial rides, which may help to increase the public's WTP and promote the construction of low-carbon cities.

The estimation result of WTP is CNY 3.19 per time, which is nearly five times higher than the research result of Lin and Tan in 2016 (The average WTP for NEVs in Beijing, Shanghai, Guangzhou, and Shenzhen is CNY 0.653). It can be assumed that there are three main reasons inducing this difference. Firstly, as a zero-emission vehicle, hydrogen fuel cell buses are more significant than new energy (electric and hybrid) buses in terms of positive environmental externalities. Secondly, Beijing is the first pilot city of hydrogen fuel cell buses in China during the 2022 Winter Olympics, and residents in this city have a more thorough insight into these buses and more direct experience related to these buses. Finally, with the convening of the 2020 UN Climate Change Conference, the signing of the Paris Agreement, and the establishment of carbon neutrality & peak carbon dioxide emissions in China, the Chinese public has paid more attention to the construction of low-carbon cities. This is also consistent with the influence of environmental knowledge and moral factors on WTP in this study.

4.7 Conclusions and policy recommendations

This study examines the willingness to pay and the factors influencing the willingness to pay of Beijing households to support the promotion of hydrogen-fueled buses. To better estimate the results, a peak model deals with zero responses based on the two-boundary dichotomous conditional value method. The spike value is very close to the proportion of actual zero responses in the sample. It indicates that the model fits well. The willingness to pay per household in Beijing is 3.19 CNY per ride. All households in Beijing are willing to provide 29.15 million CNY in financial support to the government for every ride on a hydrogen-fueled bus to promote hydrogen-fueled buses. Income-related to hydrogen buses, policy perceptions, hydrogen vehicle riding experience, personal ethics, environmental ethics, subjective norms, and perceptual behavior control positively influence willingness to pay. Among them, income level, environmental ethics, personal ethics, and perceptual behavior control are statistically significant at the 1 percent level and have a strong positive relationship with willingness to pay.

Based on the above findings, we propose four policy recommendations for promoting the promotion of hydrogen-fueled buses.

First, Increase the pricing of hydrogen bus tickets appropriately and use the extra revenue to promote the positive environmental externalities of hydrogen buses.

Second The Internet (via cell phones and computers) is the primary way for the public to receive information about hydrogen-fueled buses, so online promotion should be the primary way to increase respondents' environmental knowledge and ethical awareness.

Third Optimize the hydrogen bus ride experience by increasing the number of hydrogen buses and allowing hydrogen buses to use Beijing's dedicated bus lanes and ensuring a smooth commute to and from work during peak hours. This would help increase individual perceptual and behavioral control (ride comfort, time savings) and thus promote the popularity of hydrogen buses.

Fourth, the public's willingness to pay needs to be brought to the attention of policymakers. Furthermore, mention when bidding for hydrogen energy buses.

Because this part of the value may be ignored by the relevant investors, emphasizing the public's willingness to pay will help increase investors' interest in investing and thus promote the development of hydrogen vehicles.

Hydrogen energy bus consumer questionnaire

1. Your gender
A male
B female

2. Your age
A Under 25
B 25-55 years old
c 56-65 years old

3. Your education level
A University degree or above
B Other levels

4. Your family income level (refer to the average family income of Shandong Province is 9350 CNY)
A Above average
B Average and below

5 Whether you have a stable job
A Yes
B No

Whether there are elderly or children in your household members
A Yes
B No

7. The state of your health or that of your family members
A Good
B In general

8. Do you know anything about hydrogen energy or the means of transportation associated with it
A Understand
B Don't know

8-1. How do you get your information (single selection)

A Books
B Web surfing
C phone
D TV
E Community Advocacy

(empty)

9.Have you ever ridden a hydrogen bus [Multiple choice]

A Yes

B No

10.Are you aware of the policies regarding hydrogen energy or hydrogen vehicles?

A Yes

B No

11. Do you think hydrogen buses are good for mitigating carbon emissions in cities?

A Yes

B No

12.In order to build a low-carbon city (improve the environment, purify the air, etc.), will you actively choose hydrogen energy buses as a means of travel

A Yes

B No

13.Do you think hydrogen buses are very important to you and can contribute to the low-carbon construction of cities [Multiple choice]

A Yes

B No

14.Do your family or friends support your hydrogen buses as a means of transportation

A Yes

B No

15.Do you have enough resources to pay extra for hydrogen buses [Multiple choice]

A Yes

B No

16.Suppose that the government is vigorously promoting hydrogen energy buses as a means of transportation for green travel, but it is facing certain financial pressure. Consider the positive environmental externalities of hydrogen buses (zero emissions, improved air quality, etc.) and the financial pressures faced by governments. Whether you or your family is willing to pay extra for the promotion of hydrogen buses (assuming the bus fare is two dollars), taking into account your own circumstances? If you choose A, you only need to answer the first set of questions, if you

choose B, you only need to answer the second set of questions, if you choose C, you only need to answer the third set of questions [Multiple choice]

A Yes I am going to answer the first group

B Yes I am going to answer the second group

C Yes I am going to answer the third group

First group

17. Are you willing to pay an extra $1? If yes, answer question 18, if otherwise answer question 19 [Multiple choice]

A Yes

B No

18.Are you willing to pay an extra $2? End of answer [Multiple choice]

A Yes

B No

19.Are you willing to pay an extra $0.5? End of answer [Multiple choice]

A Yes

B No

Second group

20. Are you willing to pay an extra $2? If yes, answer question 21, if otherwise answer question 22 [Multiple choice]

A Yes

B No

21. Would you like to pay an extra $3? End of answer [Multiple choice]

A Yes

B No

22.Are you willing to pay an extra $1? End of answer [Multiple choice]

A Yes

B No

Third group

23. Are you willing to pay an extra $3? If yes, answer question 24, if otherwise answer question 25 [Multiple choice]

A Yes

B No

24. Are you willing to pay an extra $4? End of answer [Multiple choice]

A Yes

B No

25.Would you like to pay an extra $2? End of answer [Multiple choice]

A Yes

B No

26.What is your reason for not paying extra?   [Multiple choice question]

A Yes

B No

How much are you willing to pay?   [Fill in the blank]

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Chapter 5

The willingness of the Weihai public to pay for support low-carbon travel by shared Electric bikes

This paper evaluates the willingness-to-pay (WTP) of shared Electric bikes in Weihai City through payment card-CVM. A total of 398 samples were obtained through an online questionnaire. Among them, 271 people agreed to pay, and 118 refused to pay, accounting for about 30% of the total sample. The calculation results show that the willingness to pay the public in Weihai is about 0.76 yuan per time. Meanwhile, the factors influencing the willingness to pay were discussed. People with more education, income, and resources to use Shared Electric Bikes tend to be more willing to pay. At the same time, we asked questions about those who refused to pay, mainly due to low-income levels. Therefore, we believe that increasing the public's income level and knowledge about Shared Electric Bikes sharing can help promote the use of Shared Electric Bikes and the public protection of the environment.

5.1background

5.1.1Research Background

（1）As the world's largest energy consumer and carbon emitter, China plays an important role in achieving the global emission reduction target under the situation of continuous global climate warming. urban carbon dioxide emission reduction is particularly important. Climate warming caused by the increase of greenhouse gases, especially CO2, has become the focus of the world. In recent years, with the sustainable economic development, China has surpassed the United States and become the world's largest carbon emitter. Cities have become the biggest carriers of carbon emissions, and industrial activities, transportation, waste disposal, commercial and domestic energy consumption are the main sources of carbon emissions [1]. Cities account for 67% of global greenhouse gas emissions from energy consumption, and this share is expected to rise to 73% by 2030[2]. Therefore, to mitigate the impact of climate change on people's lives, it is particularly important to implement carbon emission reduction at the city level. In December 2015, the Paris Climate Summit was held. The Paris Agreement pointed out that only by peaking greenhouse gas emissions as early as possible and striving for net zero greenhouse gas emissions in the second half of this century can the world reduce the ecological risks and survival crisis brought by climate change. At the Paris Climate Summit, the Chinese government published its Intended Nationally Determined Contributions (INDC), which defines China's intended action targets by 2030 [3], namely, carbon dioxide emissions should peak around 2030 and strive to reach the peak as early as possible, carbon dioxide emissions per unit of total domestic production should be reduced by 60%-65% compared with 2005, and non-fossil energy should account for about 20% of primary energy consumption. According to the latest energy consumption data from the BP Statistical Yearbook of World Energy, after the Paris Climate Summit, China's energy consumption in 2016 increased by only 1.3%, coal production decreased by 7.9%, and oil production decreased by 7.2%, the largest decline in history.

（2）The rapid growth of the total quantity of vehicles in our country and the continuous increase in the energy consumption of urban transportation have aggravated the greenhouse effect, but also caused urban traffic congestion, air pollution, haze weather and other environmental problems, threatening the health of the residents, the development of urban low-carbon traffic urgent. Transport carbon emissions are an important part of urban carbon emissions, especially for

developed countries, where energy consumption carbon emissions from transport sector account for 1/4 to 1/3 of the national total carbon emissions (IEA, 2016; Wang et al., Introduction to Doctoral Dissertation 2018, East China Normal University 2 2017). Studies have shown that transport carbon emissions have passed a period of rapid growth, and the peak of transport carbon emissions is expected to occur within 10 years after the peak of total carbon emissions. Statistics from the International Energy Agency (IEA) show that the transportation industry is the world's second largest carbon emission industry after the power industry. It is expected that in 2040, France and the UK will cancel gasoline and diesel vehicles and replace them with electric vehicles. Electrification will be the trend of energy development in the future. But consumers around the world are not yet ready to say goodbye to the age of oil [4].

（3）The rise of shared transportation creates a new opportunity for the realization of urban low-carbon transportation. As a supplement to urban public transportation, shared bikes can help solve the "last kilometer" travel problem, and the construction of ecological civilization cannot do without public participation. Research on residents' shared transportation travel behavior is conducive to the development of urban low-carbon transportation. Sharing economy has already appeared in developed countries such as Europe and America [5], but it is always in a state of moderate enthusiasm. In recent years, with the continued development of a new generation of information technology, sharing economy combines government, enterprises and residents together with its efficient management mode, competitive industrial environment and attractive living environment. The most special one is the rapid development of shared transportation mode, which has become the smart node of building green ecological smart city.

Shared transportation is an innovative practice mode driven by the development of Internet technology. Under the background of "Internet +" thinking, it is an "innovative, green, open and shared" transportation form to solve the problems of resource waste, air pollution and traffic congestion. Based on the products and services of the Internet of everything, it fully integrates online and offline. The promotion of shared bikes has covered more than half of the provinces and cities in China. For large cities, the travel combination of shared bikes with buses and subways is increasingly favored by residents. The emergence of shared bikes has solved the "last kilometer" commuting problem for urban residents, enabling residents to enjoy more convenient travel and more cost-effective sharing services, but also alleviating traffic congestion and air pollution caused by vehicle exhaust during the rush hour.

China has committed to the Paris Agreement to achieve carbon neutrality by 2060.Shared Electric Bikes in line with the national green philosophy, and it has been encouraged in various countries as an emerging, efficient, low-carbon, and economical way to travel and enhance the competitiveness of traditional public transportation [6].　With national carbon neutrality and emission peak mandate, the development of urban public transportation is an effective way to mitigate the carbon emissions of urban transport. Policymakers have continued to support Shared Electric Bikes, which can help reduce traffic congestion [7]. Shared Electric Bikes as a micro-transportation service are increasingly seen as a sustainable mode of transportation in cities [8]. The construction of ecological civilization is inseparable from public participation, and the study of residents' shared transportation travel behavior is beneficial to the development of

low-carbon urban transportation, which plays an important role in alleviating urban congestion, reducing urban carbon emissions and providing a healthy lifestyle for residents.

5.1.2 Research Significance

Sharing traffic behavior is a kind of environmental behavior, also is a kind of carbon reduction behavior, is the construction of ecological civilization and environment friendly society manifested intuitively. Shared transportation, especially shared bikes, as the main popular mode of shared transportation in China, solves the difficulty of traveling in the "last kilometer" of the city, and is extremely beneficial to the urban transportation and ecological environment, so it is favored by residents.

As an emerging green travel mode, Shared Electric Bikes have been widely used in many cities in Shandong province, including Jinan, Tai'an，Linyi and a series of other cities. Tai'an City built in mount tai, is a famous tourist city, mount tai is one of the world natural and cultural heritage, the world geological park, tai shan forest farm, Cu company forest farm were first and second big state-owned forest farm in Shandong province, taian, mount tai is one of the important ecological barrier in north China Shandong and even, in the Yellow River basin ecological protection and high quality development plays an indispensable role. "Actively choosing a green and low-carbon way of travel is a small thing that we citizens can do to protect our beautiful homeland and ecological environment. The construction of the slow travel system in Tai 'an City has been carried out steadily, and the application of digital technologies such as Internet and big data has made the promotion and use of e-bikes more standardized and convenient. E-bikes of Meituan, Xiaowan and Qingjie operators are all the more popular in Tai 'an City. The share of e-bike trips continues to increase, and green travel is deeply popular among the people. With a permanent population of more than 5.6 million, Tai 'an receives millions of tourists every year, and more than 100,000 students in various colleges and universities, there is a large demand for travel tools. The emergence of shared battery cars has become the first choice for many citizens, tourists, and students in Tai 'an. Figure 5-1 shows a shared battery car in Tai 'an.

Figure5- 1.Sharing battery car in Tai An City

Shared Electric Bike is a very effective way to reduce greenhouse gas emissions (Bigazzi & Wong, 2020) [9], however, it has not been promoted in Weihai. With the recovery of tourism in the post-New Crown period and the influx of high school graduates from all over the country (there are many universities in Weihai), the demand for shared electric bikes is increasing. Moreover, Weihai is mountainous and has many slopes. Hence, the traditional shared electric bikes are not only not conducive to green travel for the public but even harm green travel. However, unfortunately, his promotion has not been taken seriously. Therefore, we studied the public's willingness to pay for shared electric bikes in Weihai. This is not only related to the development of low-carbon transportation, but also related to the development prospects of shared transportation and the construction of ecological smart cities. This is of important reference value for the future government to formulate and optimize the shared transportation travel planning and can also provide a feasible path for low-carbon transportation travel for urban residents and promote the construction of a shared transportation low-carbon development system with the joint participation of the government, enterprises and the public. We also discuss the factors that affect the public's willingness to pay based on the theory of planned behavior.

Based on the theory of planned behavior, this paper evaluates the willingness to pay for electric vehicle sharing in Weihai City. The influencing factors of willingness to pay are discussed. It is helpful to promote the formation of low-carbon travel behavior habits of urban residents and the formation of environmental awareness, promote the government to attach importance to social environmental education and the publicity of residents' healthy lifestyle, and alleviate the urgent environmental problems such as traffic congestion, greenhouse effect, haze pollution and energy consumption in large cities. Contribute to the construction of ecological civilization and the green, low-carbon and circular development of society.

The theory of planned behavior, as a common tool for analyzing and studying public behavior, has been widely used to study customer behavioral intentions in various industries such as health, leisure, and management [10].

The theory of planned behavior, has been applied to the study of green consumption behavior, waste sorting behavior at the environmental level [11], but less research has been done on shared transportation behavior.The conditional value approach is the most effective way to measure the

non-use value of public environmental goods [12]. The reasonable and orderly shared transportation to travel as a green and low-carbon travel mode, its travel behavior is also a kind of pro-environmental behavior. At the level of pro-environmental behavior, shared transportation travel behavior is a public environmental product that benefits the environment in terms of low-carbon emission reduction. However, unfortunately, its value has not been estimated. This is not conducive to the promotion of shared electric bikes.

Moreover, public environmental products are eligible for the evaluation scope of the conditional value method. Therefore, this study uses the conditional value approach to estimate the public's willingness to pay and focuses on the willingness to pay and the factors that influence the payment of shared electric bikes. It contributes to the construction of low-carbon cities.

The research flow is as follows: A review of the existing literature is presented in the second part. In the third part, the methodology is presented. In the fourth part, the main results are analyzed and discussed. In the fifth part, the conclusions are stated.

The main research content of this paper is divided into five chapters, which are as follows:
Chapter One, background. This chapter mainly introduces the research background and significance of this paper.

Chapter two, literature review. This chapter is divided into four sections. The concept of shared transportation and its research progress are discussed. This paper discusses the concept of pro-environment behavior and the research progress of pro-environment of shared transportation. The last section describes the relevant research progress of the factors influencing the sharing transportation travel behavior. In addition to providing relevant theories and literature basis for this study, the main concerns of this study are put forward.

The third chapter expounds the methodology. First, the goods to be valued are the willingness to pay for the battery car in Weihai and the willingness of the public to pay for the shared battery car. Secondly, it discusses the conditional value method and discusses the factors that affect the public's willingness to pay based on the theory of planned behavior. Finally, the questionnaire is designed.

