Sustainable consumption and production: From private goods, impure public goods to public goods

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(Degree)
博士（経済学）

(Date of Degree)
2020-03-25

(Date of Publication)
2022-03-25

(Resource Type)
doctoral thesis

(Report Number)
甲第7678号

(URL)
https://hdl.handle.net/20.500.14094/D1007678

博　士　論　文

令和　元　年　12 月

神戸大学大学院経済学研究科

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（持続可能な消費と生産 :私的財から不純粋公共財、公共財へ）

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Acknowledgement

The following thesis could not complete without the guidance and support of a lot of people. First, I would like to express my sincere gratitude to my advisor Professor Shen Junyi for his continuous support of my Ph.D. study. He was patience for all of my questions and would shed the light for me once I was stuck at a tough problem. He always shared his wisdom with me and I have learned much knowledge from him not only about how to become a better scholar but also how to live my life. I could not have imagined having a better advisor and mentor for my Ph.D. study.

Besides my advisor, I would like to thank my vice advisor Professor Kenji Takeuchi for his helpful advice about my thesis. The two years' training in your seminar will be a treasure in my academic career. I learned how to broaden my imagination in the seminar and understood the importance of discussion which made me think deeper and more comprehensive.

My sincere thanks also go to my colleague Dr. Wang Enci for her support for my thesis. Her constructive ideas inspire me and I could not finish my first research without her help. We discussed a lot and many exciting ideas burst out during the discussion.

Last but not least, I need to thank my parents who always encourage me to explore unknown puzzles and support me to step into the journey of studying in Japan. My gratitude for them just grows with the increase of age and I could not imagine if I could make it to the end without their unconditional love. The graduation from Kobe University might be the best present to repay them for their whole support.

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Abstract

The topic of this paper focuses on the issues of sustainable consumption and production (SCP) in China from the perspective of “bottom-up”. The system of SCP has been appealing more attention in the last decade since the World Summit on Sustainable Development (WSSD) held at Johannesburg in the year 2002. “Top-down” governance (e.g., an environment tax) that refers to policies and regulations implemented by a government is commonly regarded as an effective means to deal with environmental issues. However, it might encounter the risk of rent-seeking or harm social welfare considerably. To avoid this dilemma, sustainable consumption and production, which concerns about the behavior of consumers and producers, could be a great compensation. The inherent relation between sustainable consumption and sustainable production indicates we should regard these two behavior as a whole. However, it will be clearer to understand the whole SCP system if we discover the essence of each part.

In this paper, I discuss the SCP issues from three representative aspects. (i.e., private goods, impure public goods, and public goods). The studies of private goods and impure public goods focus on sustainable consumption and the study of public goods focuses on sustainable production. First, in the study of private goods, I choose to analyze the consumers’ preference for electric vehicle and their attributes by applying Multinomial Logit and Random Parameter Logit models. A stated choice survey was conducted in Shanghai to examine the attitudes of Shanghai residents towards electric vehicles and their attributes. I find that the respondents in each of the three groups(the full sample, a subsample of potential electric vehicle purchasers, and a subsample of unlikely electric vehicle purchasers) preferred electric vehicles with a longer driving range, a shorter charging time, a faster maximum speed, lower pollution emissions, lower fuel cost, and a lower price. However, an overlong driving range seems not to be a must for potential EV purchasers. In addition, a comparison of the two subsamples showed that potential electric vehicle purchasers were willing to pay more than their counterparts for enhancing vehicle attributes. I also investigate the determinants of likely electric vehicle purchase and find a number of demographic characteristics that were statistically significant.

Second, in the study of impure public goods, I implemented a dictator game experiment to examine how the increase of the public characteristic in an impure public good affects individuals' prosocial behavior(e.g., sustainable consumption), a within-subject design was used in the experiment. The dictator game was repeated six times with an impure public good introduced in four of them. I observe that the increase of the public characteristic in an impure public good partly crowds out individuals' subsequent donations, which could be explained by a seemingly "mental accounting" mental process. In addition, I also find that the selfish behavior of individuals in dictator games with impure public goods, to some extent, has an inertia influence on their subsequent donations when the impure public good is removed.

Finally, in the study of public goods, I try to figure out how the rural residents in China value the agri-environment policy (i.e., the policy that protects the agri-environment public goods) using best-worst scaling method. I use the best-worst scaling method to analyze how the agri-environment policy will actually impact on rural residents' attitude to the policy. A stated choice survey was conducted in Anhui and Multinomial Logit, Random Parameter Logit, and latent class logit models were used to value the rural residents' attitude to the agri-environment policy. we found that the respondents thought the policy which had the objective of protection of underground water quality, the assignment of straw recycling, technology provided by the government, 30% farmers be supervised, 6000RMB subsidy directly given by the government is the best agri-environment policy. Nonetheless, the respondents thought the policy which had the objective of protection of biodiversity, the assignment of purchase pesticides and fertilizers in the prescribed list, technology not provided by the government, 50% farmers be supervised, 4500RMB subsidy given by making a contract with the government is the worst agri-environment policy. The results of the latent class logit model suggested the respondents who are older, have fewer children under the middle school, less agree with the rural environment will have a large impact on agriculture production and have more knowledge of agriculture environment protection will show more sensitive to the attributes of agri-environment policy. The concluding remarks are also presented at the end of this thesis.

Chapter I

Introduction

Since mankind entered the industrial revolution era, the consumption of natural resources is increasing every year. The environment of this planet has been suffering from various damages by mankind during the last century even though a lot of efforts have been taken since the 1960s. Mankind still faces severing environment problems. Generally, If the global population reach 9.6 billion by 2050, the equivalent of almost three planets could be required to provide the natural resources needed to sustain current lifestyles. First, lacking fresh water to some extent is an urgent problem. Since less than 3 percent of the world's water is fresh (drinkable), of which 2.5 percent is frozen in Antarctica, Arctic and glaciers. Humanity must, therefore, rely on 0.5 percent for all of man's ecosystems and freshwater needs. However, humankind is polluting water in rivers and lakes faster than nature can recycle and purify. Second, despite technological advances that have promoted energy efficiency gains, energy use in OECD countries will continue to grow another 35 percent by 2020. Commercial and residential energy use is the second most rapidly growing area of global energy use after transport. Furthermore, food-related energy consumption and waste generation could be another bothersome problem. Each year, an estimated 1/3 of all food produced – equivalent to 1.3 billion tons worth around $1 trillion – ends up rotting in the bins of consumers and retailers, or spoiling due to poor transportation and harvesting practices. Besides, Land degradation, declining soil fertility, unsustainable water use, overfishing, and marine environment degradation are all lessening the ability of the natural resource base to supply food.

Several targets called The Sustainable Development Goals have been set to resolve the aforementioned problems. The Sustainable Development Goals (SDGs) are a collection of 17 global goals set by the United Nations General Assembly in 2015 for the year 2030. Goal 12: Responsible consumption and production are one of the goals which ensure sustainable consumption and production patterns. The targets of Goal 12 not only include using eco-friendly production methods and reducing the amount of waste, but also ensuring that people everywhere

have the relevant information and awareness for sustainable development and lifestyles in harmony with nature. Moreover, target 12.1 calls for the implementation of the 10-Year Framework of Programmes on Sustainable Consumption and Production. This framework, adopted by member states at the United Nations Conference on Sustainable Development, is a global commitment to accelerate the shift to sustainable consumption and production in developed and developing countries.

1.1 Sustainable Consumption and Production

The system of Sustainable Consumption and Production(SCP) has been appealing more attention in the last decade since World Summit on Sustainable Development (WSSD) held at Johannesburg in the year 2002 (Sabapathy, 2007). The definition of SCP first receive recognition in WSSD is:

- To promote social and economic development
- Within the carrying capacity of ecosystems
- By addressing and, where appropriate, de-linking economic growth and environmental degradation
- Through improving efficiency and sustainability in the use of resources and production processes
- And reducing resource degradation, pollution, and waste.

In the process of SCP implementation, All countries should take action, with developed countries taking the lead, taking into account the development needs and capabilities of developing countries through mobilization, from all sources, of financial and technical assistance and capacity-building for developing countries. Governments, relevant international organizations, the private sector, and all major groups should play an active role in changing unsustainable consumption and production patterns. Production and consumption policies should be developed to improve the products and services provision, while reducing environmental and health impacts, using, where appropriate, science-based approaches, such as life-cycle analysis. Hence, SCP is one of the key objectives of sustainable development that promotes resource and energy efficiency,

sustainable infrastructure, and access to basic services, green and decent jobs and a better quality of life for all.