The fourth chapter gives the results of questionnaire survey. We obtained the public's willingness to pay at 0.76CNY per visit.

Chapter five draws the conclusion of this paper. Shared battery cars are important for green travel. The CVM estimates non-use value by investigating WTP, but this study subject is easily overlooked. We estimate the willingness to pay for electric vehicle sharing. By assessing the willingness to pay, the environmental value of electric vehicle sharing is emphasized. Therefore, it provides reference significance for the government to formulate corresponding environmental protection policies. Based on the feedback from residents and the factors affecting payment, the following policy suggestions are put forward.

5.2 Literature Review

5.2.1 The shared transportation idea and its development

The shared use of cars, bicycles, or other low-speed forms of transportation that allow users to access short-term transportation services based on individual needs, rather than the rights of cars，is how shared transportation is defined. Although most of the mobile network-supported transportation services have only been available in the last ten years, sharing transportation is a significant sector of the sharing economy. Zurich, Switzerland, had its first car-sharing program in 1948, and Amsterdam, the Netherlands, launched its first bike-sharing scheme in 1965. Economic progress and shifting social attitudes toward automobile ownership and urban living are to blame for the expansion of shared transportation. The emergence of location-based systems and smartphone apps has expanded the potential for shared transportation services. the growth of ride-hailing services like Didi, car-sharing businesses like car2go and EVcard, car-rental businesses like Uber and Lyft, and bike-sharing businesses like moblike and ofo. Shared bikes, shared vehicles, rental autos, and carpooling are typical examples of shared transportation. Bicycle sharing is a B2C business model that originated in China.

The study of shared transportation in foreign countries was started earlier，Car sharing and carpooling studied the original intention of the public to choose car-sharing and the reasons for car-sharing (carpooling) [13]. Subsequently, more studies focused on the study of shared bicycles, the construction of shared bicycle network system and the social demand of shared bicycles. The impact of shared bicycles on individual health and the environmental impact of shared bicycles [14], but there are few studies on behavioral intention and attitude of shared transportation travel.

5.2.2 Concept of pro-environment behavior

Environmental problems (global warming, urban air pollution, water depletion, environmental noise, biodiversity These environmental problems are largely attributed to inadequate understanding of human behavior [15] [16] [17]. Environmental Behavior represents behavior that alters the availability of materials or energy from the environment, or that alters the structure and dynamics of an ecosystem or biosphere [18]. Pro-environmental behavior (PEBs) refers to behavior that is beneficial to the environment, or that contributes to environmental protection and awareness . Environmental protection refers to the reduction of negative environmental impacts and the increase of positive effects, as shown in Figure 5-2, and the phenomenon of reducing negative environmental impacts caused by the reduction of environmental load and the phenomenon of improving positive environmental impacts in favor of environmental protection are widely recognized as environmentally friendly behaviors. Gradually deepen people's awareness and understanding of environmental protection and technological innovation, to change their behavior, and the negative environmental impact will be reduced[19].
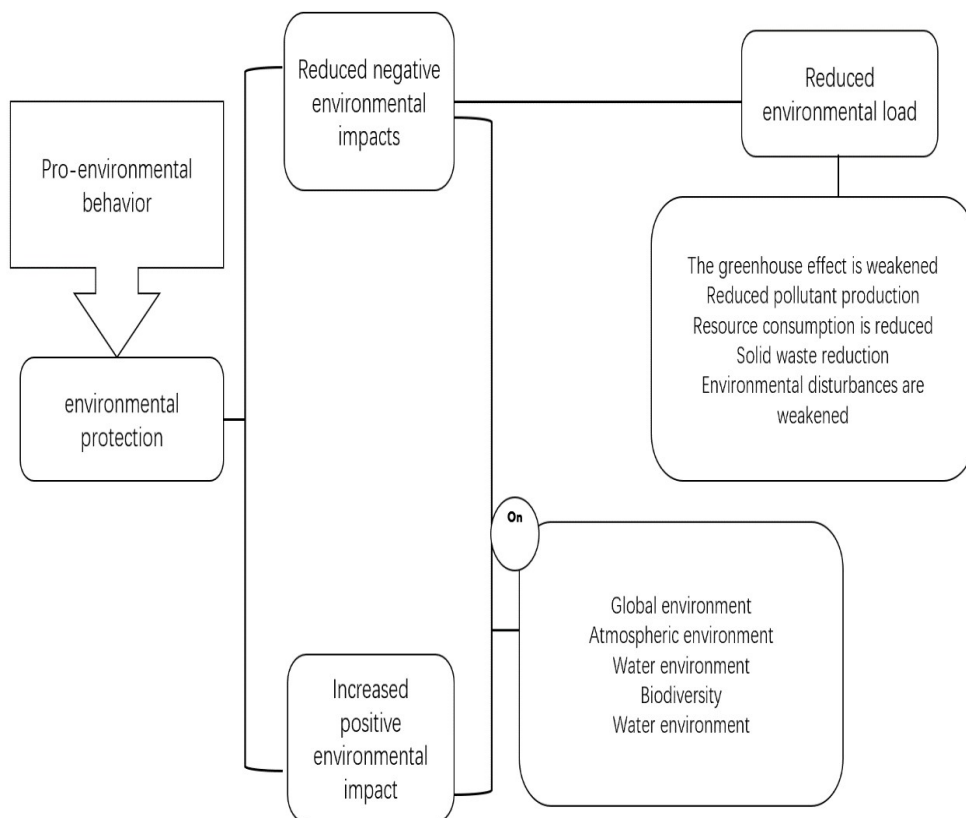
Figure5- 2.Concept map of pro-environmental behavior

Governments in other nations encourage citizens to act in an environmentally friendly way to lessen the stress on the environment.

To cut greenhouse gas emissions by 25% from 1990 levels by 2020, the Japanese government, for instance, has started a campaign called "25 Challenges." Japan participates in a range of environmental-friendly activities. In terms of ecological lifestyle, the list of pro-environmental behaviors included environmentally friendly bags, recyclable beverage bottles, public transport, the use of bicycles, setting the appropriate temperature for air conditioning, turning off lights, saving water, turning off taps at any time, environmentally friendly driving, and living kitchens. The choice of energy-saving products includes LEDs instead of incandescent bulbs, energy-saving electrical appliances, environmentally friendly cars and promoting the use of fuel cells and energy-efficient water heaters. Pro-environmental actions in renewable energy options include installing solar panels, installing solar water heaters, promoting wind power, and encouraging companies to use green electricity. Pro-environment behaviors in green buildings and green homes include environmentally friendly decoration, environmentally friendly building, promoting the use of efficient insulating materials, insulating glass, and installing solar panels. Among the actions supported by CO2 reduction projects are the choice of carbon offset products and the consumption of locally produced products.

Both the UK Department for Environment, Food and Rural Affairs (UKDefra) and the US Department of Environmental Protection (UKDefra) have lists of pro-environment behaviour.

Defra promotes and classifies environmentally friendly behaviour because of 12 objectives and behaviour areas such as consumption, food and drink, personal transport, household products and travel. Actions on home energy efficiency include installing insulation products, buying energy-efficient homes, better energy management and use, installing efficient heating systems, using renewable energy to generate electricity, and changing energy tariffs. Pro-environmental practices in waste and recycling include buying products with a long-life cycle, reusing, repairing, reselling, recycling, reducing unwanted packaging, reducing waste generation, and increasing household composting. In the household water saving, purchase water saving products, strengthen the effective use of water resources. In terms of personal transportation, we should use energy-saving and low-carbon cars, drive economically, use cars as little as possible, choose alternative means of transportation for short trips, and use shared cars, carpooling and rental cars to reduce short distance flights. In terms of buying eco-friendly products, buying energy-saving products, banning the use of goods that have a major impact on international biodiversity and environmental sustainability, buying wood products from a sustainable perspective, buying plants, and encouraging the development of small ecosystems in the garden.

The EPA's list shows recommended environmental behavior goals, such as reducing environmental load and keeping residents from being exposed to toxic substances. Environmentally friendly behaviors in energy saving include turning off electrical lights, cooking in microwave ovens, purchasing green electricity, timely maintenance of air conditioning and refrigeration systems, minimizing the use of air conditioning and heating, and using insulated pipes and water heaters. Reduce air pollution and greenhouse gas emissions. In terms of water conservation, keep the faucet running low when bathing and brushing your teeth, take more showers than baths, fill the dishwasher before washing dishes, fill the washing machine before washing clothes, choose the right water level and load load for washing clothes, buy efficient plumbing and appliances, regularly check household appliances and toilets, and preferably water your garden or lawn early in the morning. Set up sprinklers to only water lawns or gardens and not streets, use softener hoses to water trees, keep a healthy yard, clean yards without hoses, and use rainwater on landscaping to reduce stormwater runoff. Buy fewer items that can be reused, only essentials, buy goods without packaging, and buy fewer toxic chemicals.

Some pro-environmental behaviors in recycling include fixing things when they break, reducing the use of disposable cups, using towels or tablecloths instead of napkins, cleaning juice bottles and filling them with water, reducing the use of disposable utensils, reusing boxes, buying pens and pencils with replaceable pins, and donating old items to Hope Elementary instead of throwing them away. In terms of the pro-environment behavior of recycling, recycling paper, plastic, glass bottles, cardboard, aluminum cans, recycling electronics, composting food scraps, weeds, dead plants, purchasing products that can be recycled and products that can be reused will promote the development of a circular economy. Ensure safe drinking water, improve indoor air quality, use pesticides safely, and reduce living in harmful environments. Use safe cleaning products to stop environmental pollution Buy an environmentally friendly home.

5.2.3 Research progress on the pro-environment of shared transportation travel

After a literature search, the researchers concluded that bike-sharing systems are an eco-friendly mode of transportation. Young people educated people and middle-income people are more likely to choose shared transportation because they are more concerned about environmental issues. Bike-sharing is an expression of transport sustainability, an environmentally friendly form of public transport, a complementary form of traditional public transport, and a green and environmentally beneficial (health, emission reduction and congestion reduction) way to travel. De believes that shared bikes are an environmentally friendly way to travel, and more shared bikes will be encouraged in the future. Shared bikes are a more environmentally friendly, effective, and economically feasible way to travel. The city of Lyon reduced CO_2 emissions by 18.6 million pounds in 2009 from 2005 thanks to its bike-sharing program. Dill, Urban shared bikes play an important role in reducing car use, improving the environment, and saving resources [20]. Fagnant et al., Shared cars require less energy consumption and can reduce greenhouse gas emissions, and old polluting vehicles will be replaced by clean vehicles in time. With the potential to reduce carbon emissions [21].

Kaplan et al., (2015) showed that environmentally friendly and healthy life attitude and interest in environment-friendly holidays are conducive to the public's choice of shared bikes as a green travel mode [22]. Katzev believes that car-sharing improves the community environment. Although not all environmental goals have been achieved, in the long run, the public will increasingly rely on car-sharing for travel rather than owning them, reduce the number of cars, and are willing to try alternative tools of cars, which is the biggest environmental benefit of car-sharing [23]. Megalingam et al., showed that designing an automatic wireless ride-sharing system to reduce the overuse of road vehicles is eco-friendly and safe [24]. Midgley shows that urban shared bikes extend the travel scope of urban public transport to the greatest extent and effectively reduce urban carbon emissions by connecting with public transportation tools such as buses and subways [25]. Shaheen et al., believes that bike-sharing system is growing globally. Although its long-term sustainability is still uncertain (supportive infrastructure is needed), the public currently reduces greenhouse gas emissions and energy consumption by cycling every day. Its environmental and social benefits are immeasurable [26]. Shaheen et al., showed that compared with private cars, public bicycles provide a zero-emission option for residents to travel [27].

Vogel et al., believes that the development from traditional bike rental to modern bike sharing makes urban transportation more environmentally friendly and personalized, and the bike sharing system enhances the choice of public transportation in central urban areas [28]. Zhang et al., (2015) showed that the public can reduce their dependence on private cars and other unsustainable public transportation by using green and sustainable shared bikes. Bike-sharing is a typical example of green consumption, which can meet the public's urban transportation needs and protect the future environment [6]. Zhao et al., (2014) believes that shared bike is a typical representative of green transportation and a low-carbon way to solve the problem of the last kilometer of travel. According to Feng, low-carbon transportation and green travel are the basic requirements of eco-city construction, and shared transportation conforms to the concept of green transportation. Bike-sharing is a transitional sharing economy and green travel. The concept of ecological civilization and green development has gradually gained popularity among people. As a healthy and environmentally friendly way of travel, sharing bikes has become one of the choices for

people to travel environmentally. Urban bike-sharing travel has improved the urban environment and reduced the carbon emission of the city and city. Therefore, the governance of bike-sharing should be strengthened from the perspective of stakeholders' participation. Bike-sharing is in line with the green development concept advocated by the country. It is a green and healthy way to travel and can reduce carbon emissions. It improves the travel environment of urban transportation and pushes the development process of urban green transportation system.

Research shows that, although there are still some problems such as delayed management and influence on urban environmental order, shared transportation, especially reasonable and orderly shared bikes, reflects the requirements of low-carbon transportation and green travel. Shared bikes realize zero emissions in a real sense and solve the problem of green travel that has not been solved for many years. There is few research on the willingness to pay for shared traffic behavior in China, and most of them focus on the willingness to use shared bikes.

5.2.4 Research progress on influencing factors of shared transportation travel behavior

Zainuddin et al., based on the TPB model, showed that college students showed a strong interest in using shared bikes for short-distance commuting, and the results showed that perceived behavioral control influenced their intention to travel by shared bikes and the weather and terrain of the trip also constrained the intention to ride [29]. Travelers' environmental awareness, subjective norms, and perceived behavioral control are significantly and positively associated with bike-sharing travel intentions, and safety factors also affect travel intentions. Chen used TPB theory to investigate the effect of perceived green value on public bicycle system loyalty and showed that perceived enjoyment of use and subjective norms had a strong effect on public bicycle fidelity, with subjective norms having a stronger effect on non-shared bicycle users and environmental attitudes having a stronger moderating effect on non-users perceived green usefulness. Kaplan et al. used TPB theory to study the factors influencing the intention to travel on urban bike-sharing holidays and obtain different points of interest for frequent bike-sharing use; people living in countries that prefer cycling choose holiday bike-sharing trips, shared electric bikes have high attractiveness, high usage difficulty and low pro-environmental circulation norms for tourists, frequent bike-sharing trips and strong The pro-environmental attitude norm promotes travelers to make friends[30]. Spears studied the behavioral intentions of urban and suburban residents to share car trips based on TPB theory and showed that even though residents have positive attitudes toward sharing trips, existing habits, lack of adequate commuting alternatives, and non-driving demand remain barriers to car sharing use [31].

Chen and Lu used the two-step SEM model to study the green acceptability and green behavioral intention of using shared bikes to travel, and the results showed that the usefulness of green perception and user attitude had a positive impact on green behavioral intention, and user attitude had the greatest impact on green behavioral intention. But perceived usefulness had no significant effect on green behavior. Therefore, government agencies can work to improve the attitudes, green perceived usefulness, and perceived ease of use of both users and non-users of shared bikes to strengthen sustainable transportation modes of shared bikes. Chen studied the influence of

perceived environmental value, subjective environmental norms and environmental trust on the intention of using green transportation environment, investigated the different psychological motivations of users and non-users in using shared bikes to travel, and the results showed that the influence of subjective environmental norms was greater than the perceived environmental value of users. Environmental credibility is also a key factor in intent to use. Giang et al., Vietnam 328 studied the influencing factors of ridesharing intention in Vietnam based on TPB and TAM, and the results showed that perceived usefulness and ease of use had a positive impact on ridesharing attitude. Further research shows that attitude, subjective norm and perceived behavior control play a key role in the prediction of carpooling behavior. Kim et al. used the NAM and TPB theories to investigate the intention of sharing service in the service industry with the concept of sharing economy. The research shows that in addition to the direct influence of sharing economy consciousness on the intention of using shared service, its basic dimension has a significant impact on consumers' intention of using shared service.

Yu et al., constructed a model of TAM-TPB to explain the usage intention and explain the influencing factors of using the commercial bike-sharing system. The results show that the positive perceived usefulness affects the public's use of the shared autonomous vehicle system. Meanwhile, the behavioral attitude has a positive impact on the perceived usefulness and ease of use, while the subjective norms have no significant impact on the use intention. Yang studied more than 50 cities in China. Based on grounded theory and qualitative research, he found that travelers' psychological factors indirectly affect green travel behavior through behavioral intention, and that travel characteristics, travel preferences, behavioral outcomes and traveler attributes have moderating effects and influences on the transformation path of behavioral intention green travel behavior. Zhang based on the TRA theory, shows that subjective norms positively affect users' attitudes toward ofo shared bikes, thus influencing their travel intentions, while perceived use cost has a negative impact on shared bikes' travel intentions.

Therefore, we use TPB to study the factors influencing willingness to pay.

5.3 Research method

5.3.1 Goods to be appraise

We study the public's willingness to pay for shared electric bikes in Weihai City. We also explore the factors influencing the public's willingness to pay based on the theory of planned behavior. Understanding the factors that influence the willingness of residents to use shared electric bikes is important for implementing policies to develop sustainable transportation.

Weihai（Figure 6-3）, also known as Weihaiwei, is a prefecture-level city in Shandong Province. It is in East China and the eastern end of Shandong Peninsula, bordering the Yellow Sea in the north, east and south, echoing Liaodong Peninsula in the north, facing the Korean Peninsula across the sea in the east, and bordering Yantai in the west. By 2021, the city has jurisdiction over 2 districts and 2 county-level cities with a total area of 5799.84 square kilometers. According to the seventh census, Weihai has a permanent population of 2,906,500.

Figure5- 3.Map of Weihai

With the recovery of tourism in the post-COVID-19 era, Weihai has rebuilt some tourist attractions, such as Maotou Mountain and Huoju Eighth Street. And the arrival of the new semester, an influx of high school graduates across the country. There are many universities in Weihai, such as Harbin Institute of Technology, Weihai Branch of Shandong University, Shandong Pharmaceutical and Food Vocational College, Weihai Vocational College, Weihai Campus of Shandong Institute of Foreign Affairs Translation, Maritime Transport College of Shandong Jiao tong University, and so on. With the recovery of the epidemic, many young college students have an increasing demand for shared battery cars, and Weihai is mountainous and has many ramps. Traditional shared bikes are not only unfavorable to the public's green travel, but even have a certain negative impact on it. Therefore, it is very necessary to promote shared battery cars in Weihai.

5.3.2 The conditional value method

The conditional value method was originally proposed theoretically by S.V. Ciriacy-Wantrup (1947) to trigger the market valuation of non-market goods. The first practical application of the technique was in 1963 when Robert K. Davis used surveys to estimate the value of hunters and tourists in specific wilderness areas. He compared the results of his survey with estimates of value based on travel expenses and found a good correlation with his results. The conditional value approach uses the utility maximization principle in a hypothetical market situation. It uses a survey questionnaire to reveal consumer preferences for a public good or service for which market

prices are difficult to determine by simulating the market and finally deriving the quantity of value of the product or service.

Contingent Valuation Method (CVM) is a method that can be used for non-use valuation and belongs to the contingent preference. It does not rely on data in the real market but design a virtual market environment and ask the respondents Willingness to Pay if there is a certain degree of change in the supply quantity or quality of environmental goods in the virtual market. Willingness To Accept or change in the amount of willingness to value the economic value of environmental resources. The method was first used to assess the negative effects caused by the Valdez oil spill in 1989. Although there have been negative effects or non-use value assessment before, most of the methods are only in the hands of scholars and are not well known to the public. But in Valdez's lawsuit against the company that caused the oil spill, the theory of conditional value has been widely noticed and hotly debated. After that, the declarative preference research method represented by the conditional value theory began to be widely recognized and began to be widely used in the evaluation of non-use value.

A complete conditional value theory should not only select an appropriate survey method to investigate the willingness of respondents to pay, but also set up a complete background for the questions to be investigated, to improve the respondents' understanding of the things to be investigated. Although it is difficult to popularize and apply the will survey method, it has shown a powerful and seemingly universal potential to measure the economic value of unmarketable items, so it still has a wide application prospect.

5.3.2.1 CVM data collection

There are three main data collection methods for CVM: face-to-face interviews, telephone interviews, and webmail surveys. Email surveys have the limitation of low response rates but have the advantage of cost control and elimination of regional restrictions. Telephone interviews provide only limited information to respondents and can easily increase mutual distrust. Affects the quality of the interview. Face-to-face interviews can achieve higher response rates but can easily increase costs. This paper chooses web-based questionnaires as the data collection method based on addressing the above advantages and disadvantages.

Survey questionnaires were used to conduct the survey. Online research was previously impractical since elderly participants did not participate. However, since the number of Internet terminal devices in China has increased, WeChat users there have reached 1.1 billion, and smartphone users make up most of these users.

Internet users make up 97.5%. WeChat has grown to be a full-featured information platform that offers communication, information, entertainment, search, e-commerce, workplace collaboration, and enterprise customer care. With the benefit of high efficiency, questionnaire responses and data can be companies will ensure, and different sample attributes, such gender, age, area, occupation, industry, etc., may be specified. The surveys can also be configured with several filtering criteria, screening pages, quota controls, and other restrictions to identify the target population and to

automatically weed out invalid responses while providing manual inspection to guarantee the accuracy of the final data. Users who seriously respond to the survey will be rewarded in RMB.

5.3.2.2 CVM questionnaire format

An important component of the conditional valuation method is the questioning method used, that is, the way to ask the respondent questions in the willingness to pay question, including bid game, open open-ended, payment card, two-point choice.

Bidding game: refers to the willingness of respondents to pay by continuously increasing or decreasing the price level because of the initial bid value of the respondent. This method is greatly affected by the initial bid value, and the entire game process requires continuous communication with the respondent, which consumes a lot of time and manpower, so this method is rarely used in mainstream research.

Open-ended: It refers to letting respondents directly inform them of their willingness to pay or be compensated without giving them any relevant choices or references. On the surface, this method is simple and easy to operate, and there will be no starting point deviation, range deviation, etc.; But in fact, the estimation of willingness to pay using this method requires that the respondent is very familiar with the relevant environmental goods and can clarify his willingness to pay without other help. However, in fact, for the survey of non-market products, it is generally difficult for respondents to understand the relevant items very well, which may usually lead respondents to give up answering or fill in the answer at will, which will directly affect the reliability of the survey.

Payment card type: Payment card type is an improvement on the open foundation. Provide respondents with several bid values to refer to. Generally, respondents are given certain restrictive background materials or certain scenario settings, and the willingness to pay option is selected in a specific situation. This method is relatively simple, and also avoids the difficulty of open, but there may be a certain imaginary market deviation, in fact, people's subjective will change according to different times and places, and the choice of payment card method will inevitably produce starting point deviation, range deviation, etc., which is inconsistent with expectations.

Two-part selection: Binary selection methods can be divided into single-boundary dichotomous, two-boundary dichotomous, three-boundary dichotomous, multi-boundary dichotomous, and so on. By asking respondents whether they are willing to pay for a given bid value to support clean energy development or other ecological services, this given bid value is a random number within a certain range or a number given according to a certain law. If only asked once, this method is called single-boundary dichotomous selection. If the inquiry is carried out because of the first inquiry, a higher or lower tender value is continued, which is called a double border, etc. This simulates real market behavior, like bargaining behavior. This method has high requirements for statistical techniques, and generally requires more complex probabilistic models to perform data statistics.

Conditional valuation method is a typical declarative preference assessment method based on utility maximization theory. Different from explicit preference, respondents' answers are based on their own ideas rather than their previous purchase behaviors. The implicit assumption is that respondents can clearly understand their consumption preferences and express them truthfully during the questioning process. However, this is a subjective statement, and understanding of the same interviewee at different times may vary. In addition, there may be a variety of biases depending on the way the question is asked and the environment in which the interviewee lives. Therefore, this study analyzes some possible deviations and makes reasonable and effective responses Meter.

Imaginary bias: respondents' imaginary market is quite different from the actual market. Starting point deviation can be controlled by detailed explanation of clean energy, clearer description in scenario construction, and intuitive graphic and graphic materials: the initial bid value set in the two-boundary binary questionnaire and the minimum bid value set in the payment card are inconsistent with the real respondents' ideas, which may also be instructive to a certain extent. Conduct a preliminary survey or interview before the formal investigation begins and adjust according to the results.

Range deviation: The range of bid value is not consistent with the real situation. The solution to the starting point bias is the same as that of the strategy bias: respondents believe that the results obtained from the survey will be used as the basis for additional charges in the future, so as to deliberately exaggerate or reduce the willingness to pay when answering, thus affecting the results. Make detailed introduction before the survey to reduce misunderstanding and check the validity of the questionnaire in the questionnaire analysis stage.

Information bias: The information presented in the questionnaire has a certain influence on the respondent's willingness to pay. In the actual investigation process, we should pay attention to the transmission of information as accurately as possible, which is closest to the real situation of the non-market product. Some experts and scholars suggest that respondents should be allowed to give answers after repeated thinking, or even after deliberation by others. To increase the credibility and certainty of the content of the question, thus reducing the information bias.

Investigator bias: The information conveyed by investigators is different, inconsistent to different people or inconsistent with the real situation. Training of surveyors is required prior to formal investigation.

Protest response bias: Respondents express opposition not because utility is not improved, but for other reasons, such as opposition to imaginary market, payment tools, etc. After the core question of willingness to pay, we added a question asking the reason for the refusal to pay to measure the real consideration of the respondent, to reorganize the data.

CVM is based on a survey, the core of which is to obtain the respondents' willingness to pay through the survey. There are four main methods of guiding willingness to pay: open-ended, payment card, bidding game, and bifurcated selection. The payment card format is easy to

understand and accurate in valuation, so we use the payment card format as the questionnaire format for CVM.

5.3.3 Factors influencing willingness to pay

There are various factors that affect people's willingness to pay, and the demographic characteristics are considered as the most direct factors that affect people's willingness to pay. Therefore, we combine the demographic variables with the variables of planned behavior theory to explore the factors that affect the public's willingness to pay for the promotion of shared battery cars, which is helpful to formulate and revise relevant policies.

Demographic variables mainly include gender, age, education level and family income level.
The variables of planned behavior theory include behavioral attitudes, subjective norms, and perceived behavioral control.

Behavioral attitude is an extremely important variable in the theory of planned behavior, which directly affects the behavioral intention of individuals and indirectly affects their real behaviors [32]. As for the behavior attitude of sharing transportation, if the public likes sharing transportation and thinks that sharing transportation brings benefits to their own health (saving time, convenience, comfort, etc.), they will have a more active sharing transportation mode. However, if the public believes that shared transportation has a negative or negative impact on their lives, they will have a negative travel attitude. Studies have shown that behavioral attitudes can also indirectly affect behavioral intentions by influencing personal norms (moral norms) [33].

Subjective norm refers to the theory of planned behavior that individual subjective norm can affect individual behavioral intention [34]. Subjective norm refers to the pressure that an individual perceives when he or she takes a certain behavior from people who are important to him or herself. It is the social pressure that an individual perceives when he or she takes a certain behavior, and it is a kind of social influence. Studies have shown that employees' subjective norms affect their willingness to share knowledge. Some studies have also shown that subjective norms are closely related to behavioral attitudes and perceived behavioral control, and subjective norms can indirectly affect individual behavioral intentions by influencing behavioral attitudes and perceived behavioral control. When the public decides whether to choose sharing transportation, they will be influenced by their relatives and friends, so as to change their original attitude and behavioral intention towards sharing transportation.

Perceived behavioral control means that when attitudes and subjective norms meet the conditions for realizing behaviors, some non-motivational factors, such as perceived availability of conditions (money, time) and opportunities, play an important role [34].

In the questionnaire, we also asked the following questions about the cognition of shared electric vehicles: Do you think shared electric vehicles are beneficial to the mitigation of urban carbon emissions? Whether your family or friends support you to use the shared electric vehicle as a means of transportation. Do you have the resources to pay extra for a shared electric vehicle? How

much extra are you willing to pay each time you use it?

We combined the demographic variables with the variables of planned behavior theory to study the factors that affect the public's willingness to pay for the promotion of shared battery cars, which is helpful for the decision-making of government agencies.

5.3.4 Theory of Planned behavior and its development

Based on the theory of planned behavior and the application of payment card-CVM, this paper studies the willingness to pay (WTP) of electric vehicle sharing in Weihai City.

(1) Theory of Reasoned Action (TRA) Theory of Reasoned Action (TRA) proposed by Fishbein in 1963 TMA) (Fishbein, 1963; Fishbein and Ajzen, 1975) assumed that the individual would predict the outcome before acting, which was largely determined by the individual's own behavioral intention, which was mainly influenced by his own attitude and emotion. As shown in the diagram of rational behavior theory, the determining factors of behavioral intention mainly include behavioral attitude and subjective norms. Fishbein and Ajzen believe that behavioral intention is the possibility that people plan to take behaviors in the future, and Behavior Attitude (BA) reflects people's positive or negative emotions towards a certain behavior. People's belief in the result of a certain behavior and their estimation of the importance of the result fundamentally determine people's attitude toward this behavior. Subjective Norms (SN) are the extent to which people are influenced and relied on by their important people or social personalities, and their decisions affect individual behaviour and decisions. The combination of attitude and subjective norm forms people's behavioral intention, which causes the change of individual behavior. Different behaviors have their own characteristics. The theory of rational behavior provides a basic research framework for researchers, so that people can better understand their real behaviors（Figure 5-4）.
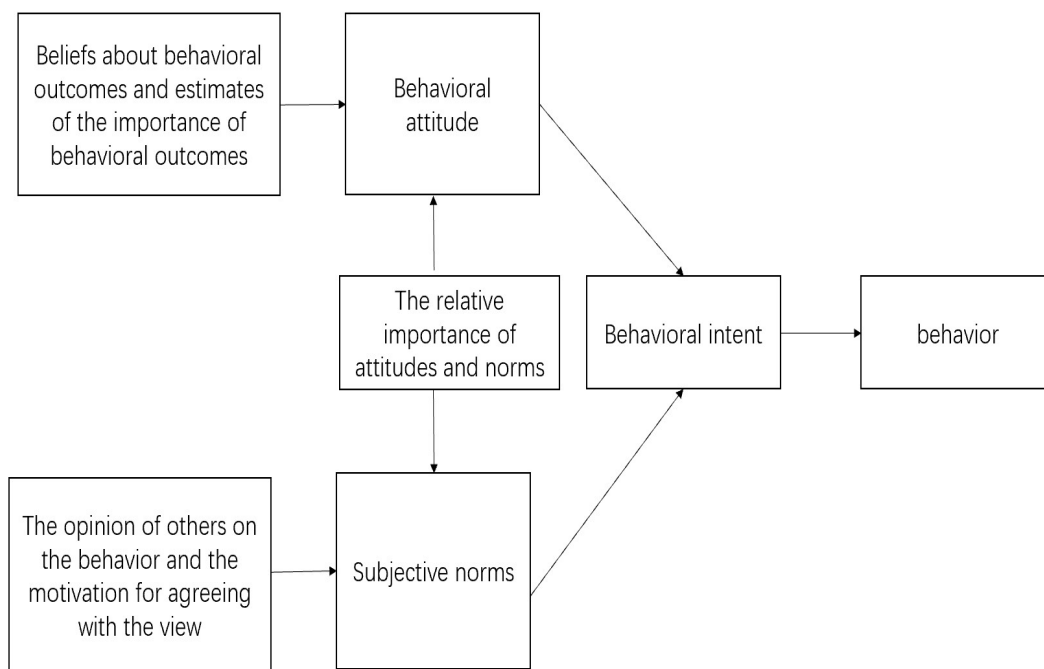
Figure5- 4.The framework of the theory of Reasoned action

(2) Theory of Planned Behavior (TPB)

Theory of Planned Behavior (TPB) comes from Fishbein's Theory of Rational Behavior (TRA). As the theory of rational Behavior encounters many unexplainable phenomena in subsequent studies, to enhance the explanatory power of the model, Ajzen incorporates Perceived Behavior Control (PBC) into the theory of rational behavior and forms the theory of Planned behavior [34]. Figure 6-5 shows the model structure of the theory of planned behavior Perceived behavioral control refers to an individual's perception of his or her behavioral control ability, which is jointly determined by control belief and perception-promoting factors. Control belief is people's perception of their abilities, resources and opportunities, and perception-promoting factors are people's estimation of the importance of abilities, resources and opportunities[35]. According to the theory of planned behavior, behavioral degree, supervisory norm and perceived behavioral control are the main factors to control and predict individual behavioral intention, and behavioral intention is the most direct factor affecting behavior. Behavioral attitude represents the public's support or opposition to the target behavior; Subjective norms represent the social pressure affecting the perception of behavior and reflect the influence of important organizations or important people on the deciding person [36] [37] [38]; Perceived behavioral control is the belief and perception of control, which represents the personal cognition to promote or hinder the behavior and the personal understanding of the realization of the behavior.
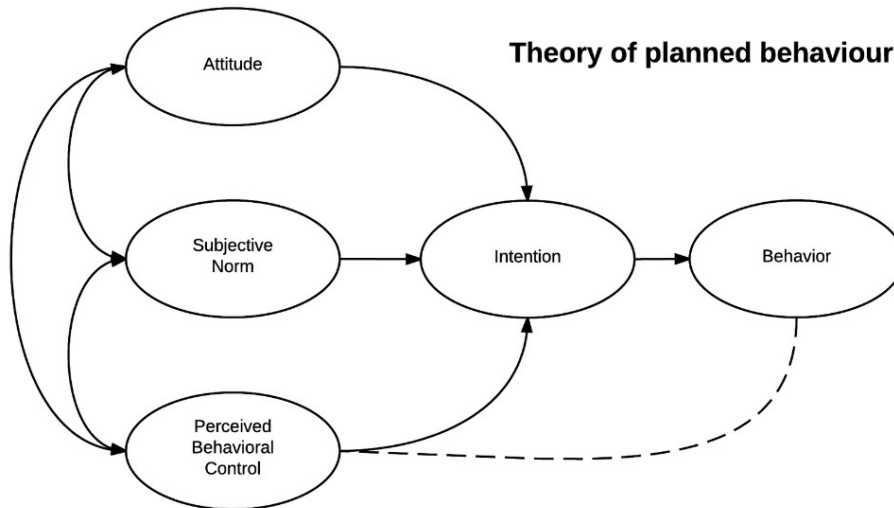
Figure5- 5.Theory of Planned Behavior (TPB) model structure diagram

5.3.5 Designing the questionnaire

In the WTP survey, bid point selection is crucial. We combined the preliminary research results, selected 0.5,1,1.5,2,2.5,3, eight bid points, and used the payment card type to estimate and get the public's willingness to pay.