Some scholars focused on the overall SCP system and discussed how to improve the efficiency of the SCP system. Berg (2011) argued that an efficient SCP policy should include three organizing principles, i.e. deliberation, efficiency, and sufficiency. Stevens (2010) thought public policy tools promoting sustainable consumption and production are discussed in terms of whether they are aimed at correcting: 1) market failures (regulations, taxes, subsidies); or 2) systems failures (labels, communications, education, public procurement). Spangenberg et al. (2013) believed that improve the eco-efficiency of production and consumption especially they thought Design for Sustainability is vital for combining the effects of satisfier efficiency with the supply and product "efficiencies". The inherent relation between sustainable consumption and sustainable production indicates we should regard these two behavior as a whole. However, it will be clearer to understand the whole SCP system if we discover the essence of each part.

1.2 Sustainable consumption

Most government policies Promoting sustainable consumption and production focus on stemming the environmental impacts of unsustainable industrial production practices whereas promoting sustainable consumption is equally important to limit negative environmental and social externalities as well as to provide markets for sustainable products (OECD, 2008). The definition proposed by the 1994 Oslo Symposium on Sustainable Consumption defines it as "the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations."

There are a bunch of researches try to figure out the determinants of sustainable consumption behaviors such as individual factors and situational factors. Individual factors such as environmental concerns, habits, and knowledge have been analyzed in previous studies. Environmental concerns and responsibility were found to have a positive and direct impact on ecological knowledge, purchase intention and actual purchase behavior (Makatouni, 2002; Padel

and Foster, 2005; Wang et al., 2014; Zhao et al., 2014). Habit and past behavior guide consumer preferences and influence their purchasing behavior, making it difficult to change (Padel and Foster, 2005; Vermeir and Verbeke, 2006). Knowledge of environmental issues positively influenced consumer intention and actual purchase of green products (e.g., Chan et al., 2000; Eze et al., 2013). As to situational factors, price, social norm, eco-labeling and certification, product attributes and quality are several external factors that could influence the behavior of sustainable consumption. Some research show that higher prices outweighed ethical considerations and widened the attitude-behavior gap in case of purchase of green products (e.g., Connell, 2010; Gleim et al., 2013; Padel and Foster, 2005; Vermeir and Verbeke, 2006). The social norm is one of the vital reasons to positively affect sustainable consumption that proved in some studies (Planas, 2018; Demarque et al., 2015; Chen et al., 2016). According to some studies, eco-labeling also plays a significant role in motivating sustainable consumption (Young et al., 2010; Rahbar and Wahid, 2011; Atkinson, 2014). However, some other studies believe eco-labeling might not have any impact on consumer green purchase behavior if they do not trust the information provided such as Nittala (2014). Products attributes and quality are discussed in some studies, Perceived high quality of green products has a positive influence (Aertsens et al., 2011; Mondelaers et al., 2009), whereas perceived low quality of green products has a negative influence (Smith and Paladino, 2010; Tsakiridou et al., 2008) on consumer green purchase intention and behavior.

Some policies and regulations of sustainable consumption were implemented in many countries. Eco-labeling is the most prevalent measure used to lead consumption to greener one. In Mexico, energy consumed by household appliances fell by more than 50% due to standards and labels developed for washing machines, refrigerators, water heaters, lights, water pumps, boilers, thermal insulation materials, and other household products. Mandatory energy efficiency rating labels, now recognized by more than 95% of consumers, complement Minimum Energy Performance Standards for a comprehensive range of household electrical products. Price-related policies (e.g. tax and subsidy) also were applied to motivate sustainable consumption since consumers more or less are sensitive to the price of goods. France has initiated discussions at the European Union level on temporary variations in VAT taxes according to a product's social and

environmental performance as denoted by third-party certified labels. In Netherland, the local government and NGOs introduced a green loyalty point system called Nu Spaarpas which gives green points for sustainable consumer behavior and allows points to be redeemed for sustainable products and services. Furthermore, education is also one of the most powerful tools for providing individuals with the appropriate skills and competencies to become sustainable consumers, especially for children. In Australia, the National Youth Affairs Research Scheme (NYARS) sponsored Sustainable Consumption: Young Australians as Agents of Change which enumerated techniques to empower students to change their consumption patterns and act as catalysts for more sustainable lifestyles in the wider community. The academic year 2006/2007 in the United Kingdom was the year of action on sustainable schools, sponsored by the Department of Education and Skills (Dfes), to provide resources and materials to help embed sustainability in all areas of school life. The Chinese government has been promoting new automotive energy technology. From 2015 to 2016, China has ranked the first in the new energy automotive production and sales for two consecutive years, with the cumulative sales amount of new energy cars of more than 1 million.

1.3 Sustainable production

Sustainable Production is the creation of goods and services using processes and systems that are: Non-polluting, Conserving of energy and natural resources, Economically viable, Safe and healthful for workers, communities, and consumers, Socially and creatively rewarding for all working people. If production is sustainable, then the environment, employees, communities, and organizations—all benefit. These conditions can lead, always in the long term, and often in the short term, to more economically viable and productive enterprises.

Some scholars focused on how to evaluate sustainable production systems. Veleva and Ellenbecker (2001) discussed the methodology of core and supplemental indicators for raising companies' awareness and measuring their progress toward sustainable production systems. Krajnc and Glavic (2003) presented indicators for assessing and promoting business sustainability and they are divided into input and output indicators based on commonly measured environmental aspects of sustainable production. Other researches also discussed throughout the whole process of

sustainable production. The eco-design concept is known as DfE (ISO 14062) and focuses on minimizing the environmental impact of a product during its life cycle, about 30–80% of the environmental impact of a product and or service is decided at the design stage (Houe and Grabot, 2009; Clark, 2007). As to the process of production, Baldwin et al. (2005) present useful tools for improving sustainability including benchmarking, total cost, life-cycle cost, eco-portfolio analysis, and product summary matrix, design for environment, cleaner production indicators, process audit, ISO 4000 and EU Eco-Management Systems. Simpson and Power (2005) reveal that efforts to improve suppliers' environmental management practices raise critical issues of transaction costs and efficacy of approach for the buyer. Consumers and legislation have pushed companies to redesign their logistics networks to mitigate negative environmental impact. Neto et al. (2008) contribute to the design of sustainable logistics networks by balancing the planet and profit. Sarkis (2003) identifies and structures the primary strategic and operational elements for a framework that will aid managers in evaluating green supply chain alternatives. These alternatives include factors such as partners, technology, and organizational practices. Sustainability through remanufacturing, recycling and reverse logistics are also significant in a sustainable production system should also be seen as an inseparable part of a sustainable production system. Hu et al. (2002) present a cost-minimization model for a hazardous-waste reverse logistics system. They developed a linear analytical model to minimize total reverse logistics costs considering the internal and external factors such as business operating strategies and government regulations. Kim et al. (2006) discuss the remanufacturing process of reusable parts in reverse logistics. They consider that manufacturers have two alternatives for supplying parts: (i) ordering the required parts from external suppliers or (ii) overhauling returned products.

Sustainable production policies or projects of developed countries and developing countries involved in both agriculture production and manufacture production. In a project that helps protect the unique biodiversity of the Kakamega Forest, researchers at the International Centre of Insect Physiology and Ecology (ICIPE) in Kenya have developed a successful enterprise with the local community-based MFCG to produce ointments from medicinal plants. The project not only help with forest conservation, but the growers also make a much better income than they would from maize cultivation. In French, the bonus-malus system is a financial instrument that provides a

financial reward (bonus) for purchasers of fuel-efficient new cars and a financial penalty (malus) for those buying cars emitting high levels of CO2. just three months after the implementation of the scheme, the sales of the most polluting cars had decreased by 70 percent and sales of less polluting cars had increased by 38 percent. In Guatemala, the Ministry of Environment and Natural Resources released a Cleaner Production Voluntary Agreement Regional Strategy promoting public-private partnerships for the application and enforcement of environmental laws. It includes collaboration with the CCAD and the Guatemalan Cleaner Production Centre. The strategy also aims to create the appropriate conditions to improve the competitiveness and adoption of CP plans. In China, promoting the 3Rs through reduced material input, increased efficiency in production, and integration of consumption and production systems to facilitate resource circulation within industries and municipalities. Reflecting on the fast pace of China's resource-intensive growth in the last decades, one of its priorities is ecological efficiency in economic development.