The average willingness-to-pay E(WTP) of the payment card questionnaire can be calculated by the mathematical expectation formula of the discrete variable WTP:

$$E(\mathrm{WTP}) = \sum_{i=1}^{n} A_i P_i$$

Where Ai is the bid amount, Pi is the probability that the respondent will choose that amount, and n is the number of amounts available for selection.

5.4 Results

5.4.1 Data

We surveyed a total of 389 respondents. Among them, 126 people paid 0.5 yuan, 61 people paid 1 yuan, 22 people paid 1.5 yuan, 44 people paid 2 yuan, 2 people paid 2.5 yuan, and 16 people paid 3 yuan. The number of refusals to pay was 118. As the value of bids increases, there is an overall trend toward a decrease in the number of payers.

5.4.2 Data analysis and estimation results

We analyzed the factors influencing willingness to pay using Kendall's bivariate analysis. The results showed that education level and income level were positively correlated with willingness to pay among the demographic variables. Among the variables of the theory of planned behavior, perceptual behavior control was strongly correlated with willingness to pay. All the above variables were statistically significant at the five percent level.

Table5- 1.Factors influencing willingness to pay

	gender	age	Education	Income	AT	BI	PBC	WTP
gender	1							
age	-0.027	1						
Education	.291**	-0.110	1					
Income	0.202	0.102	0.186	1				
AT	-0.133	-0.124	0.006	.273**	1			
BI	-0.020	-0.110	0.112	.257*	.589**	1		
PBC	-0.002	-0.049	0.175	.301**	.214*	0.179	1	
WTP	0.023	-0.111	.274**	.301**	0.047	0.076	.478**	1

, *: Indicates statistical significance at the 5% and 1% levels, respectively.

We further analyzed the means and standard deviations of each variable. We compared them with the official data, in which there is a large difference between the income level and the official data, which may be caused by our small sample size and does not reflect the overall results. However, since in other variables, the standard deviations are not significantly different from the official data, we believe that our estimation results are valid. And suitable for the estimation of the All inhabitant.

Table5- 2.Comparison of questionnaire data with official data

Variable	Mean	Sdv	Census	Numbers
gender	0.42	0.496	0.51	389
age	1.72	0.522	0.5	389
Education	0.71	0.457	0.42	389
Income	0.37	0.486	0.37	389
AT	0.89	0.318		389
BI	0.90	0.303		389
PBC	0.60	0.494		389
WTP	0.66	0.475		389

After calculating the payment card formula in Chapter 3, we obtained the public's willingness to pay 0.76CNY per payment. Among them, 30.3% refused to pay, which is a relatively high

percentage, so we think it is necessary to know why they refuse to pay. We added a question on the reasons for refusal to pay, and the results showed that the main reason for refusing to pay is the low-income level. Therefore, we believe that increasing the income level of the population can make those who refuse to pay to participate in the use of Shared Electric Bikes.

5.5 Conclusion

This study argues that shared electric bikes are important for green mobility's estimates the non-use value by investigating WTP, but the subject of this study is easily ignored. I estimate the willingness to pay for shared electric bikes, and the environmental value of shared electric bikes is valued by assessing the willingness to pay.

I estimate the willingness to pay for the shared battery car, and then I estimate the environmental value of the shared electric bikes I propose the following policy recommendations based on the feedback from residents and the factors influencing payment.

1. Increase the population's income level as much as possible, which will help those who refuse to pay to participate in the use of shared electric bikes.

2. Increase the publicity of shared electric bikes. Make them acquire relevant environmental protection knowledge, which will also help them participate.

Increasing environmental protection investment, strengthening environmental education and propaganda, and cultivating public pro-environmental awareness will increase residents' intention to travel with shared electric bikes. Increasing investment in environmental protection can promote environmental education and social publicity, to improve residents' intention to use shared bikes. For example, integrating environmental education into the teaching system of primary and secondary schools and carrying out the second classroom of environmental protection for students will help to cultivate children's environmental awareness and correct environmental values from childhood. In colleges and universities, optional courses of environmental education can be opened to carry out osmotic teaching, to influence educates imperceptivity and guide students' pro-environmental behaviors. Environmental protection education activities can also be held regularly in communities, and environmental education manuals can be distributed to enrich residents' knowledge of environmental protection and improve ecological literacy, so that residents can take the initiative to care about environmental health around them, identify environmental problems, and carry out green consumption. Establish a museum or exhibition hall related to environmental education, which is open to the public free of charge on weekdays and weekends. Children can play in the environmental protection facilities in the museum, and adults can visit to improve their environmental quality. In this way, residents' intention to travel with shared battery cars can be improved. Figure 5-6 shows the Center for Eco-Conservation in Kyoto, Japan.

As environmental protection is not the driving force that affects residents' choice of shared transportation, residents will start from Transportation safety, health and convenience to choose

the means of travel. Increasing investment in environmental protection can also promote the improvement of infrastructure for green transportation such as shared bikes, improve the convenience and comfort of shared bikes, and make residents naturally choose green transportation.

3. Improvements can also be made to the infrastructure for green transportation travel, such as shared electric bikes to improve the convenience and comfort of shared electric bike travel so that residents will naturally be willing to choose this green travel alternative.

Information intervention should be strengthened to improve the comfort and durability of shared battery vehicles and improve the use efficiency of shared battery vehicles. Sharing electric vehicles enterprises can not only put together, but the number of electric vehicles is also not the core of the strength of the enterprise, too much electric vehicles will cause a waste of resources. If the use efficiency of shared battery cars is not improved, the result of blind use will be shared battery cars into shared garbage, abandoned battery cars piled up. Enterprises of shared electric vehicles can make regular return visits to users to understand users' intuitive feelings of using shared electric vehicles, improve the corresponding problems of users' negative evaluations, and enhance the corresponding advantages of positive evaluations, to eliminate users' negative emotions and increase the use efficiency of electric vehicles.

Enterprises of shared electric vehicles can also influence the public's travel mode through information intervention, such as informing users of the carbon emission reduction contributed after riding or linking a carbon emission calculator in the mobile APP of the bike, so that before users plan their travel routes, they can determine the carbon emission capacity brought by shared travel and the equivalent amount of fuel consumption reduction of alternative cars. Improve users' emotional attitude and confidence in using shared battery cars to travel and encourage users to use more shared battery cars to travel.

Battery sharing enterprises should also pay more attention to the technical content of battery sharing vehicles, produce or introduce more high-quality battery vehicles, increase the durability and comfort of battery sharing vehicles, and reduce the abandonment rate of bicycles. In addition, enterprises should further improve the technology of mobile APP for shared battery cars, improve the accuracy of GPS positioning of shared battery cars, so that users can check the number of idle shared battery cars nearby anytime and anywhere, and facilitate users to accurately locate the shared battery cars, which will greatly improve users' positive attitude and car experience. Users' positive attitude towards travel and car experience.

4. Increase the publicity of shared battery cars. Enabling them to acquire relevant environmental knowledge will also facilitate their participation. Make clear the key subjects of travel, guide the whole people to green travel with points and areas.

As the norm of main concept is the main factor influencing the public's choice of sharing electric vehicle travel. The public is easy to be influenced by important people around them or famous people in society and change their attitude towards travel. Battery sharing car enterprises should

increase the intensity of publicity of battery car travel. They can not only invite celebrities to advertise on TV and put-up slogans, but also invite celebrities to hold more green public free travel activities together to improve the participation of the public in shared travel. For female travelers, battery sharing enterprises can add decorations to attract them to travel, and regularly adopt incentive mechanisms, such as red charter cars. Female consumers can continue to influence her husband, parents, friends and children, driving and improving their travel probability.

For older travelers, APP training courses for the elderly can be set up offline to provide them with free online vehicle skills training. A batch of battery cars can also be set up that are easier to unlock, so as to facilitate the operation of the elderly. Small gifts can be provided to elderly users randomly on a regular basis to enhance their liking for shared bikes. More favorable travel strategies are adopted, such as monthly, seasonal, and annual cycling cards, to facilitate the popularity of shared battery cars among consumers with low income and culture. For students, we can take the class as a group and provide them with favorable monthly card service, or we can focus on promoting the monitor or teacher of the class, and then promote other students to guide green travel.

To build a low-carbon city, we should also improve our own environmental awareness, starting from ourselves.

Improve their environmental awareness, strengthen the sensitivity to environmental issues. Although the awareness of environmental protection is not the driving force to promote the public to travel with shared battery cars, it can indirectly affect the travel behavior of shared battery cars. When conducting a survey on the public's awareness of environmental protection, some respondents said they were not interested in environmental issues and thought they had nothing to do with themselves. Or the responsibility of the government; Or want to change but don't have the power to change, so let it go; Or that environmental problems are not so bad that they must be changed; Or because of the limitation of their own environmental protection knowledge and limit their attention to environmental issues. To solve these problems, in addition to the government's environmental publicity and education, the public needs to start from small things, read more environmental protection books or websites in their spare time, participate in more environmental public welfare activities, strengthen the observation of nature and the identification of environmental problems, and cultivate their own awareness of environmental protection and environmental responsibility.

Improve individual bad travel habits and reduce travel preference restrictions. Due to differences in personal attributes or family affiliation, the public has its own travel preferences, such as men are more inclined to carpool and taxi travel, the elderly is more inclined to bus travel, and government agencies and enterprise executives are more inclined to private car travel. Respondents with different attributes have different travel choices. Some respondents think that sharing battery cars is uncomfortable, inconvenient and unsafe. In the future, because of government planning the use space of shared battery cars, enterprises improving the comfort and durability of shared bikes and strengthening technological innovation, the public should also strengthen their environmental awareness, cultivate new habits of green travel, change bad travel

habits, and change the travel concept (from owning to sharing). Break the dead cycle from car travel to environmental pollution to continue to use car travel to bring environmental harm. The change of public preference and habits can effectively improve the quality of travel environment, reduce the health hazards caused by environmental pollution, and enhance the public's sense of happiness and satisfaction in life.

Cultivate a positive attitude towards green travel and maintain a sense of innovation and a happy life attitude. Positive travel attitude, desire for new things and active lifestyle are the positive influencing factors to promote shared bike travel. Car is not a symbol of status, nor is life more successful with more material wealth. Although young people tend to pursue social status, they prefer a green and sustainable lifestyle, less blindly pursue luxury goods and luxury cars, and have the activity of Gaullist. Although corporate executives with higher income level prefer luxury goods and convenient travel, they are still willing to share battery cars and try new things on weekends and holidays. Although respondents with high family private car ownership have less travel experience than those who use shared battery cars, they still hold a positive attitude towards shared battery cars and prefer a green and sustainable lifestyle. Therefore, the public should maintain their own happiness activity, and subtly guide the consumption concept of the groups with low happiness activity (such as high-income earners, the elderly, the retired people, housewives, people with more than one private car) through publicity and education, increase the publicity of green public service advertisements, and regulate the reports on the luxury consumption of celebrities. They should cultivate their awareness of innovation and creation and cultivate a green consumption concept and sustainable lifestyle in which the public pays attention to the protection of natural resources, lives in harmony with nature, cares about energy conservation, environmental protection and their own health.

Shared electric bikes consumer survey questionnaire

Low-carbon transportation and green travel are the basic requirements of eco-city construction, and shared transportation conforms to the concept of green transportation. Before this, we need to collect feedback information from the public. Could you please answer the following questions on behalf of your family? All your answers will be kept confidential and used for scientific research only.

1. Your gender [multiple choice] *
A Man
B woman

2. Your age [multiple choice] *
A Under 25 years old
 B 25-55 years old
C 56-65 years old

3. Your education level [multiple choice] *
A University degree or above
B other level

4. Your family income level (refer to the average family income of Weihai City is 9350 yuan) [Single choice] *
A Above Average
B Average or below

5. Do you think sharing electric vehicles is beneficial to mitigating urban carbon emissions? (single choice) *
A Yes
B No

6. Whether your family or friends support you to use the shared battery car as a means of travel [single choice] *
A Support
B does not support it

7. Do you have enough resources to pay the additional fee for a shared battery car [multiple choice]
A yes

B No

8. How much extra are you willing to pay per use? [multiple choice] *

A 0.5 yuan

B One dollar

C 1.5 yuan

D 2 yuan

E 2.5 yuan

F Three yuan

G is unwilling to pay extra

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Chapter 6

Willingness to Pay for Intelligent waste separation cabinet -Based on Conditional Value Approach and Theory of   Planned Behavior

Waste separation can arrange reasonable disposal methods for different types of waste, increase recycling efficiency, contribute to sustainable urban development, and reduce carbon emissions. The Intelligent waste separation cabinet（IWSC）is a new device that helps to separate waste, but the research on its willingness to pay（WTP）   still very limited. However, research on WTP is limited, which is not conducive to promoting Intelligent waste separation cabinet. This paper focuses on the WTP Shandong households to facilitate the rollout of Intelligent waste separation cabinet The results show that households' WTP is about 5.8CNY per month, and the demographic variables of gender, education level, and income level all significantly positively affect WTP. Environmental recognition, environment moral, attitudes, and perceptual behavior control all positively impact WTP, and the experience of using Intelligent waste separation cabinet recycling cabinets is also an important variable affecting WTP. We believe it is necessary to pay attention to the WTP in the formulation of relevant policies and to increase the number of places where only Intelligent waste separation cabinet can be experienced, which will promote the promotion of Intelligent waste separation cabinet.

6.1 Background

6.1.1 Research Background

The rapid development of urbanization and industrialization consumes a lot of resources and produces municipal solid waste. The rapid economic development and population growth have led to the increasing production of global urban solid waste, which not only poses a continuous threat to the living environment and health of residents, but also is not conducive to the sustainable development of cities. According to the World Bank's review, the global Municipal Solid Waste (MSW) generation levels are expected to increase to approximately 2.2 billion tons per year by 2025, so our traditional waste management systems will be far from able to manage such a large volume of waste disposal. China overtook the United States in 2004 to become the world's top garbage producer. At present, China's MSW is growing at an annual rate of 8%~9%. Two-thirds of China's cities face a "garbage siege". The management of municipal solid waste has become an important factor restricting China's economic and social development.

Generally speaking, the solid waste treatment system includes four parts: classified delivery, classified collection, classified transportation and classified treatment, and domestic waste classification is not only an important part of the municipal solid waste treatment system [1], but also the starting point of waste treatment, which directly affects the difficulty and effectiveness of subsequent treatment and reuse, Heidari also pointed out that waste can only be effectively recycled and reused after it is sorted at source, so it is of great practical significance to guide residents to participate in household waste classification[2].

Because of this, how to effectively deal with the problem of urban garbage has become a top priority, to solve the problem of household garbage is an important task for each country and city. Reverse logistics is an important means to improve sustainable living. The key to reverse logistics of garbage recycling is garbage classification. Effective classification from the source is conducive

to reducing the cost of reverse logistics and reducing the input of human and material resources. Therefore, mandatory garbage classification is an important means of national household garbage management, through garbage classification management work, can effectively solve the problem of "garbage besieged city". The key to the implementation of garbage classification is to enhance the willingness of residents to participate in the classification and recycling of urban household garbage and develop the habit of garbage classification Efficiency waste management is necessary for a clean and safe environment and keeps cities away from the harmful effects of the poor management of municipal solid waste generated in urban centers. Recycling is an important environmental activity to reduce waste and conserve resources [3] [4]. The transformation of waste infrastructure has been identified as one of the key whole-community systems in low-carbon transition cities (Rama swami et al., 2021) [5].

With the convening of the United Nations Climate Change Conference in 2020, carbon emission mitigation has attracted widespread attention from countries around the world. order to reduce the environmental pollution caused by garbage, many countries around the world began to improve the garbage problem of laws and regulations, IN order to reduce the environmental pollution caused by garbage, many countries in the world began to improve the laws and regulations on garbage problems and realized the effective garbage classification management. Among them, developed countries have carried out garbage classification management earlier, and obtained remarkable performance, and have rich management experience. Such as: Germany, Japan, the United States and other countries. Germany has been implementing garbage classification for a long time. Through various legal and educational means, coercion and advocacy, the garbage classification system has been constantly improved. Japan's garbage classification system is relatively mature and has a higher management effect. Waste classification standards are refined, and attention is paid to the development of education and publicity activities. In primary school, household waste classification or resource utilization are included in the teaching curriculum, and in kindergarten, environmental protection lectures begin. Garbage sorting has become an important embodiment of the quality of Japanese citizens.

As the world's largest carbon emitter, it is imperative for China to reduce carbon emissions. China, as the world's largest carbon emitter, has become urgent to reduce carbon emissions. In the Paris Agreement, China pledged to peak carbon dioxide emissions by 2030 and become carbon neutral by 2060, and smart recycling cabinets could help China meet its goals sooner. This highlights the potential to reduce carbon emissions through systematic optimization of waste management.

The Chinese government also attaches great importance to the issue of garbage management, and in 2000, 8 cities were selected to carry out the pilot work of garbage classification, which opened a chapter in garbage classification. In 2004, laws and regulations were revised to provide institutional guarantees for garbage classification. The publication of the Technical Guidelines for Household Waste Treatment in 2010 promotes resource recycling and specifies the types of live waste to be recycled. In 2017, provinces and cities began to implement garbage sorting on a large scale. Since 2018, all provinces and cities have actively carried out garbage classification management, established garbage classification demonstration areas, and strived to drive the people of the province and city to carry out garbage classification. A model example of waste

sorting in many provinces and cities is Shanghai, which in July 2019 passed regulations mandating waste sorting by residents. Since the implementation of garbage classification in Shanghai, all environmental sites in the city have actively set up propaganda slogans and facilities and equipment for garbage classification, and all residents have joined the garbage sorting work, and the environment has been significantly improved. In June 2020, the total amount of domestic waste removed and transported in Shanghai reached 96.8 tons, and the compliance rate of residential area classification increased from 15% before the implementation of the regulations to about 90%. There are more than 21,000 classified drop-off points in planning and transformation, and garbage classification has achieved obvious results. Due to the complexity and diversity of domestic garbage, residents can not accurately distinguish garbage classification standards in the early stage, with continuous practice, residents' awareness of garbage classification has gradually increased, actively changed behavioral habits, and consciously classified garbage. Despite the good results of garbage sorting in Shanghai, there are still some problems. At present, Shanghai's garbage classification is still a bit rough in terms of fineness, although there are regulations promulgated to supervise violations, but no one has been responsible, and only the lack of rewards for punishment, only by setting reasonable incentive policies to arouse people's interest, can people's consciousness be stimulated. Therefore, it is necessary to further improve the supervision and management system, use intelligent and information development, intelligent supervision, apply information technology to garbage classification, and improve the efficiency of garbage classification and recycling.

In addition to Shanghai, other provinces and cities are also actively carrying out garbage classification work, but most cities still adopt the method of mixed collection, do not clearly require classification, lack a sound legal system, and the garbage sorting facilities are not perfect, and the results in garbage sorting and recycling work are low. In general, the overall garbage classification target in China is still far from the expected and improving the ecological environment and solving the problem of garbage management require the attention and efforts of national government departments, provinces and municipalities, relevant management staff and even every resident. It is necessary to strengthen residents' awareness of garbage classification and recycling, improve garbage sorting facilities and equipment, and improve the garbage management system, and it is necessary to strengthen supervision measures and use policies, technology, and education to jointly promote garbage classification. pl Translate the full text.

Garbage sorting leads the new fashion of low-carbon life. Garbage sorting and recycling has become a hot topic across the country.   Efforts will be made to improve the coverage of the garbage classification system. In April 2019, the Ministry of Housing and Urban-Rural Development called for the classification of domestic waste in cities at the prefecture level and above, and said that by 2025, cities at the prefecture level and above should have a domestic waste classification and treatment system. In Beijing, Shanghai, Hangzhou and other large and medium-sized cities and some rural areas, garbage sorting and recycling has become an essential activity in residents' daily life.

At present, there are still many littering phenomena in China, which not only pose a continuous threat to the living environment and health of residents, but also are not conducive to achieving

carbon neutrality. China has launched a "Zero Waste City" initiative to minimize solid waste generation in urban areas and maximize recycling. Shandong Province, as the second largest province in Chinese, has long had the phenomenon of garbage littering (figure 6-1). In order to solve the above problems, the regulations on the management of domestic waste in Shandong Province were officially implemented in March 2022, and it was specified that by the end of 2025, smart garbage recycling cabinets will be basically established in districted cities（figure 6-2）.

Figure6- 1.The phenomenon of littering

Figure6- 2.Intelligent waste separation cabinet

When you are at home, you should first classify the garbage, and pack different garbage in different garbage bags. Also popularized the classification of garbage into categories: recyclable garbage: plastic bottles, cartons, magazines, advertising leaflets and other clean paper, etc. can be recycled; Food waste includes fruit peels, vegetable leaves, leftovers, after-meal waste, etc. Waste batteries such as discarded lamps, paint, etc. are hazardous waste. Remember, garbage needs to be sorted accurately.

The intelligent garbage sorting equipment integrates the wireless data transmission module, sensor module, weigh module, combined with the platform function, to realize the intelligent management of the garbage sorting and recycling bin. Residents by scanning the QR code information, voice prompt function, choose to open different classification bins, the garbage can automatically detect the end of garbage delivery, automatically close the box door, and in the process of closing the door, real-time detection of anti-pinch to avoid accidents, after the door is closed, the garbage will be weighed as the user's points.

The platform can query the garbage delivery in real time, including personnel information and garbage weighing, when the garbage bin overflow alarm, the platform will prompt the alarm signal, notify the personnel to deal with the garbage in time, and form an integrated intelligent management system for the garbage can.

In terms of intelligent waste separation cabinets, About how he uses it，I will introduce it（figure 6-2）.First of all, the user needs to scan the code, then select the location that needs to be placed, and the garbage cabinet will automatically open. After the garbage cabinet is completed, the garbage cabinet will automatically close, and users can earn some points, and when the points reach a certain level, they can get free goods with points in the vending machine on the left。Gifts

include small soap, toothpaste, toothbrush, laundry detergent, mask, dish soap, dishwashing sponge, etc., and the corresponding points are exchanged for the corresponding gift.It is a system to promote people to throw garbage, and promote people to carry out Waste sorting.

6.1.2 Research Significance

The effective classification and recycling of household garbage can greatly reduce the environmental pollution caused by garbage and solve the dilemma of reverse logistics of garbage recycling from the source. Therefore, improving the willingness of residents to classify household garbage can greatly reduce the harm caused by garbage to people. In order to improve the recycling efficiency of household garbage, it is necessary to study the important factors affecting household garbage classification from the Angle of individual behavior and intention. At present, many scholars have studied the garbage sorting behavior of residents. The theory of Planned behavior (TPB) is one of the most used theories to study the garbage sorting behavior of residents. Many scholars have conducted extended research because of the theory of planned behavior. Numerous studies have explained the internal and external influences of residents' garbage sorting behavior, indicating that residents' behavioral motivation greatly affects their behavioral intention. However, most of the current theoretical studies on garbage classification intention and behavior are based on the theory of planned behavior. With our country attaching importance to garbage classification recycling, many measures have been taken to improve the behavior of garbage classification recycling of residents, which is affected by many factors.

The rapid growth of urban population and the increase of the total amount of household waste have brought great challenges to the society and threatened people's living environment and health. In recent years, although our country has been aware of the importance of garbage classification and recycling, and put forward corresponding countermeasures to alleviate environmental problems, and at the level of residents' behavior, a series of measures were taken to promote garbage classification, but the overall residents' garbage classification and recycling behavior and waste management problems have not been significantly improved. Residents' garbage sorting and recycling behavior is influenced by many factors, including the improvement of laws and regulations on garbage sorting in terms of macro policies, the government's incentive and punishment policies, the government's publicity and education on garbage sorting, as well as the establishment of garbage sorting and recycling system and the convenience of sorting and recycling facilities. The improvement of garbage sorting and recycling facilities provided by communities not only directly affects the garbage sorting behavior of residents, but also relates to the realization of community environment.

With the popularization of information technologies such as big data, Internet of Things and artificial intelligence, intelligent garbage recycling cabinets begin to appear in communities, which solve the problem of garbage classification by relying on technical support and play a certain role in promoting and supervising the garbage classification behavior of residents. However, if the intelligent garbage recycling cabinet is to be widely used in many communities, it is necessary to study the use behavior of the intelligent garbage recycling cabinet, and further explore the use and acceptance degree of the intelligent garbage recycling cabinet on the user level

with the support of information technology, as well as the effectiveness of auxiliary garbage classification and recycling management. The conclusion of the study is useful for garbage management workers to take effective measures to promote garbage classification of residents.

As an important policy of waste management, garbage sorting and recycling plays an important role in emission reduction and environmental protection, but it has received limited.

attention. This is not conducive to decision-makers developing corresponding promotion policies. If residents can effectively sort and recycle household waste, such as paper and metal, the reasons for energy conservation and emission reduction will be strengthened. Beijing was the first city in China to adopt garbage sorting, and due to insufficient participation of residents at the micro level, recycling support measures are not perfect, and the sorting accuracy rate is not high. Since the government's budget to support waste sorting is limited and requires the active participation of residents [6]. it is important to further discuss their willingness to pay. Assessing the public's willingness to pay is an important means of measuring public acceptance and has very important social significance [7]. Assessing willingness to pay not only helps to understand public acceptance, formulate policies based on public acceptance preferences, but also helps to assess the environmental value of public environmental products and provide financial support for the promotion of government projects. He et al. investigated the willingness of Beijing residents to pay for smart waste recycling cabinets (IGSS) and the conditions that affect WTP. Using the framework of Planned Behavior Theory (TPB), the concept of environmental protection is introduced to estimate the average annual price of 319.2 yuan (US$49.43) per household to reduce municipal solid waste in Beijing [8]. Berenger proposes that when selecting the most appropriate solid waste management system for a given region, decision-makers must consider the technical aspects and implementation costs, as well as residents' attitudes, public environmental awareness, behavior, and willingness to pay (WTP) [9]. ProMed conducted a random survey of four first-tier cities in China to identify variables that affect residents' willingness to pay for waste sorting. LaRiviere proposes that some residents are willing to sort household waste even though they can dispose of it directly, simply because they have a pro-environmental attitude [10]. Han et al. show that in rural China, respondents are willing to pay for waste management services, use collection facilities to install in local villages, sort recyclable waste, deliver household waste collection facilities, and clean up. Through the above literature research, it can be shown that most people's attitude towards garbage classification is almost positive, with environmental awareness and environmental protection attitude, but there is still a lack of relevant research on the willingness to pay for intelligent garbage recycling cabinets in Shandong Province [11].

6.1.3 Research content and framework

As the second largest province in Chinese, Shandong Province has reference significance in the promotion of intelligent garbage collection cabinets. Therefore, this paper takes the willingness of households in Shandong Province to pay for smart garbage collection cabinets as the research object and discusses the public's willingness to pay for smart garbage collection cabinets and its influencing factors. And evaluate the environmental value of smart garbage collection cabinets.

the specific research process is as follows:

Firstly, the first section of the first chapter introduces the background of this study, expounds the serious problems caused by household garbage to the environment, and the implementation of garbage classification is the key to carry out garbage management. The second section explains the theoretical research significance of this study on garbage classification and recycling. The third section is a summary of the whole research content and framework.

The second chapter reviews the existing literature. This chapter mainly reviews the introduction, application, and theory of intelligent waste recovery cabinet by reading many domestic and foreign literatures and related news reports.

Chapter three introduces the methodology.

In Chapter four, the main results are analyzed and discussed.

The fifth chapter elaborates the conclusion.

Chapter six illustrates the policy impact.

6.2 Literature review

6.2.1 Concepts related to living waste

Domestic garbage refers to waste that has been thrown away in daily life that still has the original value of the items, or waste that has lost its original value, as well as waste products considered by laws and regulations. The scope of domestic garbage includes not only household garbage generated by ordinary residents in the process of daily life at home, but also garbage generated by enterprises and institutions in the process of operation.

Garbage classification refers to the process by which residents sort and put garbage according to the classification standards stipulated by the state. The per capita daily garbage production is significant, and many types of garbage are produced. Suppose the garbage is incinerated nearby and landfilled. In that case, it not Only pollutes the ecological environment, such as groundwater sources, soil, and air, but will also affect human health and even be life threatening. Therefore, cities at home and abroad will recycle or uniformly treat all kinds of classified and collected garbage according to the output and composition of garbage, combined with the requirements of different types of garbage treatment methods. That is, when residents implement garbage classification, the trash is sorted first and then put in, which is conducive to the subsequent transportation and terminal treatment of garbage and can improve the efficiency of garbage disposal. Public garbage classification is the basis of the entire garbage recycling and treatment process, and it is also the most critical link, which can effectively improve the utilization rate of garbage, help the subsequent classification transportation and classification treatment, reduce the cost of classification, and reduce.

The difficulty of garbage disposal, recycling of recyclables, organic treatment of kitchen waste, and recycling Saves natural and human resources to minimize resource consumption, reuse trash, and avoid adverse effects on human health and the ecological environment.

Presently, China divides domestic waste into four categories: kitchen waste, which mainly refers to leftover rice, fruits and vegetables, and flowers. Perishable garbage in household life, such as green plants; Receivable items, primarily refer to wastepaper, glass, waste express boxes and other trash that can be recycled in ordinary life; Hazardous waste mainly refers to expired drugs, alkaline batteries and other garbage that will endanger human health in daily life; Other junk refers to living debris other than the above three types of waste, such as broken ceramic tiles.

6.2.2 Theory of planning behavior related to smart garbage collection cabinets

Planned behavior theory is a new mode of behavior theory research proposed by Ajzen [12], which is a further supplement and development of rational behavior theory, the main idea of planned behavior theory is that the production of actual behavior depends on the intention of behavior. The factors affecting behavioral intention mainly lie in three points. First, attitude, which refers to the positive and negative evaluation of the individual's choice of a certain behavior to form a self; The second is subjective norms, which refer to the social pressure that individuals will face to choose a certain behavioral premonition; The third is perceptual behavior control, which refers to the difficulty of individuals choosing a certain behavior to predict its execution. At present, the theory of planned behavior is the most recognized theory of attitude and behavior relations, and it is widely used in psychology, management and many interdisciplinary disciplines. The theory can better understand and predict the behavior intention, self-efficacy, and sense of control of individuals, and at the same time, it also increases the explanatory power of people's specific attitudes to their behavior [13]. Its theoretical model is shown in the figure below（Figure 6-3）. Therefore, this paper adopts the framework of planning behavior theory to study the payment willingness of smart garbage recycling cabinets of residents in Shandong Province.
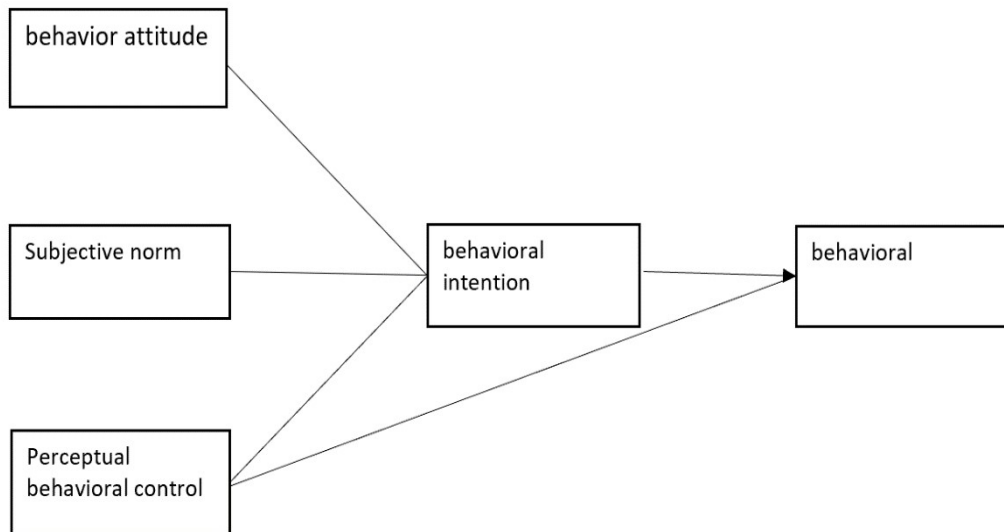
Figure6- 3.Theoretical model of planned behavior

Planning behavior theory (TPB) is one of the most influential and commonly used psychological theories used to explain waste sorting behavior, and many scholars have used TPB to study waste sorting and recycling behavior.