The remainder of the thesis is organized as follows: In chapter II, I will conduct a stated choice survey in Shanghai to examine the attitudes of Shanghai residents towards electric vehicles and their attributes. I find that the respondents in each of the three groups(the full sample, a subsample of potential electric vehicle purchasers, and a subsample of unlikely electric vehicle purchasers) preferred electric vehicles with a longer driving range, a shorter charging time, a faster maximum speed, lower pollution emissions, lower fuel cost, and a lower price. However, an overlong driving range seems not to be a must for potential EV purchasers. Besides, a comparison of the two subsamples showed that potential electric vehicle purchasers were willing to pay more than their counterparts for enhancing vehicle attributes. I also investigate the determinants of likely electric vehicle purchase and found several demographic characteristics that were statistically significant. In chapter III, I will implement a dictator game experiment to examine how the increase of the public characteristic in an impure public good affects individuals' prosocial behavior. A within-subject design was used in the experiment. The dictator game was repeated six times with an impure public good introduced in four of them. I observe that the increase of the public characteristic in an impure public good partly crowds out individuals' subsequent donations, which could be explained by a seemingly "mental accounting" mental

process. In addition, I also find that the selfish behavior of individuals in dictator games with impure public goods, to some extent, has an inertia influence on their subsequent donations when the impure public good is removed. In chapter IV, I would like to find out the attitude of farmers in China on agri-environment policies. I plan to utilize best-worst scaling to analyze how the agri-environment policy will impact on farmers' attitude to the policy. Meanwhile, the demographic characteristics of farmers will be included to analyze the impact on farmers' attitude in different groups. The concluding remarks will be presented in Chapter V.

Chapter II

Examining consumers' preference for electric vehicle and their attributes: Evidence from Shanghai data

2.1 Introduction

Electric vehicles (EVs) have emerged as the most prominent representatives of what are commonly referred to as new energy vehicles (NEVs). Their zero-level carbon emissions during use, low energy consumption and relatively simple and mature technology have elevated electric vehicles to a leadership role in setting the future course of the auto industry. In China, the development of NEV industries, especially the electric car industry, is in line with this trend. The Chinese government not only vigorously fosters and develops NEV companies, but also actively promotes the application of NEV technology. In recent years, the Chinese central and local governments have increased subsidies for new energy vehicles. The expected increase in sales, however, has thus far not materialized.

Research on consumer attitudes towards NEVs began earlier in developed countries than in developing countries such as China. Liao et al. (2017) reviewed the literature on consumer preferences for electric vehicles in 2016. They classified and summarized the influence factors of consumer preferences, such as socioeconomic variables, psychological factors, mobility condition, and social influence. Therefore, we also reviewed from the effects of demographic characteristics, vehicle attributes, social factors, and policy issues on consumer preferences for NEVs. First of all, on demographic characteristics, Power (2008) carried out a large-scale survey of 44,931 drivers in the US and found that highly educated and higher-income consumers were more willing to purchase an NEV. Furthermore, they found that, based on health issues, older drivers were more

likely to consider an NEV. In contrast, Potoglou and Kanaroglou (2007) identified middle-income consumers as having the highest potential for purchasing an NEV. Gao and Kitirattragarn (2008) interviewed New York taxi owners and found that younger owners, those who had been in the job for a shorter time, and those who had higher incomes were more willing to consider buying a hybrid vehicle. Similarly, Peters et al. (2011) found that a consumer's degree of concern regarding environmental issues and awareness of environmental behaviors influenced the decision to purchase an NEV, although the symbolic meaning associated with NEVs can have a negative effect on the willingness of an individual to pay for such a vehicle. In several other studies, the adoption of electric vehicles was shown to be motivated by environmental attitudes (Carley et al., 2013; Krupa et al., 2014). Kang and Park (2011) investigated factors influencing Korean consumers' acceptance of hydrogen fuel cell vehicles. Their results suggested that perceived risk, perceived benefits, consumer needs, consumer values, product perception, product experience, personal values (such as concern for the environment and a belief that individual efforts will bring positive results) affect acceptance. Erdem et al. (2010) demonstrated that factors such as gender, education level, wage, marital status, environmental awareness, risk attitude, acceptance of new technology, and the number of household-owned cars significantly affect the willingness of consumers to pay for hybrid electric vehicles (HEVs). Their research also pointed out that familiarity with the performance of cars was a significant factor affecting HEV purchases.

The earliest research on the influence of various NEV properties and performance features on consumer preferences dates back to the 1990s. Ewing and Sarigöllü (1998) used discrete choice experiments involving three alternatives (traditional cars, electric vehicles, and high fuel utilization vehicles) for US residents. They found that the price of the car, maintenance costs, speed performance, charging time, driving range, and pollution emission levels significantly affected the choice between an electric car and a higher fuel utilization vehicle. Caulfield et al. (2010) found that Irish consumers were more interested in attributes such as safety, reliability, and fuel costs than they were in the price of the car or its pollution emission level. In examining consumer attitudes towards natural gas vehicles, Saldarriaga-Isaza and Vergara (2009) surveyed Colombian residents and found that such factors as the size of the engine, whether the vehicle was owned by a company, price, and weekly mileage affected the decision to purchase a natural gas

vehicle. They also showed that consumers who were familiar with incentive policies that promoted NEV ownership and use, as well as individuals with a higher education level, were more willing to accept natural gas vehicles. Zhang et al. (2011) targeted private car owners in Nanjing, China, and found that they chose NEVs mainly based on purchasing pressure (the influence of friends, legal or regulatory requirements, tax incentives for purchasing alternative fuel vehicles, etc.) and product attraction. Hidrue et al. (2011) specifically quantified how various levels of NEV performance affected an individual's willingness to pay for an electric vehicle. In a web-based survey of 3,029 US residents, they showed that, in addition to age and education, green consumption and expectations of gasoline prices were important influences. They also reported that specific properties of the car such as driving range, charging time to full power, pollution emissions, cost of energy consumption, and relative speed had a more critical impact on the consumer's willingness to pay than did the individual's demographic characteristics. Such results suggest that safety, reliability, acquisition cost, driving range, charging time, and charging mode are significant factors for potential NEV purchasers. Jensen et al. (2013) investigated whether a consumer's choice of an electric vehicle was influenced by driving range, top speed, battery life, and fuel cost. They found that driving range was the major concern. In contrast, Degirmenci and Breitner (2017) argued that the environmental performance of electric vehicles was a stronger predictor than price and range confidence, asserting that the environmental properties of electric vehicles are more important than their general attributes. In addition, Helveston et al. (2015) analyzed the vehicles' properties by comparing the survey data of China and the United States. Chinese consumers were more concerned about driving range and charging time. A few reviews discussed the new technology of NEVs. For example, Carlucci et al. (2018) took hybrid electric vehicles as the research object to consider the relationship between hybrid technology and consumers' purchasing decisions. Their research also showed that total costs and running costs were major factors.

With respect to social influences, interpersonal network factors and social utilitarian factors appear to play a vital role in the decision to purchase an NEV. Heffner et al. (2007) pointed out that the symbolic significance of these vehicles was an important factor in the early California new energy car market. This is somewhat similar to Lane and Potter's (2006) findings that British

consumers were not particularly aware of the cost, performance, and environmental impact of clean cars, but rather it was the hot news related to clean cars that most affected their purchase decision. The impact of interpersonal networks on the NEV purchase decision has been analyzed by a number of scholars. For example, Axsen and Kurani (2011) studied the influence of interpersonal relationships on the cognition of hybrid electric vehicles (HEVs). They concluded that the interpersonal relationships of potential buyers played a significant role in their evaluation of HEV technology, and that the closer the relationship, the greater the impact. This suggests that knowing an HEV expert or someone who has related expertise and skills can have a positive effect on an individual's willingness to pay for an HEV.