TPB argues that most human actions are goal-oriented, and therefore the individual exhibits an environmentally friendly attitude because he has "intentions" that are influenced by people's "attitudes," "subjective norms," and "perceptual behavioral control" [12]. Meng et al. combined TPB theory and A-B-C theory to establish a hypothetical model and proposed that individual subjective factors and external contextual factors affecting the classification and recycling behavior of household waste can be considered at the same time [14]. Liu et al. based on the theory of planned behavior, persuasion theory and five personality theory, established an impact model of public education on residents' willingness to sort waste, and analyzed the role of attitude, subjective norms, perceptual behavior control, and conscientious personality [15]. Fan et al. uses planned behavior theory (TPB) to construct a "motivation-intention-behavior" theoretical model to systematically illustrate the antecedents of domestic waste sorting behavior. Studies have shown that general and specific environmental motivations largely influence behavioral intent [16]. Botetzagias et al. explores how individual ethics and demographic characteristics interact with standard "planned behavior theory" predictors, thereby explaining recycling intention [17]. Most studies using TPB in waste sorting and recycling behavior have attempted to incorporate other predictors. Ethics and situational factors are the most used and are generally considered to enhance the predictive power of TPB models. Through the above analysis, we can find that the theory of planning behavior has been widely used in garbage sorting and recycling. Therefore, in our study, the extended theory of planning behavior theory is also discussed as a variable that affects the willingness to pay.

Guagnano et al. (1995) put forward the attitude-behavior-condition theory, believing that

individual behaviors are jointly affected by residents' attitudes and external conditions [18]. Meng established A hypothetical model combining TPB theory and A-B-C theory and proposed that individual subjective factors and external situational factors affecting residents' behavior of household garbage classification and recycling could be considered at the same time [19]. Liu established a model of the impact of public education on residents' garbage sorting intention based on the theory of planned behavior, persuasion theory and the theory of five personalities, and analyzed the effects of attitude, subjective norms, perceived action control and conscientious personality [20]. Boonrod et al. (2015) explored the effects of various incentive mechanisms on residents' behavior of garbage classification at source through experiments [21]. Fan used the theory of planned behavior (TPB) to build a theoretical model of "motivation-intent-behavior" to systematically explain the antecedents of household garbage classification behavior. The research showed that general and specific environmental motivations greatly affected the behavioral intention [22]. In addition, Chen discussed the internal motivation mechanism and behavioral decision-making mechanism of residents' garbage recycling behavior from the perspective of psychological empowerment, which can be used to understand the internal driving mechanism behind garbage recycling behavior [23]. Botetzagias and Dima et al. explore how individual ethics and demographic characteristics interact with standard "planned behavior theory" predictors to explain recycling intentions [24].

6.2.3 Factors influencing the willingness to pay related to garbage sorting and recycling

Conditional valuation method (CVM) is a simple and flexible non-market valuation method to evaluate and manage Beijing residents' willingness to pay for municipal solid waste (WTP). CVMS can obtain environmental products by asking questions. WTPS ask questions directly to respondents through questionnaires. It is also the only method that can be used to include what is commonly referred to as the economic value of the presence or passive use of ingredients in environmentally friendly products. CVM has been widely used by researchers to determine the value of various environmental facilities and environmental damage conditions for natural protection and restoration, as well as historical culture, health hazard reduction and health index improvement, as well as public policy development and other research fields.

Most studies using planned behavior theory in garbage sorting and recycling behavior try to incorporate other predictors. Moral norms and situational factors are the most used and are generally considered to enhance the predictive power of theoretical models of planned behavior. Davis suggested that situational variables should also be added to the model to study the impact on garbage classification behavior by evaluating the convenience of garbage classification facilities and garbage classification time [25]. Ramayah(2012) adds environmental knowledge to his model [26]. Bernstad recently supported this argument by stressing the importance of convenience and the existence of the necessary infrastructure to participate in garbage recycling [27].

Kuang and Lin (2021) found that those who are more knowledgeable about municipal waste sorting are more likely to participate in waste sorting [28]. Other researchers believe that knowledge is another key factor in driving recycling, and that respondents with sufficient knowledge (who are more knowledgeable about the recyclability and toxicity of waste) can

improve their recycling behavior [29]. Other researchers found that personal morality was the most important factor to promote residents' participation in garbage sorting and recycling. Moreover, many previous studies have shown that convenience does promote recycling behavior [30]. Sidique et al. (2010) argues that demographic variables are critical to the influence of behavior [31]. Song et al. (2012) found that education levels and household income may influence people's willingness to pay for e-waste recycling [32]. Tan argues that higher levels of environmental protection knowledge have a significant impact on changing environmental behavior [33]. Pakpour et al. (2014) found that attitudes, subjective norms, perceived behavioral control, and moral obligations significantly predicted household waste collection behavior in Iran [34].

Although the smart garbage collection cabinet is a new type of garbage sorting and recycling equipment, the research on it is still very limited, but the above research results related to garbage classification are crucial for studying the public's willingness to pay for the smart garbage collection cabinet. Therefore, based on the above related research results, we incorporate demographic variables, Moral implications, environmental recognition, use experience, and planning behavior theory variables into the discussion of payment willingness in smart recycling cabinets.

6.2.4 Research on CVM

CVM is also known as the willingness value evaluation method, the contingent evaluation method, etc. The method is to directly investigate and ask people about the maximum WTP for environmental improvement under a hypothetical market situation [35].

Through the average WTP of individual WTP research area, the value of environmental resources can be obtained, which can guide the pricing of environmental protection related costs and use it to measure public preferences to further formulate corresponding public strategies, so it is of great significance for the research of environmental policies and strategies. So far, CVM has been widely used in the fields of resources, environment, urban planning, and other fields [36].

According to the design pattern of the core valuation questions, the CVM questionnaire can be divided into continuous type, the former includes bid game, open, payment card, and discrete, the latter includes single-boundary dichotomous and dual-boundary dichotomous. The bid-and-game questionnaire continuously increases or decreases the payment amount until the maximum WTP of the respondent is identified, and the open-ended questionnaire directly asks the respondent about the maximum amount of money they are willing to pay, which is difficult for the respondent to answer because this method does not give the respondent an initial hint price. The payment card-based questionnaire gives a series of amounts from which respondents choose a maximum WTP. However, the above three ways have certain limitations. Due to the need to ask respondents multiple times, the bidding game tends to cause a low response rate to the questionnaire. The limitation of open-ended is the [37]. The payment card-based method is prone to "rounded consumption" and affects the estimation results. Compared with the above methods, the dichotomous questionnaire only needs to answer "yes" or "no" to a certain bid value without

giving the specific value of its WTP, so it is incentive-compatible and in line with people's daily consumption decision-making habits [37]. Since the two-boundary dichotomous has advantages over the single-boundary dichotomous in terms of valuation accuracy, the bipartite guidance technique was used to obtain WTP.

6.3. Data collection and methodology

6.3.1 Data Collection

6.3.1.1 Location of Data Collection

We conducted a questionnaire survey in Shandong Province, China. Shandong Province, as the second largest province in Chinese, has been seriously buried in garbage in recent years. Shandong Province's vigorous development of intelligent garbage recycling cabinets is an inevitable choice. Therefore, we chose Shandong Province as the survey site （Figure 6-4）.
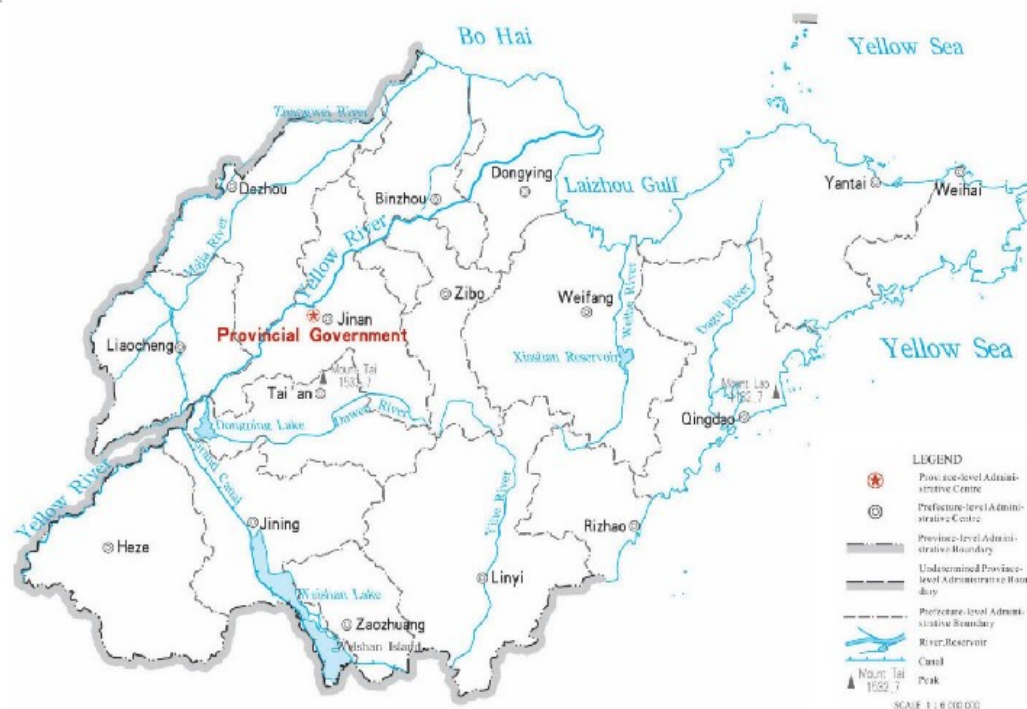

Figure6- 4.Map of Shandong Province

Prior to the formal questionnaire, we conducted a pre-survey of a sample of thirty people, which was used to determine the bid value, the scope of the bid, and the payment instrument.

Based on the results of the pre-survey, we chose electricity as a payment tool, which is mandatory and well known to respondents. In terms of bid value, a total of five bidding points were set according to the results of the pre-survey: 0.5, 1, 2, 3, 4. The five bidding points are divided into three groups: (0.5/1/2), (1/2/3), (2/3/4) CNY.

The questionnaire is divided into four parts（Figure 6-5）, the first part is the demographic information of the respondents, mainly including the respondents' gender, age, education, educational background, work, family income level, family composition and health status.

The second part asks questions about the respondents' understanding of smart garbage collection cabinets and whether they have used smart garbage collection cabinets.

The third part is based on questions related to planning behavior theory and is used to discuss the impact of planning behavior theory on willingness to pay. Questions with three main variables are included:

(1) Attitude: To improve the urban environment and promote the construction of low-carbon cities, will you actively use intelligent garbage recycling cabinets?

(2) Subjective norms: Do your family or friends support your use of smart garbage collection cabinets?

(3) Perceptual behavior control: whether you have enough time and energy to use the smart garbage collection cabinet (considering that the smart garbage collection cabinet will add a little extra time compared to ordinary garbage bins).
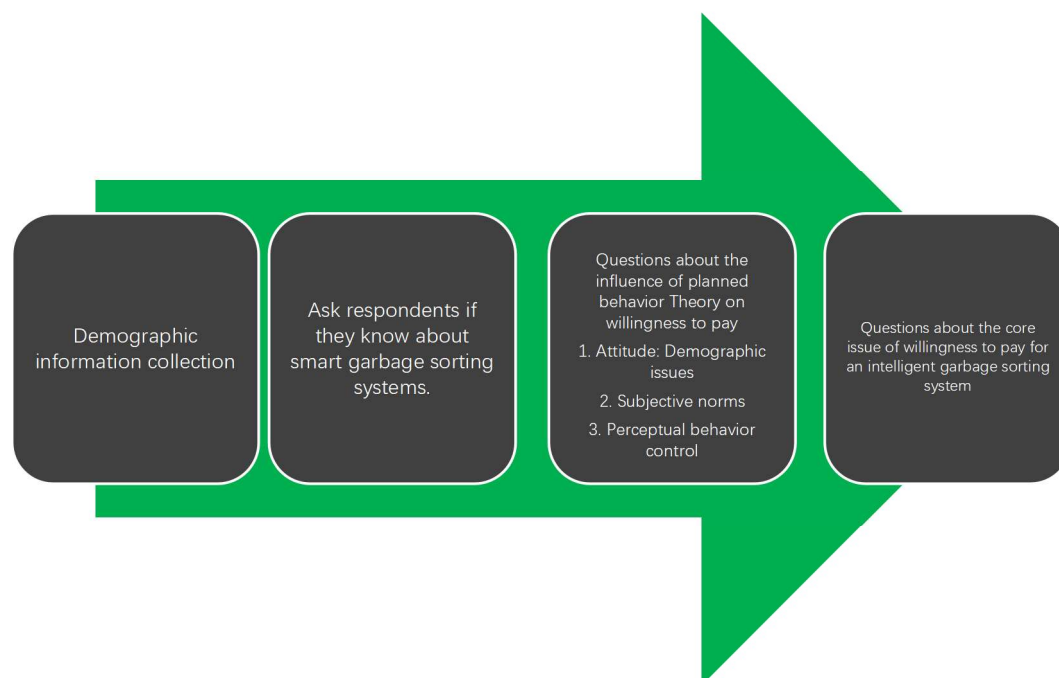
Figure6- 5.The questionnaire consists of four parts

The core problem of the fourth part about the willingness to pay for smart waste recycling cabinets is that it is assumed that the government is vigorously promoting the construction of urban smart waste recycling cabinets to promote the construction of green cities and low-carbon cities. But there is a certain financial pressure. Considering the positive environmental externalities of the smart recycling cabinet (zero emissions, improved air quality, etc.), whether you or your household is willing to pay an additional monthly electricity bill for the construction of the smart waste collection cabinet for the next year, taking into account your own financial situation?

6.3.2 The DBDC-CVM model

In DBDC format, respondents would be asked whether they are willing to pay or accept the bidding value of a specific amount C_i (i=1, ..., n). The first answer of "Yes" or "No" would be regarded as a reference basis for the second inquiry to adjust the bidding amount. As for WTP, when the answer of the respondents is "Yes" for the first time, another higher bidding amount C_i^H would be asked for the second time, otherwise they would be provided with another lower bidding amount C_i^L, i.e. $C_i^L < C_i < C_i^H$; The T denotes the response after a given amount C_i, willing to pay then $T = Y$ and refusal to pay then $T = N$ .Therefore, there are four possible outcomes: unwilling-unwilling, unwilling-willing , willing-unwilling, and willing-willing. The binary-indicator variables would be $A_i^{NN}, A_i^{NY}, A_i^{YN}$, and A_i^{YY},respectively. $G_c(C; X)$ represents the cumulative distribution function (CDF) of WTP, C represents the bidding value, Y represents an unknown parameter that needs to be valued, and the logarithmic likelihood function can be expressed as follows.

$$\ln L = \sum_{i=1}^{N} \left\{ A_i^{YY} \ln\left[1 - G_c\left((C_i^H; Y)\right)\right] + A_i^{YN} \ln\left[G_c\left(C_i^H; Y\right) - G_c(Ci; Y)\right] + A_i^{NY} \ln[G_c(C_i; Y) - G_c\left(C_i^L; Y\right)] + A_i^{NN} \ln G_c\left(C_i^L; Y\right) \right\}$$

Formulating $1 - G_c(.)$ as logistic CDF and combining this with $Y = (\alpha, \beta)$ yields:

$$\square \ (C_i; Y) = [1 + \exp(\alpha - \beta\square)]^{-1}$$

The mean value of WTP is $\overline{C} = \alpha/\beta$, where $\overline{C}$ is the mean value of WTP。

6.4 Results and discussion

6.4.1 Statistics

We collected data from Shandong Province as the study area, considering that there may be some limitations in the cognition of adolescent children and older adults. Therefore, minors under the age of 18 and seniors over the age of 65 do not fall within the age range of the online questionnaire. A total of online questionnaire surveys was conducted among respondents aged

18-65 in Beijing. A total of 810 online questionnaires were delivered and 639 responses were received. The response rate to the questionnaire was 78.8%, of which 33 were invalid questionnaires (questionnaire response time was less than 1 minute), which we eliminated. A total of 606 valid questionnaires were obtained for data analysis.

The responses of respondents from each bidding group are shown in Table 6-1. It can be seen that as the number of bids increases, the number of people who choose to pay both times gradually decreases, but the number of respondents who refuse to pay does not increase with the value of bids. The proportion of respondents (YN) who agreed to pay on the first inquiry was the highest. About 94% of the respondents are willing to pay for smart waste collection cabinets, indicating that the public has a high degree of recognition of smart waste collection cabinets. About 6% of respondents refused to pay anything.