To assess the influence of policy factors, Ozaki and Sevastyanova (2011) conducted a survey of 1,484 Toyota Prius owners in the UK to determine their motives for buying a hybrid vehicle. They found that fiscal policy and related preferential policy were the main motivations for their purchase. Gallagher and Muehlegger (2011) predicted that exemption from business or income taxes could effectively increase the sales of hybrid electric vehicles. In examining the sales of hybrid vehicles in the US from 2000 to 2006, they found that the effects of a business tax exemption were obvious and significant. Similarly, Chandra et al. (2010) provided supportive evidence that purchase tax exemption policy and tax rebate policy were significant incentives for NEV purchasers. On the other hand, Diamond (2009) studied US residents to determine how government incentive policies affect the purchase of NEVs and found that such policies did not stimulate consumer demand for hybrid cars; rather, it was the price of gasoline that was the most significant factor.

In the current paper, we use stated choice survey data collected in Shanghai, China, to examine the attitudes of Shanghai residents towards EVs and investigate how Shanghai consumers value various vehicle attributes. We believe that our study makes three contributions to the literature: First, previous studies on the purchase of NEVs in China have been mainly focused on government policies (Luo, 2014) and the demographic characteristics of consumers (Zhang , 2011). To the best of our knowledge, there is no published stated choice survey research investigating Chinese consumer preferences for specific NEV attributes. We fill this void. Second, in addition to presenting empirical results for our full sample, we also provide results for two

subsamples—potential EV purchasers and non-EV purchasers (that is, individuals who declare themselves unlikely to buy an EV in the next 10 years). We believe that these subsample results offer a more focused insight into Chinese consumer preferences. Third, we examine the determinants of being a potential EV purchaser. This is obviously important for both policy makers and EV manufactures, as understanding the factors that determine whether an individual is a potential EV purchaser can help both government and industry identify target consumers when devising new promotion policies or plans. Taken as a whole, our study has important policy implications for promoting the development of NEVs in China.

The remainder of the paper is organized as follows: The next section describes elements of the survey. Section 2.3 presents the econometric issues. Empirical results are presented and discussed in Section 2.4. The final section offers conclusions and suggestions for further research.

2.2 Methodology

2.2.1 Multinomial Logit model

The choice model in this study is based on random utility theory. The basic assumption in the random utility approach to choice modeling is that decision makers are utility maximizers; that is, given a set of alternatives, the decision maker will choose the alternative that maximizes his/her utility (Shen, 2006). Since the utility U of an alternative for an individual cannot be observed, it is assumed to consist of a deterministic component V and a random error term ε . Formally, the utility of alternative i for individual q can be expressed as:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{1}$$

Hence the probability that individual q chooses alternative i from a particular set J, which is composed of j alternatives, can be written as:

$$P_{iq} = P(U_{iq} > U_{jq}; \forall \quad i \neq j \in J) = P(\varepsilon_{jq} < \varepsilon_{iq} + V_{iq} - V_{jq}; \forall \quad i \neq j \in J) \tag{2}$$

To transform the random utility model into a choice model, certain assumptions about the joint distribution of the vector of random error terms are required. If the random error terms are assumed to follow the extreme value type I distribution and are assumed to be independently and identically distributed (IID) across alternatives and cases (or observations), the multinomial (or conditional) logit (MNL) model is obtained (McFadden, 1974). In the MNL model, the choice probability in Equation (2) is expressed as:

$$P_{iq} = \exp(\mu V_{iq}) / \sum_{j=1}^{J} \exp(\mu V_{jq}) \tag{3}$$

If we make the further assumption that the deterministic component of utility is linear in its parameters, i.e., $V_{iq} = \beta' X_{iq}$, then Equation (3) can be given as:

$$P_{iq} = \exp(\mu\beta' X_{iq}) / \sum_{j=1}^{J} \exp(\mu\beta' X_{jq}) \quad (4)$$

where μ represents a scale parameter that determines the scale of the utilities, which is proportional to the inverse of the distribution of the error terms. Typically, it is normalized to 1 in the MNL model. X_{iq} are the explanatory variables of V_{iq}, the attributes of alternative i. β' is the parameter vector associated with vector X_{iq}.

It is well known that heterogeneity among individuals is extremely difficult to examine in the MNL model (Shen, 2006; Louviere et al., 2000). This limitation can be relaxed, to some extent, by interaction terms between individual-specific characteristics and the various choices. However, there is a limit to this method since it requires a priori selection of key individual characteristics and attributes and involves a limited selection of individual-specific variables (Boxall et al., 2002).

2.2.2 Random Parameters Logit model

One approach that can account for individual heterogeneity is the Random Parameter Logit (RPL) (or Mixed Logit) model, which allows model parameters to vary randomly through assumed distributions (normal, log-normal, triangular, etc,). The model is a generalization of the MNL model and is summarized below:

$$P_{iqt} = \exp(\beta' X_{iqt} + \varphi' F_{iqt}) / \sum_{j=1}^{J} \exp(\beta' X_{jqt} + \varphi' F_{jqt}) \quad (5)$$

Where β' is a parameter vector associated with $i = 1,...,J$ alternatives and $q = 1,...,Q$ individuals that is randomly distributed across individuals. φ' is a vector of non-random parameters. X_{iqt} is a vector of individual-specific characteristics and alternative-specific attributes at observation *t*, and is estimated with random parameters. F_{iqt} is a vector of individual-specific characteristics and alternative-specific attributes at observation *t*, and is estimated with fixed parameters.

In this specification, a subset or all of the parameters in the β' vector can be assumed to be randomly distributed across individuals. These random parameters can also be defined as a function of the characteristics of individuals and/or other attributes that are choice invariant. Based on these defined attributes, the mean and standard deviations of the specified random parameters and contributions from these choice invariant attributes on random parameters are estimated by using the Maximum Simulated Likelihood (MSL) method. The RPL model is sufficiently flexible to provide the modeler a tremendous range within which to specify individual unobserved heterogeneity. To some extent, this flexibility offsets the specificity of the distributional

assumptions (Greene and Hensher, 2003).

2.3 Survey design and data collection

2.3.1 Questionnaire

The questionnaire used in this study has three main parts: In the first part, respondents were presented with eight statements. These statements are mainly based on relevant literatures and surveys (Erdem et al., 2010; Ewing and Sarigöllü, 1998; Caulfield et al., 2010; Saldarriaga-Isaza and Vergara, 2009; Zhang et al., 2011; Hidrue et al., 2011). Some have been adjusted through our pilot survey that was involved 100 questionnaires and implemented in driving schools in Baoshan district in Shanghai. For instance, the Statement 7 used in the pilot survey (i.e., "Driving a car more or less will have negative impact on the environment") was adjusted to the current one, which is based on the opinion from the pilot survey that the previous statement, to some extent, implies a negative impression of driving a car. In addition, we dropped "and other people" from the previous Statement 6 (i.e., "I think that our consumption should be responsible for the environment and other people") in the final questionnaire. A five-point Likert scale (strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree) was used. The details of the statements are given in Table 1. As shown, the statements are not only related to environmental consciousness and green consumption, but also refer to specific characteristics of China as well as general NEV features. As an example, Statement 3 relates directly to China's current reality. For developing countries like China, there is an inevitable contradiction between economic development and environmental protection. How Chinese consumers view this conflict is extremely important to the country's future development.

Table 1. The statements revealing respondents' environmental consciousness.

Statement 1	Environmental problems never bother me because I think environmental pollution problems are overestimated.
Statement 2	I have little or no fear that environmental problems will have an impact on myself and my family's health.
Statement 3	I can accept some of the developing countries like China have several pollution problems.
Statement 4	I am willing to pay more to buy environmentally friendly products.
Statement 5	I am willing to pay more to buy products with new technology.
Statement 6	I think that our consumption should be responsible for the environment.
Statement 7	Driving new energy vehicles can reduce the current environmental pollution.
Statement 8	I think that decreasing pollutant emission is important for me to choose a new energy vehicle.

The second section of the questionnaire targeted respondent preferences for various NEV

attributes. In our experiment, six attributes and four assigned levels of each attribute were used to generate hypothetical choice sets. In each choice set, we presented three alternatives: Traditional Vehicle, Electric Vehicle 1, and Electric Vehicle 2. The Traditional Vehicle serves as the status quo alternative. As presented in Table 2, each electric vehicle has six attributes (driving range, pollution level, charging time, speed, fuel cost, and price) and each attribute has four levels. These attributes and their levels were determined through a careful pre-investigation of current electric vehicle market data. We used SAS to create the choice sets. A fractional factorial design was employed and 64 valid choice sets were generated. These choice sets were further randomly divided into 16 versions, with each version consisting of four choice sets. Table 3 presents an example of the choice sets. Based on traditional gasoline vehicle market data, we choose the best-selling traditional vehicles (SAIC Volkswagen - Lavida) as a reference. The fuel cost for the Traditional Vehicle was assumed to be 0.5 RMB/km; the price was from 120,000 to 150,000 RMB. It should be noted that these two values did not vary across the choice sets. They were presented solely to allow respondents to easily compare with the values for the other two alternatives.

Table 2. Attributes and their levels of electric vehicles

Attributes	**Levels of attributes**
Driving range (kilometers on a full charge)	100 km, 200 km, 300 km, 400 km
Pollution degree (compared to traditional vehicle)	Reduced by 25%, by 50%, by 75%, by 95%
Charging time (for traveling 100 km)	5 hours, 3 hours, 1 hour, 10 minutes
Maximum speed (compared to traditional vehicle)	10% slower, 5% slower, 5% faster, 10% faster
Fuel costs (RMB per kilometer)	0.35 RMB/km, 0.25 RMB/km, 0.2 RMB/km, 0.1 RMB/km
Price (compared to traditional vehicle)	6,000 RMB higher, 24,000 RMB higher, 50,000 RMB higher, 100,000 RMB higher

Table 3. An example of choice sets

Features	**Traditional Vehicle**	**Electric Vehicle 1**	**Electric Vehicle 2**
Driving range (full charge)	–	200 km	400 km
Pollution degree (compared to traditional vehicle)	–	75% reduced	95% reduced
Charging time (for traveling 100 km)	–	1 hour	3 hours
Maximum speed (compared to traditional vehicle)	–	5% faster	5% faster
Fuel cost	0.5 RMB/km	0.1 RMB/km	0.1 RMB/km
Price (compared to traditional vehicle)	120,000 to	100,000 RMB	100,000 RMB

	150,000 RMB	higher	higher
Please choose one most-desirable vehicle by placing a √ in □	□	□	□

Questions in the third section of the questionnaire were related to demographic characteristics, which included gender, age, educational attainment, occupation, and annual income. Respondents were also asked whether they expected to own an electric vehicle sometime in the next 10 years. This yes/no question served as an indicator of potential EV purchase in our empirical analysis.

2.3.2 Data collection

Face-to-face interviews were conducted in Shanghai from December 2014 to November 2015. As venues for the survey, we chose 23 driving schools in the Baoshan, Hongkou, Jiading, Pudong, and Minhang districts, as well as a number of 4s automotive shops located in these same districts. We considered the likelihood of finding potential car buyers at these venues to be relatively high. Survey respondents were individuals who were seeking to obtain a driving license or who intended to buy a car.

A summary of the demographic characteristics of our survey respondents is provided in Table 4. Of the 760 respondents providing valid responses through a written survey, 487 (64.1%) were male and 273 were female (35.9%). The proportion of male respondents in our sample was higher than that reported in the Shanghai Statistical Yearbook 2016, which shows the official 2015 male-female ratio as 49.6% versus 50.4%. The mean age of respondents was 34; only 0.8% were younger than 17 or older than 60. Approximately 63% of the respondents had an annual income of at least 100,000 RMB (about 14,500 USD, where 1 USD = 6.70 RMB), which was considerably higher than the overall average in Shanghai. This is mainly due to the venues that we chose for the survey, as respondents there were highly likely to be potential car purchasers with an income that would allow them to buy and maintain a car. As for education level, 19.5% of the respondents held at least a master's degree, which was a higher percentage than the overall Shanghai percentage. Finally, more than half of the respondents showed an inclination to own an EV car in the next 10 years, and approximately 43% indicated that they pay attention to policies related to owning and driving an NEV.

Table 4. Demographic characteristics of the respondents (n = 760).

Demographic characteristics	**% in sample**

Gender	
Male	64.1%
Female	35.9%
Age (mean = 34)	
17 and below	0.4%
18-34	55.2%
35-59	43.9%
60 and above	0.4%
Educational attainment	
Bachelor degree or below	80.5%
Master degree or above	19.5%
Occupation	
Mid-level or manager in enterprise	14.4%
Salariat	27.0%
Entrepreneur	5.6%
Civil servant	11.0%
Professionals (teachers, doctors, lawyers, etc.)	14.4%
Others (student, freelance, etc.)	27.5%
Individual annual income (RMB)	
Less than 100,000	36.8%
100,000 - 200,000	39.5%
200,000 - 300,000	13.5%
300,000 - 400,000	5.2%
400,000 and above	5.0%
Family with cars	
Yes	62.7%
No	37.3%
Own an EV in the coming ten years	
Yes	54.5%
No	42.6%
No answer	2.9%
Pay attention to policies related to NEV	
No	17.9%
Neutral	38.7%
Yes	43.4%

2.4 Results

2.4.1 Preliminary comparison between potential EV and non-EV purchasers

Based on their answers to the question regarding expected EV ownership in the next 10 years, we divided the respondents into two categories—potential EV purchasers and non-EV purchasers. In this subsection, we present a simple comparison of the demographic characteristics (educational attainment, occupation, and income) of the respondents in these two categories. Formal Logit regression results are given in Subsection 4.3.

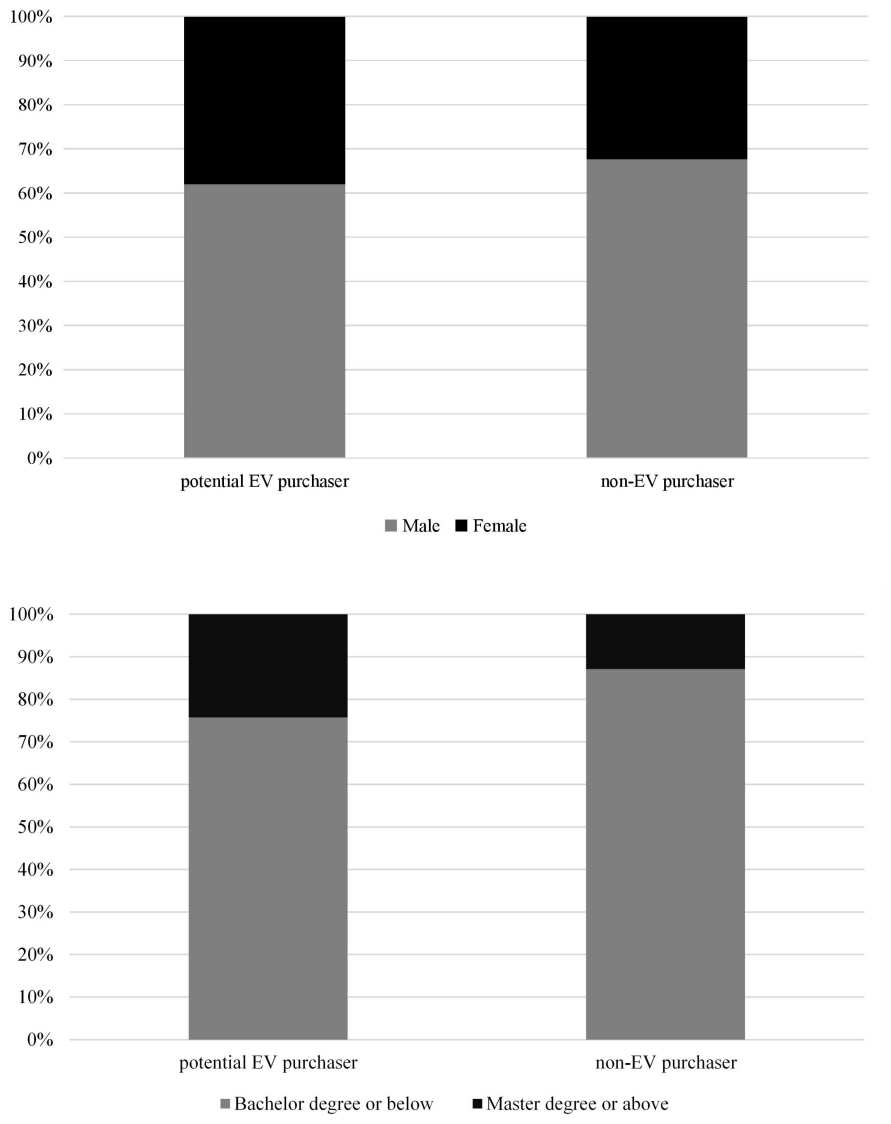

Figure 1. Gender and Educational attainment of potential EV and non-EV purchasers

As shown in the first histogram in Figure 1, the proportion of female potential EV purchasers is significantly higher than that of non-EV purchasers (38.0% versus 32.4 %, $z = 5.47$, $p <$

0.001).The bottom histogram presents that the proportion of potential EV purchasers holding at least a master's degree is significantly higher than that of non-EV purchasers (24.4% versus 14.5 %, $z = 11.54$, $p < 0.001$). These suggest that the purchaser who is female and hold higher educational attainment may be an important factor affecting an individual's interest in owning an EV.