Table6- 1.Response distribution

Bid Amount	YY	YN	NY	NN	SUM
(0.5/1/2) CNY	61 (30%)	74 (37%)	43 (21%)	24 (12%)	202(100%)
(1/2/3) CNY	50 (25%)	105 (52%)	38 (19%)	9 (4%)	202 (100%)
(2/3/4) CNY	33 (16%)	123 (61%)	38 (19%)	8 (4%)	202 (100%)
sum	144 (24%)	302 (50%)	119 (20%)	41 (6%)	606 (100%)

The average value and standard deviation of the covariates of the statistical sample are shown in Table 6-2, in which gender, age, whether there is or not of work status, education level, and wage income can be obtained from the Shandong Bureau of Statistics official data, through comparison, it can be known that the age distribution has a more obvious gap with the results of official statistics, and gender, family income level, education level and whether there is a job are closer to official statistics.

The deviation between the age distribution and the official data may be due to the limitations of the questionnaire method, since most of the online questionnaires are answered by mobile phone and computer users. Older people use mobile phones and computers less frequently, which can also be found in the age distribution in Table 2, where respondents over 45 account for only 10.2% of the total sample size, while respondents under 45 account for more than 80%. Apart from differences in age distribution and official data, the remaining variables were not much different from official data, so we considered our sample to be suitable for estimating WTP for the entire population.

The statistics of online questionnaire data show that the proportion of male respondents is relatively high. The proportion of respondents over 45 years old decreased significantly, indicating that the online questionnaire has an age tendency. Most of the interviewees have family members who are in good health, have stable jobs and have higher income levels than the average monthly income of households in Shandong Province. 72.8% of respondents believe that the use of smart

waste systems is an environmental protection act. However, the percentage of respondents with experience with smart garbage collection systems is low, only 33%. In the answers to the psychological variable questions related to the theory of planning behavior, 82.7% of the respondents had a positive attitude towards the use of smart garbage collection cabinets. 54.3% believe that their family or friends will support their use of smart recycling cabinets. 63.3% of respondents believe they have sufficient resources to use smart garbage collection cabinets.

Table6- 2.Covariance estimation result

Variable	Option	Numbers	Proportion/%	Mean	Dev	Census
Demographic attributes						
Gender	Male =1	325	53.2	0.53	0.50	0.50
	Female=0	281	46.8			
Age	18 ≤ Age <25 =1	267	44.1	1.66	0.60	1.49
	26 ≤ Age ≤ 45=2	277	45.7			
	45< Age ≤ 65=3	62	10.2			
Education	University degree	197	32.5	0.33	0.49	0.35
	or above=1	409	67.5			
	others=0					
Job	Have job=1	430	71.0	0.71	0.45	0.57
	No=0	176	29.0			
Physical condition	Health=1	539	88.9	0.90	0.43	
	others=0	67	11.1			
Household Income	More than 7000	381	62.8	0.63	0.49	0.54
	CNY=1	225	37.2			
	others=0					
Environmental recognition and experience						
Environmental recognition	Recognition =1	441	72.8	0.73	0.48	
	others=0	165	27.2			
Use experience	Have =1	202	33.4	0.33	0.50	
	others=0	404	66.6			
Moral implications						
Moral	Yes = 1	509	84.0	0.84	0.36	
	No = 0	98	16.0			
Theory of planned behavior						
Attitude	Yes = 1	501	82.7	0.83	0.41	
	No = 0	105	17.3			
Subjective norm	Yes = 1	329	54.3	0.85	0.36	
	No = 0	277	45.7			
Perceived behavioral control	Yes = 1	385	63.3	0.63	0.48	
	No = 0	221	36.7			

6.4.2 Valuation Results

The maximum fit function was used to estimate each set of parameters, and the results are shown in Table 6-3. According to the different properties of the variables, we set up four estimation models, respectively evaluate the willingness to pay for the four models and discuss the impact of each set of variables on the willingness to pay. Model 1 mainly contains demographic variables.

Model 2 adds two variables, the environmental recognition variable and the experience of the smart garbage collection cabinet, to Model 1. Model 3 adds environmental ethics variables to Model 2. Model 4 adds three important variables (attitude, subjective norms, and perceptual behavior control) in planned behavior theory to Model 3. The aim is to better discuss the impact of these variables on willingness to pay.

In the four models, the demographic variables were statistically significant at the 1% level of gender, education level and willingness to pay, indicating that men and highly educated respondents had a stronger willingness to pay. Income level and willingness to pay were statistically significant at the 5% level, indicating that income level and willingness to pay also had a strong correlation. Respondents with higher income levels are more willing to pay.

The environmental recognition and use experience of smart garbage collection cabinets were statistically significant at the 5% level in models 2-4, indicating that people who recognized smart garbage collection cabinets were beneficial to the environment and had relevant use experience had a higher willingness to pay.

Environmental ethics variables are statistically significant at the 1% level in models 3-4, indicating that individuals are considered to protect the environment Respondents with moral obligations had a higher willingness to pay.

In the TPB variable of Model 4, the level of attitude and perceived behavior is controlled at 5%, which is statistically significant, indicating that people who hold a positive attitude towards the intelligent garbage recycling cabinet (think it is essential) and have enough resources (time, money and energy) have a higher willingness to pay. There was no significant relationship between subjective norms and willingness to pay.

According to the data of China's seventh population census, the current number of households in Shandong Province is about 35.184 million, and if the willingness to pay is extended to all households in Shandong Province, the willingness to pay of all households is about 204 million CNY per month.

Table6- 3.Estimation Result with Covariance

Variable	Model 1		Model 2		Model 3		Model 4	
	Coef	p values	Coef	p values	Coef	p values	Coef	p values
Constant	1.196	0.000	3.154	0.000	3.482	0.000	3.427	0.000
Demographic attributes								
Gender	0.575	0.001***	0.576	0.001***	0.572	0.001***	0.563	0.002***
age	0.038	0.774	0.027	0.838	0.036	0.791	0.027	0.843
education	0.604	0.002***	0.595	0.002***	0.551	0.006***	0.535	0.008***
income	0.505	0.014**	0.511	0.017**	0.498	0.018**	0.521	0.011**
Job	0.088	0.663	0.096	0.635	0.081	0.692	0.060	0.771
Physical condition	0.082	0.784	0.052	0.861	0.077	0.798	0.067	0.825
Family members （social psychology）								
Environmental recognition			0.468	0.024**	0.414	0.033**	0.415	0.032**
Experience			0.498	0.017**	0.451	0.026**	0.465	0.022**
Moral								
Moral environment.					0.566	0.006***	0.575	0.001***
Theory of Planned Behavior								
Attitude							0.437	0.035**
Subjective norm							0.051	0.512
Perceived behavioral control							0.399	0.045**
Bid	0.623	0.000***	0.625	0.000***	0.629	0.000***	0.630	0.000***
WTP	5.809	0.000***	5.801	0.000***	5.792	0.000***	5.798	0.000***
95% confidence interval	5.658 ～ 6.096 CNY		5.526 ～ 6.076 CNY		5.530 ～ 6.008 CNY		5.525 ～ 5.785 CNY	
99% confidence interval	5.644 ～ 3.183 CNY		5.438 ～ 6.186 CNY		5.511 ～ 6.054 CNY		5.514 ～ 5.786 CNY	

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

6.4.3 Descriptive Analysis

Since the concept of smart garbage collection cabinets is still relatively new, the public's understanding of them may be limited. That's why we asked people with experience with smart recycling cabinets to learn more about their access to information. This may help inform the promotion of smart garbage collection cabinets. A total of 202 people with experience in smart recycling cabinets were questioned, of which 107 were obtained through mobile phones, 40 through the Internet, 32 through TV, 13 through books, and 10 through community promotion （Figure 6-6）.
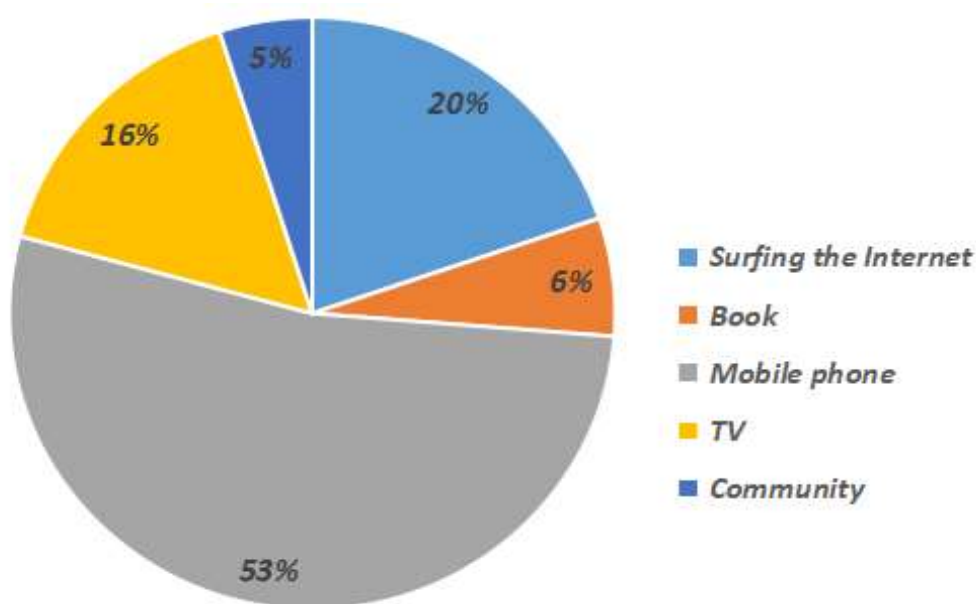

Figure6- 6.Access to information

6.5 Discuss

This study evaluates the public's willingness to pay for smart waste recycling cabinets in Shandong Province and its influencing factors and contributes to the formulation of relevant policies and the promotion of smart waste cabinets. It also provides a reference for promoting better public participation in urban environmental protection and promoting the construction of low-carbon cities. So far, although researchers have conducted extensive research on garbage classification and recycling, Shandong Province, as a province with more than 100 million Chinese, has not been in-depth research on the willingness to pay for its smart garbage recycling cabinets and its influencing factors. The results of this research will help to provide reference value for the promotion of smart garbage recycling cabinets in Shandong and even the whole of

China.

In our study, gender among demographic variables was significantly correlated with willingness to pay, with male respondents tending to have a higher willingness to pay. This differs from the conclusions reached by some researchers [33] [36]。 This may be due to the high proportion of men among the respondents or the greater focus on environmental protection among men. Many researchers have come to similar conclusions, education level and income level are positively correlated with willingness to pay [33], in China income level tends to have a significant positive correlation with education level, and their awareness of the importance of protecting the environment increases with their knowledge, and because of the higher income level, they tend to be more active in paying for environmental products.

Environmental recognition has a significant positive correlation with willingness to pay, and in our study, environmental recognition mainly refers to the recognition that smart waste recycling cabinets can contribute to the urban environment and low-carbon construction. This is like the findings of Zhang [38]. Environmental recognition is a kind of environmental awareness, and the cultivation of environmental awareness is mostly generated through books or related knowledge publicity. On the other hand, the importance of cultivating environmental awareness is highlighted. With the continuous development of mobile phone intelligence, mobile phone has become the main way to obtain relevant information. Therefore, mobile phones should be used as the main information dissemination.

tool to increase the publicity of mobile phone videos or related knowledge. Develop an individual's awareness of the importance of the environment. This will contribute to environmental protection and the construction of low-carbon cities.

The experience of smart garbage collection cabinets is also positively correlated with the willingness to pay. Explain that people who have used smart garbage collection cabinets are more inclined to pay.

Shandong Province was the first province in China to promote smart garbage recycling cabinets. In major urban areas, there are experiential smart garbage collection cabinets. However, the number is still relatively limited.

About one-third of the respondents in our study had had a relevant experience. Therefore, it is necessary to increase the number of experience smart garbage collection cabinets. Because this will help increase the public's willingness to pay and further promote the construction of smart garbage recycling cabinets.

Environmental ethics mainly refers to the belief that protecting the environment is part of an individual's ethical standards, and in our study, environmental ethics is significantly positively correlated with willingness to pay, which is consistent with the findings of Bai R [39]. Individuals' perception of moral factors often motivates them to actively participate in activities that are conducive to environmental protection. It also includes paying for hydrogen energy, heat island

effect mitigation, etc. It also highlights the need for increased education on environmental ethics. Planning behavior theory is widely used due to its high behavioral prediction and explanatory properties [33] [36]。It contains three main variables: attitude, subjective norms, and perceptual behavior control. In our study, attitude, perceptual behavior control and willingness to pay were significantly positively correlated. There is no obvious correlation between subjective norms. This is consistent with the conclusions reached by some researchers [40]. However, unlike the conclusion of Ajzen [12], the author of the theory of planned behavior, that attitudes, subjective norms, and perceptual behavior control can all influence the behavior of individuals. This may be because the respondents are all representatives of the family. The number of payments paid by households is determined by the representatives who conduct the questionnaire interviews. The attitudes of their family members and friends do not influence whether they decide to pay or not. In our study, perceptual behavior control was the most strongly associated with WTP among the planned behavior theory variables. This is consistent with the conclusion reached by Tan [33], that is, when respondents believe that they have enough resources (money, time, etc.) [41].

They will support the construction of smart waste cabinets. At present, due to the impact of the new crown in China, it has caused a certain economic recession. Therefore, how to increase income and improve residents' perceptual behavior control is a problem that policymakers need to consider.

In our study, households in Shandong Province had an average monthly WTP of 5.8CNY. The annual WTP of households is 69.6CNY, which is lower than the willingness of Beijing households to pay for smart garbage recycling cabinets (319.2 yuan). The reason for this may be that the income of households in Shandong Province is lower than that in Beijing. It may also be because Beijing is the first city in China to promote smart waste recycling cabinets, and residents know and use them more than Shandong Province, and their awareness of the positive environmental externalities of smart waste recycling cabinets is also higher than that of Shandong Province, so they have a higher willingness to pay.

6.6 Conclusions and policy recommendations

This study explores the willingness of households in Shandong Province to support the construction of smart garbage recycling cabinets and their influencing factors.

The willingness of households in Shandong Province to pay is 5.8CNY. Gender, income level, education level, environmental awareness of smart recycling cabinets, user experience, and environmental ethics will have a positive impact on willingness to pay. Attitude and perceptual behavior control in planned behavior theory also have a significant positive impact on willingness to pay.

Based on the above research results, we put forward three policy suggestions to promote the construction of smart waste recycling cabinets.

First, when decision-makers formulate relevant smart waste recycling cabinet promotion policies,

the public's willingness to pay needs to be considered.

Second, mobile phone Internet access is the main way for the public to obtain information about smart recycling cabinets, so mobile phone advertising should be used as the main publicity method to improve respondents' environmental awareness and environmental ethics.

Third, the public's experience of smart garbage collection cabinets is very important, so it is necessary to appropriately increase the pilot of smart garbage collection cabinets in various jurisdictions to increase the relevant experience of respondents.

Consumption questionnaire about intelligent waste separation cabinets

China, as the world's largest carbon emitter, has become urgent to reduce carbon emissions. China pledged in the Paris Agreement to peak its CO2 emissions by 2030 and become carbon neutral by 2060. A smart waste-sorting system could help China reach its goal sooner. Before this, we need to collect feedback information from the public. Could you please answer the following questions on behalf of your family? All your answers will be kept confidential and used for scientific research only. Advantages of intelligent garbage cabinet:

1. Sorting kitchen waste mainly composed of perishable organic components, providing high-quality raw materials for waste composting, producing high-quality organic fertilizer, which is conducive to continuously improving soil fertility and reducing fertilizer consumption.

2. The classification of hazardous waste reduces the components of heavy metals, organic pollutants, and pathogenic bacteria in the waste, which is conducive to the harmless treatment of the waste and reduces the hidden danger of water, soil and air pollution in the waste treatment.

3. Improved waste recovery rate, reduced the demand for raw materials, and reduced carbon dioxide emissions. 4. Promote professional knowledge of environmental protection and garbage, improve the cognition of the whole society in the field of environmental sanitation, reduce the difficulty of sanitation workers' work, and create an atmosphere of respect and care for sanitation workers. Intelligent garbage sorting equipment can not only bring you convenience, but also urge residents to carry out garbage sorting, reduce the source of garbage, and make contributions to environmental protection.

1. Your gender
A male
B female

2. Your age
A Under 25
B 25-55 years old
c 56-65 years old

3. Your education level
A University degree or above
B Other levels

4. Your family income level (refer to the average family income of Shandong Province is 9350 yuan)
A Above average
B Average and below

5 Whether you have a stable job

A Yes

B No

6. Is there a smart garbage recycling cabinet near your home

A Yes

B No

7. The state of your health or that of your family members

A Good

B In general

8. Are you familiar with the intelligent garbage sorting system

A Understand

B Don't know

8-1 How do you get your Information? (Single option)

A book

B Surfing the Internet

c Mobile phone

D TV

E Community publicity

9. Whether you have used the smart garbage sorting recycling station to throw rubbish

A Yes

B No

10. Do you think it's immoral to throw rubbish everywhere

A Yes

B No

11 Do you think the use of intelligent garbage sorting and recycling stations is beneficial to the mitigation of urban carbon emissions.