Figure 2 shows the occupation distributions of potential EV and non-EV purchasers. While the distributions of the two groups are generally similar, more professionals and civil servants appear to prefer EVs. In addition, as can be seen in the distributions of annual income in Figure 3, respondents with higher incomes appear to be more willing to purchase an EV. This result is, to some extent, consistent with the results of the surveys of US consumers that are reported in Power (2008) and Gao and Kitirattragarn (2008).

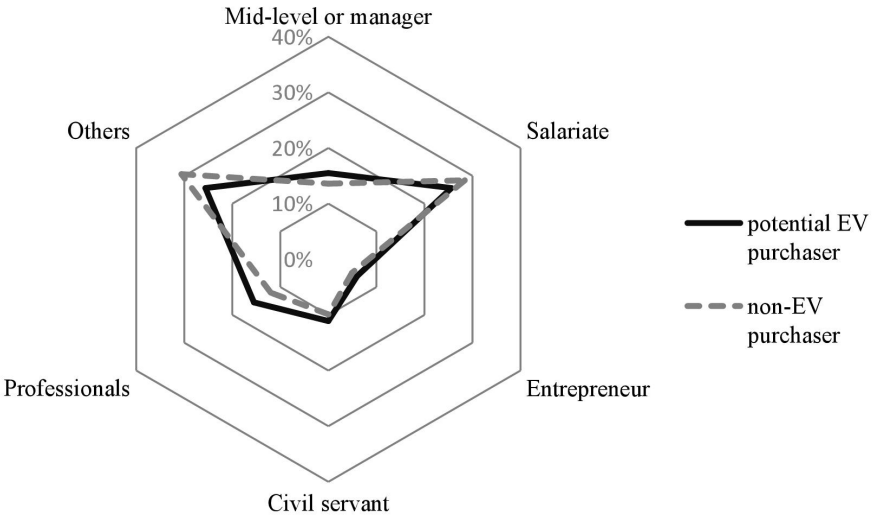

Figure 2. Occupation distribution of potential EV and non-EV purchasers

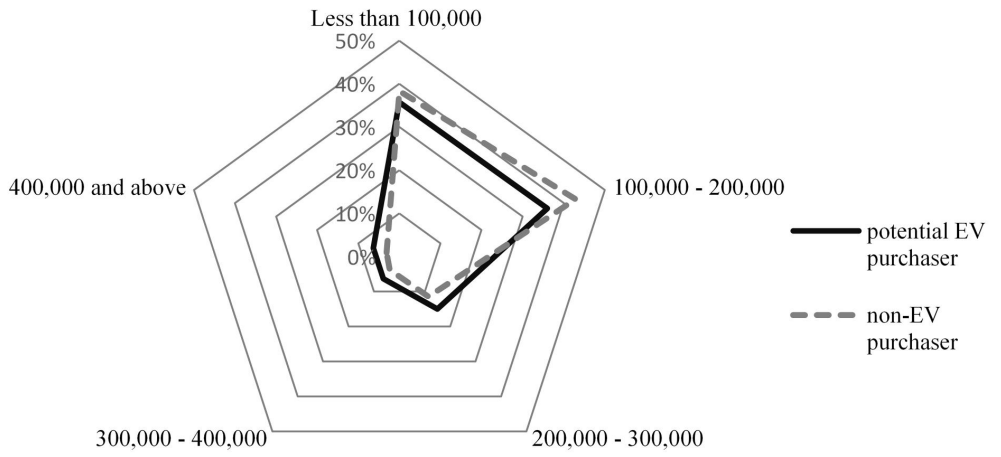

Figure 3. Income distribution of potential EV and non-EV purchasers

2.4.2 Results of the MNL and RPL regressions

Tables 5 and 6 give the results of the MNL and RPL models, respectively. In both models, estimates are shown for each of the three sample groups—the full sample, the subsample of potential EV purchasers, and the subsample of non-EV purchasers. Different from most previous research, we further divide the sample into two subsamples, so that we could observe whether these two groups have distinct preferences for the attributes of EV. The log likelihood values in the MNL model in all three cases were slightly lower than those in the RPL model, and the Log likelihood ratio test (LR=19.96, $p < 0.05$) suggests that the RPL model is statistically superior. In addition, a number of the standard deviations of the assumed random parameters in the RPL model are significant**,** which provides supportive evidence that taking unobserved individual heterogeneity into account is necessary. In both the MNL and RPL regressions, two of the EV attributes (driving range and charging time) were treated as discrete variables, while the other four attributes (pollution degree, maximum speed, fuel cost, and relative price) were treated as continuous variables.

2.4.2.1 Results of the full sample

Results of the MNL model for the full sample appear in the second column of Table 5. As shown, all the estimated parameters except in the case of *3 hours charging time* are statistically significant and have the expected signs. For example, relative to the base level of 100 km d*riving*

range, the parameters of the three alternative levels (200 km, 300 km, and 400 km) are significant and positive, and their magnitudes increase with driving range. This implies that the respondents prefer an EV with a longer driving range. *Pollution degree* and *maximum speed* are significant, with the expected positive signs, suggesting that the respondents prefer an EV that offers greater pollution reduction and/or a higher maximum speed. Estimates of the parameters of the two cost variables (fuel cost and relative vehicle price) show negative signs, which is consistent with fundamental economic theory. The statistically insignificant parameter of *3 hours* c*harging time* suggests that the respondents may consider three hours to be essentially the same as five hours for EV charging.

In the RPL model, we assumed that the parameters of *driving range*, *charging time*, *pollution degree*, *maximum speed*, and *fuel cost* follow a normal distribution. In order to calculate easily our "willingness to pay" (WTP) values, we treated the parameter of *relative price* as fixed. As shown in the second column of Table 6, there appears to be little difference between the means of the parameters shown here and the MNL estimates with respect to both signs and significance. However, the estimated standard deviations of *pollution degree*, *fuel cost*, and *10 minutes charging time* shown in the third column are significant, indicating that there exists heterogeneity among respondents in their preferences for these attributes.

Table 5. Estimation results of the MNL model

	Full Sample	**potential EV purchaser**	**Non-EV purchaser**
EV1 Constant	0.316**	-0.318	0.832***
	(2.25)	(-0.71)	(3.74)
EV2 Constant	0.141***	0.209	0.503
	(3.19)	(3.62)	(0.74)
Driving range (100 km as the base)			
200 km	0.370 ***	0.485***	0.263***
	(4.60)	(4.55)	(2.01)
300 km	0.633 ***	0.606***	0.605***
	(7.87)	(5.56)	(4.69)
400 km	0.848***	0.822***	0.865***
	(10.38)	(7.53)	(6.56)
Charging time (5 hours as the base)			
3 hours	0.197	0.472	0.066
	(0.24)	(0.22)	(0.50)
1 hour	0.283***	0.319***	0.319**
	(3.52)	(3.02)	(2.42)
10 minutes	0.547***	0.595***	0.560***
	(6.96)	(5.69)	(4.33)

Pollution degree	0.747***	0.745***	0.899***
	(6.95)	(5.14)	(5.26)
Maximum speed	2.611*	3.138***	1.421**
	(7.19)	(6.24)	(2.51)
Fuel costs	-0.982***	-0.700*	-1.450***
	(-3.25)	(-1.72)	(-3.00)
Relative price	-0.126***	-0.100***	-0.173***
	(-14.74)	(-8.97)	(-12.00)
Log likelihood	-2955.81	-1499.50	-1282.76
Sample size	3040	1656	1296

Notes: ***, **, and * indicate statistically significant at 1%, 5%, and 10% level of confidence, respectively. Z-statistics are reported in parentheses.