A Yes

B No

12. To build a low-carbon city, do you think it is necessary to conduct garbage sorting

A Yes

B No

13. You are denying that the intelligent garbage sorting and recycling station is very important to you and can contribute to the low-carbon construction of the city

A Yes

B No

14. Do people around you (including family, friends, neighbors) support you in paying for garbage sorting

A Support

B Not supported

15. Do you have enough resources to pay the additional cost of a smart garbage sorting system

A Yes

B No

16. Suppose that the government is vigorously promoting smart waste recycling system to alleviate urban carbon emissions but faces certain financial pressure. Considering the positive environmental externalities of smart waste recycling systems (waste recycling, improving urban environment) and the financial pressure faced by the government. Are you or your family willing to pay extra for a smart garbage collection system, considering your own situation? If you choose A you only have to answer the first set of questions if you choose B you only have to answer the second set of questions if you choose C you only have to answer the third set of questions

A means I'm going to answer the first group.

B is for group two

C is for group three

The first group

17. Would you like to pay an extra 3 yuan? If yes, answer question 18. If not, answer question 19

A Yes

B No

18. Are you willing to pay an extra 5 yuan? Finish the answer

A Yes

B No

19. Would you like to pay an extra 1 yuan? Finish the answer

A Yes

B No

The second group

20. Would you like to pay an extra 5 yuan? If yes, answer question 21. If not, answer question 22

A Yes

B No

21. Would you like to pay an extra 7 yuan? Finish the answer.

A Yes

B No

22. Would you like to pay an extra 3 yuan? Finish the answer

A Yes

B No

The third group

23. Are you willing to pay an extra 7 yuan? If yes, answer question 24. If not, answer question 25
A Yes
B No

24. Would you like to pay an extra 9 yuan? Finish the answer
A Yes
B No

25. Would you like to pay an extra 5 yuan? Finish the answer
A Yes
B No

26. What's your reason for not paying extra?
A Lack of authenticity in the project
B There is something wrong with the questionnaire design
C Economic pressure
D Government programs have nothing to do with me
E I'm not interested in low-carbon urban construction

How much are you willing to pay?

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Chapter 7

CONCLUSION AND POLICY

IMPLICATIONS

According to the 2021 United Nations, 56.2% of the world's population lives in cities, and this proportion is expected to reach 68% by 2050. The figure is 431 million people living in Tokyo, the world's largest city, followed by Mumbai (260 million), Guangzhou (220 million), Shanghai (220 million) and Delhi (210 million). Urban pollution that results, an increase in carbon emissions, and the heat island effect are now significant elements influencing people's daily lives. International nations have proposed remedies in reaction to this. China's goal is to reach carbon neutrality by 2060 after committing to the Paris Climate Agreement, which calls for a peak in carbon emissions by 2030. By examining public opinions toward urban low-carbon initiatives and their willingness to pay for them, this study evaluates the environmental benefit of these plans. Further discussion is given to the variables that affect people's payments for these tactics. also forecasters. It has helped make low-carbon urban development more successful.

In my study, I mainly discuss the low-carbon strategies of Beijing, the capital of China, Shandong Province, and Weihai, Shandong Province. It mainly includes: the promotion of hydrogen energy buses, the use of smart garbage collection cabinets, the green travel of shared battery cars, the willingness to pay for environmental protection and carbon emission reduction, and the relevant determinants affecting residents' willingness to pay.

The low-carbon policy for the city is being implemented, and the actions are part of the public environmental product. Low-carbon urban initiatives often go unnoticed for their environmental value and advantages. It is difficult to quantify using market-based methods. considered to be non-market value. One of the most popular ways for measuring non-market value and estimating the worth of environmental improvements is the conditional value method, which is applied in our research. As a result, we estimate public environmental products using the conditional value technique. A popular technique for determining the environmental value of public environmental goods is the conditional value method. We also utilize the respondents' socioeconomic and demographic data as variables to talk about the things that affect willingness to pay. The theory of conjoint dynamics predicts the willingness to pay.

7.1 Conclusion

Following these steps: theoretical research; methodological research; experimental research; and conclusion.

The research background and research aims are mostly given in the first chapter, which serves as an introduction in general. This study's objectives are to evaluate the environmental economic worth of low-carbon urban plans and to talk about the variables affecting respondents' willingness to pay for public environmental goods.

The second chapter, which explains the pertinent theoretical foundation, is devoted to theoretical research. A study of the literature on the evaluation of low-carbon plans under climate-value settings was conducted, and recent pertinent research were compiled. We also discover from the

review of the literature that there is very little mention of the planning behavior theory's influencing elements in the pertinent studies on people's willingness to pay for low-carbon city policies.Therefore, in the following research, we discuss the effect on willingness to pay through the theory of planning behavior as an influencing factor.

Focuses on the evaluation of conditional valuation studies of low-carbon city strategies. Due to the non-market-oriented nature of low-carbon city measures, traditional market valuation methods are difficult to accurately assess their economic value [1]. The conditional value method is currently an important method used internationally to assess the economic value of non-market-based environmental goods. In recent years, the carbon emissions of cities in various countries due to urbanization have increased, and the value of evaluating low-carbon urban strategies through conditional value methods has also increased. However, there is a lack of studies summarizing this willingness to pay and literature reviews. We summarize research on conditional value methods and low-carbon city strategies. It also provides the countries of relevant research, data collection methods, specific low-carbon strategies, induction methods of willingness to pay, and valuation results of willingness to pay, etc., which contribute to the research and valuation of low-carbon city strategies in the future. In addition, we discuss the influencing factors on willingness to pay, and explore the influence of behavior on willingness to pay through various theoretical frameworks that affect behavior. We also discuss the effectiveness of different payment instruments and data elicitation techniques and highlight the corresponding reliability and validity tests in future studies.

The technique section of Chapter 3 is primarily divided into two sections: theoretical foundation and experimental design. The relevant theoretical background is primarily explained in the first section. It describes the components of low-carbon cities' economic worth and how to estimate it. It also explains why low-carbon cities have economic value. By using questionnaires to estimate each respondent's willingness to pay, it is usual practice to estimate the environmental economic value. Investigating the variables that affect people's willingness to pay can aid in better implementing tried-and-true low-carbon techniques and achieving greater economic and environmental benefits. It has significant practical implications [2]. In the last article, we discovered that there has been comparatively little research on planning behavior in the field of low-carbon urban solutions.

As a result, we go into further detail on the idea of planning behavior that accounts for willingness to pay. The economic value theory of urban low-carbon solutions is also explained. The second section outlines how the experiment will be set up for our study, including the questionnaire's structure, the estimating model, and the method of payment. Additionally, the peak model is employed to address the issue that the present conditional value method's zero response has on the precision of estimation results. Peak models that are used to calculate urban low-carbon policies are elaborated on for their environmental usefulness.Using a two-boundary bipartite valuation model to estimate the outcome of willingness to pay, this shows how the peak model is calculated and its advantages over conventional methods.

In Chapter 4, we used online questionnaires to examine Beijing households' willingness to pay for

the promotion of hydrogen energy buses and their affecting factors. Buses that run on hydrogen fuel are an essential component of the development of low-carbon cities as a source of green transportation. Beijing is crucial to the growth of hydrogen energy buses in China because it is a test city for these vehicles. Unfortunately, no research has been done on how well-liked hydrogen buses are among the general people or how beneficial they are to the environment. Peak models have also been employed to calculate consumer demand for hydrogen-powered buses. The findings indicate that households in Beijing are prepared to spend 3.19 yuan per trip. Positive environmental externalities are worth approximately 29.15 million yuan every journey. The primary determinants of willingness to pay are household economic level, environmental knowledge, personal environmental ethics, and perceptual behavior control. As a result, governments should increase public awareness, foster environmental ethics, optimize the design of hydrogen fuel bus timetables and the riding experience, and enhance people's perception and behavior management skills. Finally, it is important to assess the value of hydrogen buses' favorable environmental externalities because doing so will spur investor interest.

In Chapter 5，We evaluate the willingness to pay (WTP) of shared electric vehicles in Weihai through payment card-CVM. A total of 398 samples were obtained through the online questionnaire. Of these, 271 agreed to pay and 118 refused to pay, accounting for about 30% of the total sample. The calculation results show that Weihai citizens' willingness to pay is about 0.76 yuan per time. At the same time, the factors that affect the willingness to pay are discussed. People with more education, income, and resources tend to be more willing to pay for shared electric vehicles. At the same time, we asked questions about those who refused to pay, mainly due to low-income levels. Therefore, we believe that increasing the public's income level and understanding of shared EV sharing can help promote the use of shared EVs and the public's protection of the environment.

Chapter 6 focuses on the willingness of Shandong households to pay to promote the promotion of smart garbage recycling cabinets. Garbage sorting can arrange reasonable treatment methods for different types of waste, increase recycling efficiency, contribute to the sustainable development of cities and reduce carbon emissions. The intelligent garbage collection cabinet is a new type of device that helps to sort garbage. The results of this chapter show that the willingness of households to pay is about 5.8CNY per month, and the demographic variables of gender, education level, and income level all have a significant positive impact on the willingness to pay. We also introduce the theory of planned behavior and discuss the impact of environment-related variables on willingness to pay. Environmental cognition, environmental moral level, attitude, perceptual behavior control will have a positive impact on the willingness to pay, and the experience of using the smart garbage collection cabinet is also an important variable affecting the willingness to pay. We believe that it is necessary to pay attention to the willingness to pay when formulating relevant policies, and at the same time increase the number of experience places that can only be used in garbage collection cabinets, which will promote the promotion of smart garbage collection cabinets.

Chapter 7 provides a summary of the article. This paper explains the economic worth of urban low-carbon solutions at the level of economic value using the theories of labor economic value

and subjective economic value. In terms of valuation techniques, this study believes that the conventional conditional value method has some drawbacks in the estimation of willingness to pay, particularly the problem of respondent individuals' zero-response treatment, which has not yet been satisfactorily resolved. The two-boundary dichotomous conditional value approach and the peak model can overcome the limitations of conventional valuation techniques.In terms of experimental subjects, we mainly discussed the low-carbon strategies of Beijing, Shandong Province and Weihai City, Shandong Province, including the promotion of hydrogen energy buses, the use of smart waste recycling cabinets, the green travel of shared battery cars, the willingness to pay for environmental protection and carbon emission reduction, and discussed the relevant determinants affecting residents' willingness to pay. We believe that planning behavior theory can make good predictions of willingness to pay, and that planning behavior theory is applicable to different public environment products.

7.2 Policy implications

Based on the experiments and discussions above, this research provided policy implications as follows.

7.2.1 Increase publicity on the importance of low-carbon city strategies

In our study, Guerrero noted that publicity significantly promoted residents' waste sorting behavior. In practice, the effectiveness of publicity in promoting household waste sorting varies from person to person [3]. Active advocacy, garbage sorting and recycling through multiple media channels, many studies have shown that publicity is effective. Wang found that information obtained directly through the media favored household participation in recycling [4]. Therefore, we believe that increasing the publicity of low-carbon strategies in cities is of great significance to increase public participation. We recommend the following strategies.

1. Media publicity: Through the Internet, television, radio, newspapers and other mass media, the concept, significance and strategy of low-carbon cities can be promoted, and successful cases can be introduced to improve citizens' awareness and acceptance of low-carbon cities.

2. Organize events: Low-carbon city strategies can be promoted through various forms of activities, such as forums, seminars, exhibitions, cultural events, etc., to engage citizens and promote the benefits of low-carbon living.

3. Publicity: You can use public places, bus stops, billboards, and other public facilities to put up posters, slogans, etc. to promote the concept and strategy of low-carbon cities, so that citizens can access this information in their daily lives.

4. Education and promotion: The concept and strategy of low-carbon cities can be incorporated into the education curriculum to publicize and educate students, so that the younger generation can understand the importance of low-carbon life earlier.

5. Social media publicity: Through social media platforms such as WeChat, Weibo, QQ, etc., information related to low-carbon cities can be released, attracting the attention of a wider audience, and allowing more people to understand and support the construction of low-carbon cities.

7.2.2 Encourage study of pertinent conditional value techniques

The goal of reducing urban carbon emissions dates back to the middle to late 20th century, but it wasn't until the 2021 Paris climate conference that nations from all over the world set specific targets for doing so. This is despite recent advances in the conditional value methods used to study urban environments. The scientific community is deeply concerned about environmental issues like carbon emissions as a result of this. And it never stops. By 2030, the Chinese government wants to reach a maximum level of carbon emissions. By 2060, achieve carbon neutrality. Many studies on low carbon are now being conducted by Chinese specialists. However, there is currently a dearth of conditional value approach research on low-carbon cities. In this study, we evaluated the environmental value of these initiatives using the conditional value technique, which serves as a guide for developing policy. Our research is, regrettably, still in its early stages. Therefore, we think that further research should be done on low-carbon urban conditional value methodologies, and low-carbon policies should be thoroughly and effectively evaluated in terms of their environmental value [5].

7.2.3 Promote low-carbon urban education

Young people are the future of our motherland, and strengthening low-carbon education in schools is of great significance. To advance low-carbon urban education, we need to do the following:

1. Strengthen the school curriculum, integrate low-carbon, environmental protection, sustainable development, and other contents into the curriculum, and cultivate students' environmental awareness and low-carbon lifestyle.

2. Encourage students to participate in low-carbon activities, such as environmental volunteer services, green travel, energy conservation and emission reduction, etc., to feel the benefits of low-carbon life through practical experience.

3. Carry out low-carbon education and publicity activities, including distributing publicity materials, holding thematic lectures, and displaying environmental protection scientific and technological achievements, etc., to enhance public awareness and support for the construction of low-carbon cities.

4. Strengthen teacher training, improve teachers' knowledge and ability of low-carbon, environmental protection, and sustainable development, and set an example for students.

5. Establish a low-carbon city teacher exchange platform, promote experience exchange and

resource sharing among teachers, and improve the level of low-carbon city education.

7.2.4 Strengthen personal awareness of low carbon

Protecting the environment is everyone's responsibility. We need to start with ourselves.

1. Pay attention to environmental protection news: track environmental protection policies and industry development news, pay attention to the latest low-carbon technologies and developments in the field of energy conservation and emission reduction, and let yourself understand the necessity and feasibility of low-carbon life.

2. Self-education: Reading books and articles related to low-carbon life can deepen your understanding and awareness by learning more about the environment and climate change.

3. Reduce energy consumption: Take measures to reduce energy consumption, such as using solar energy, choosing energy-efficient appliances, and promoting green and low-carbon practices in homes or companies.

4. Choose sustainable products and services: choose environmentally friendly and sustainable products and services, such as buying environmental labels, using renewable energy to supply electricity, and using public transportation according to actual conditions.

5. Cultivate low-carbon habits: low-carbon travel methods such as cycling, walking, and public transportation, driving less, using disposable items such as plastic bags, turning on and off lights at ordinary times, and regularly cleaning indoor air conditioners, refrigerators, and other electrical appliances to cultivate low-carbon living habits.

6. Participate in low-carbon communities: participate in community activities, public welfare organizations and environmental protection actions, actively participate in the popularization and promotion of low-carbon life and give full play to their own strength to contribute to environmental protection.

7.2.5 Timely disclosure of environmental information

The construction of low-carbon cities is inseparable from the maintenance of every citizen. In order to increase the participation of residents and improve the urban environment, it is necessary to disclose information about the environment in a timely manner, especially the use of environmental protection funds. The Chinese government's information disclosure has advanced somewhat since the passage of the Government Information Transparency Law, according to research by the Ministry of Environmental Protection [6]. The Pollution Information Transparency Index (PITI) was created by the Institute of Public and Environmental Affairs (IPE) and the Natural Resources Defense Council (2009) to measure the extent.

113 localities throughout the nation offer public access to government data. The findings indicate

that the eastern developed provinces had higher levels of government information disclosure than the less developed provinces.

Provinces in the Midwest. Zhang et al.'s [7] investigation on the province-specific information disclosure practices of environmental protection departments and ministries. Timely disclosure of environmental information typically includes the following:

1. Air quality, including the concentration of pollutants such as PM2.5, PM10, and O3.

2. Water quality, including pollution of rivers, lakes, groundwater, etc., and protection of drinking water sources.

3. Noise pollution, including urban noise sources, industrial disturbances, etc.

4. Soil pollution, including the impact of industrial waste, sewage treatment, etc. on the soil environment.

5. Ecological environment, including the protection of wild animal and plant resources, nature reserves, etc.

6. Industrial pollution such as waste gas and wastewater, including the discharge of industrial enterprises, waste treatment, etc.

7. Other factors affecting environmental quality, including atmospheric greenhouse gas emissions, disaster prevention, etc.

In short, timely disclosure of environmental information is an important means to protect the public's right to know, participate and supervise, which is conducive to improving the transparency and fairness of environmental protection and promoting the effectiveness of environmental governance.

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