	Full sample		**Potential EV purchaser**		**Non-EV purchaser**	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
EV1 Constant	0.172		-0.904		0.807***	
	(0.77)		(-1.43)		(3.06)	
EV2 Constant	0.174***		0.329***		0.051	
	(2.85)		(2.60)		(0.62)	
Driving range (100 km as the base)						
200 km	0.505 ***	0.688	0.863***	1.551*	0.304**	0.302
	(4.08)	(1.21)	(3.20)	(1.90)	(1.97)	(0.56)
300 km	0.864 ***	0.393	1.161***	0.856	0.690***	0.123
	(5.51)	(0.79)	(3.65)	(0.92)	(4.28)	(0.28)
400 km	1.123***	0.167	1.405***	0.719	0.992***	0.053
	(6.41)	(0.54)	(3.34)	(1.09)	(5.71)	(0.08)
Charging time (5 hours as the base)						
3 hours	0.073	0.461	0.186	0.437	0.023	0.666
	(0.66)	(1.17)	(0.98)	(0.68)	(0.13)	(0.96)
1 hour	0.361***	0.773	0.584**	1.220*	0.336**	0.093
	(3.18)	(1.24)	(2.56)	(1.67)	(2.23)	(0.07)
10 minutes	0.697***	1.303***	1.224***	3.096***	0.592***	0.715
	(5.18)	(2.72)	(3.22)	(2.76)	(3.95)	(1.35)
Pollution degree	0.930***	1.486***	1.316***	2.755**	0.928***	1.291***
	(5.30)	(3.32)	(3.34)	(2.35)	(4.55)	(2.63)
Maximum speed	3.241***	2.323	5.604***	2.060	1.517**	2.671

	(5.23)	(0.61)	(3.34)	(0.56)	(2.32)	(0.70)
Fuel costs	-1.230***	4.145***	-1.615*	8.502**	-1.730***	0.788
	(-2.73)	(2.70)	(-1.75)	(2.56)	(-2.90)	(0.50)
Relative price	-0.157***		-0.174***		-0.193***	
	(-7.47)		(-3.96)		(-9.33)	
Log likelihood	-2945.83		-1483.76		-1279.15	
Sample size	3040		1656		1296	

Notes: ***, **, and * indicate statistically significant at 1%, 5%, and 10% level of confidence, respectively. Z-statistics are reported in parentheses.

2.4.2.2 Results of the subsamples

Based on a simple comparison of the subsample results presented in Tables 5 and 6, there appears to be very little difference in attribute preferences between potential EV purchasers and non-EV purchasers in both the MNL and RPL models. The only apparent difference is that several standard deviations of the random parameters in the RPL model are significant in the potential EV purchaser subsample but not in the non-EV purchaser subsample. This would seem to imply that there is heterogeneity among potential EV purchasers with respect to these attributes.

We also sought to determine whether there are differences in the willingness to pay values between the two subsamples. These values were calculated by dividing the parameters of the various attributes by the parameter of *relative price*.

Table 7 provides the WTP values for *driving range*, *charging time*, *pollution degree*, and *maximum speed* using both the MNL and RPL estimates. From the table, we find that (i) except for *3 hours* c*harging time*, all the WTPs are significant; (ii) all the WTP values in the subsample of potential EV purchasers are substantially higher than those in the subsample of non-EV purchasers, regardless of which model is used; (iii) the largest WTP disparity between potential EV purchasers and non-EV purchasers is for *maximum speed*, implying that improving the performance of this attribute might be the most important issue for attracting potential EV purchasers; (iv) in the RPL model, the net increase in WTP for each 100 km increase in *driving range* diminishes among potential EV purchasers—from 49,598 RMB for a driving range increase from 100 km to 200 km, to 17,126 RMB for a driving range increase from 200 km to 300 km, and to 14,023 RMB for a driving range increase from 300 km to 400 km—implying that an overlong driving range might not be a must for potential EV purchasers; and (v) the decrease in *Charging time* from 1 hour to 10 minutes seems to receive more intense reaction from potential EV purchasers than non-EV purchasers.

Table 7. Willingness to pay values in the MNL and RPL models

	MNL model		RPL model	
	Potential EV purchaser	**Non-EV purchaser**	**Potential EV purchaser**	**Non-EV purchaser**
Driving range (100 km as the base)				
200 km	48,563***	15,202***	49,598***	15,751**
300 km	60,679***	34,971***	66,724***	35,751***
400 km	82,307***	50,000***	80,747***	51,399***
Charging time (5 hours as the base)				
3 hours	47,261	3,815	10,690	1,192
1 hour	31,942***	18,439**	33,563**	17,409**
10 minutes	59,577***	32,370***	70,345***	30,674***
Pollution degree	74,597***	51,965***	75,632***	48,083***
Maximum speed	314,208***	82,139**	322,069***	78,601**

Notes: ***, **, and * indicate statistically significant at 1%, 5%, and 10% level of confidence, respectively. The unit of the WTP values is RMB.

2.4.3 Determinants of being a potential EV purchaser

According to the WTP results reported above, potential EV purchasers are willing to pay more than non-EV purchasers for the enhancement of each of the EV attributes presented to them. In this sense, to promote EVs in China, it is extremely important to know what makes a person a potential EV purchaser.

Table 8. Factor analysis results

Variable	Factor1	Factor 2	Factor 3	Uniqueness
Statement 1	0.1714	0.0734	***0.6147***	0.5874
Statement 2	0.0758	0.0906	***0.6062***	0.6186
Statement 3	0.0299	-0.0190	***0.3505***	0.8759
Statement 4	0.2334	***0.6085***	-0.1277	0.5590
Statement 5	0.1452	***0.6111***	0.0025	0.6054
Statement 6	***0.4377***	0.3757	-0.1767	0.6360
Statement 7	***0.5891***	0.1284	-0.0779	0.6304
Statement 8	***0.6024***	0.2509	-0.1402	0.5545

Notes: Factors 1, 2, and 3 refer to green consumption consciousness, acceptance of new product and new technology, and environmental protection awareness.

We used a Logit regression model to examine the determinants of being a potential EV purchaser. In addition to treating demographic variables as independent variables in the model, we added variables related to the individual's environmental awareness and green consumption consciousness. These additional variables were identified by conducting a factor analysis of the eight items included in the first part of the questionnaire. In all, three new variables were created and added to the Logit regression. Our three-factor solution was supported by the KMO test (the overall KMO measure of sampling adequacy = 0.708). Table 8 presents the results of the factor analysis. As shown in the table, the first new variable (factor 1) is marked by high loadings on statements 6, 7, and 8, and refers to the respondent's green consumption consciousness; the second new variable (factor 2) is marked by high loadings on statements 4 and 5, and refers to the respondent's acceptance of new products and new technology; the third new variable (factor 3) is marked by high loadings on statements 1, 2, and 3, and refers to the respondent's environmental protection awareness. It should be noted that the larger the values of factor 1, factor 2 and factor 3, the higher are the respondent's green consumption consciousness, the respondents' acceptance of new products and new technology and the environment protection awareness, respectively.

Table 9. Potential EV purchaser results from the Logit regression

Variable	**Coefficient**	**Marginal effect**
Constant term	-0.046	
Female	0.202***	0.050***
Age	-0.004	-0.001
Master degree or above	0.479***	0.117***
Individual annual income	0.092***	0.023***
Mid-level or manager	-0.351***	-0.086***
Salariat	0.126*	0.031*
Entrepreneur	-0.050	-0.012
Civil servant	-0.079	-0.019
Professionals (teachers, doctors, lawyers, etc.)	-0.056	-0.014
Family with cars	-0.149***	-0.037***
Pay attention to policies related to NEVs	0.712***	0.175***
Green consumption consciousness	0.258***	0.063***
Acceptance of new product and new technology	0.261***	0.064***
Environmental protection awareness	0.102***	0.025***
Log likelihood	-5072.30	
Sample size	680	

Notes: ***, **, and * indicate statistically significant at 1%, 5%, and 10% level of confidence, respectively.

Z-statistics and/or standard errors are not reported for the sake of space saving.

Table 9 reports the Logit regression results. As indicated, females, highly educated residents with a degree at the master's level or higher, members of the salariat, and residents who pay attention to policies related to NEVs are more likely to be potential EV purchasers. On the other hand, managers or holders of mid-level positions and respondents in families that already own a car are less likely to be potential EV purchasers. Additionally, the probability of being a potential EV purchaser increases with age, individual annual income, green consumption consciousness, acceptance of new products and new technology, and environmental protection awareness. These Logit results are obviously important for both policy makers and EV manufactures, as understanding the factors that determine whether an individual is a potential EV purchaser can help both government and industry identify target consumers when devising new promotion policies or plans.

2.5 Discussion and conclusion

In the current study, we conducted a stated choice survey in Shanghai to investigate the electric vehicle preferences of Shanghai residents. MNL and RPL models were used to analyze data for three samples—the full sample, a subsample of potential EV purchasers, and a subsample of non-EV purchasers. We found that the respondents in all three samples preferred EVs with a longer driving range, a shorter charging time, a faster maximum speed, lower pollution emissions, lower fuel cost, and a lower price. A comparison of the two subsamples showed that potential EV purchasers were willing to pay more than their non-purchaser counterparts for enhancing each of the EV attributes presented to them.

The WTPs for driving range increase in the distances, which suggests that consumers prefer longer driving ranges. However, the net increase in WTP for each 100 km increase in driving range diminishes among potential EV purchasers, which means driving range longer than 400 kilometers might not be necessary. In the current EV market in China, the top three enterprises of EV sales are BAIC (Beijing Automotive Industry Corporation) Motor, BYD (Build Your Dreams) Auto, and SAIC (Shanghai Automotive Industry Corporation) Motor. The driving range varies from distinctive types of EVs produced by these enterprises. For example, BYD e5 of BYD Auto could reach 300 kilometers driving range whereas the EV of BAIC Motor is just 150 kilometers. Based on our WTP results, the enterprises still have room to improve driving range to a suitable (but not too long) level for meeting consumers' needs.

Compared to 5 hours charging time, the WTPs for 10 minutes and 1 hour charging times are

statistically significant, while that for 3 hours is not. This implies that consumers are willing to pay for reducing charging time. However, there is a boundary. If charging time needed is above this boundary (e.g., 3 hours in this study), consumers are not willing to pay more for speeding up battery charging. Based on these results, fast charging technology is extremely essential and needs serious improvement when promoting EVs. The government might provide financial and/or technical supports to EV manufactures on the improvement of charging technology (e.g., graphene battery technology) to meet with the requirement of potential EV purchasers.

The determinants of being a potential EV purchaser were also investigated. We found that such factors as gender, age, educational attainment, occupation, income, green consumption consciousness, acceptance of new products and new technology, environmental protection awareness, whether the family already owns a car, and awareness of policies related to EVs were significant factors. By knowing these, both policy makers and EV manufacturers might design specific strategies for inducing Chinese consumers to be potential EV purchasers.

With respect to other policies to promote EVs, both the Chinese Central Government and the Shanghai Municipal Government have provided subsidies for purchasing EVs since 2013. Thus far, however, the subsidies have been focused on just one EV attribute—driving range. Since our empirical results offer supportive evidence that individuals are willing to pay for enhancing other EV attributes (e.g., reducing charging time, lowering pollution emissions, and increasing maximum speed) and an overlong driving range might not be a must for potential EV purchasers, government consideration of subsidizing these other attributes would seem appropriate.

Furthermore, the government should also improve the charging infrastructure in both urban and rural areas including on the expressway. This is because the charging problem during a long-distance travel is concerned by many Chinese consumers. According to the data from China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA), 171,609 charging stations had been constructed in China until June 2017. These charging stations mainly distribute in the developed provinces. For example, the top three of charging station amount-Beijing, Guangdong, and Shanghai contributed 69,037 in total, which accounts for 40% of the total charging stations. In contrast, in the less developed provinces such as Jilin, Inner Mongolia, and Tibet only 213 charging stations in total had been constructed. This unbalanced distribution of charging stations among regions is considered to be a critical factor that affects consumer's choice for EVs since the EV owners cannot drive freely during a long-distance travel. While we did not include the number of charging stations in the current study due to the reason that the charging mode in China was a controversial topic during the period of our survey, this factor is worthy of further investigation in the near future.

In addition, comparing with subsidy policies, a free license plate for an EV seems attractive to consumers. Since 2016, the Shanghai government has provided free license plates to EV owners. A private car license plate auction was introduced in Shanghai more than twenty years ago as a way to control the number of private vehicles. However, since the auction’s introduction, the

average winning price has continued to increase, while the chances of actually winning a plate have continued to decline. In May 2017, the average winning price soared to 90,209 RMB (about 13,464 USD, where 1 USD = 6.70 RMB), while the success rate fell to 3.8%. Given this circumstance, offering free license plates for EVs should be a very attractive "subsidy" to consumers and might be an important factor affecting their choices of an EV. Further research is needed to explore this issue.

Moreover, the data used in this paper was collected in Shanghai – one of the most developed metropolitan areas in China. There are huge regional differences in China, not only in the levels of economic development but also in the policies implemented by local governments such as subsidies, license plates, and regulations on cars. Therefore, whether the results obtained in the current study would also be applicable to consumers in other provinces of China is still unknown. Country-level data is needed to further explore our research question at much deeper extent.

Finally, it should also be noted that our results are based on a hypothetical choice survey, which means that there may be a hypothetical bias. Future research is highly encouraged in order to facilitate a comparison of our results with results estimated from actual purchase data.

Chapter III

Revisiting the impact of impure public goods on consumers prosocial behavior: a lab experiment in Shanghai

3.1 Introduction

Environmental issues have always been critical problems discussed by environmental economists. The externality is known as the basic cause inducing environmental problems from the perspective of standard economic theory. To eliminate the externality, "Top-down" governance (e.g., an environment tax) that refers to policies and regulations implemented by a government is commonly regarded as an effective means to deal with environmental issues. However, it might encounter the risk of rent-seeking (Damania, 1999; Helm, 2010) or harm social welfare considerably. To avoid this dilemma, green consumption and production, especially green consumption as a "bottom-up" measure, have become prevalent in recent years. Instead of compelling consumers to behave environmentally friendly, green consumption, which involves green products and services, could conveniently enable us to contribute to the environment. A great deal of previous literature focused on the factors impacting green consumption through empirical methods (e.g., Laroche et al., 2001; Albayrak et al., 2013; Panzone et al., 2016; Amatulli et al., 2017). Nevertheless, they rarely defined green consumption appropriately to describe how the factors affect the purchase of green products and theorize how green consumption influences consumers' behaviors after purchasing green products.

Green consumption could be treated as a means of private provision of a public good called "impure public good." Cornes and Sandler (1994) first attempted to model characteristic of an impure public good in which they imagined consumers could acquire joint characteristics–both

private characteristic and public characteristic in one commodity. Applications of this model have been studied in various fields, such as warm-glow giving (Andreoni, 1989; 1990), military alliances (Sandler and Murdoch, 1990), household refuse collection (Dubin and Navarro, 1988), agricultural research (Khanna et al., 1994), pollution abatement (Rübbelke, 2003), and environmentally friendly consumption (Kotchen, 2005; 2006). Kotchen (2005; 2006) followed the steps of Cornes and Sandler whilst improving the model so that it could explain more issues. Kotchen (2005) separated an impure public good into a conventional commodity as well as direct donation and applied comparative statics to capture how market prices, green production technologies, and social pressure impact the demand for an impure public good and its public characteristic. Kotchen (2006) eliminated the numeraire in Kotchen's (2005) model and demonstrated that according to heterogeneous preferences and endowments, the impure public good could have either a beneficial or a detrimental effect on environmental quality and social welfare.

Instead of utilizing the traditional methodology to reveal the relationship between an impure public good and direct donation, Munro and Valente (2016) implemented a within-subject dictator game experiment, wherein the impure public good was set as the combination of a private good and a public good. The counterintuitive result shown in this study was that the impure public good more or less decreased the activity of consumers' donation in specific green production technology. This study also found that a self-interested impure public good (i.e., one whose proportion of private characteristic is larger than that of its public characteristic) seems able to influence direct donation, whereas an altruistic impure public good does not. Munro explained that impure public goods gave individuals an excuse for decreasing their prosocial behavior without guilt. Engelmann et al. (2017) combined a real product (i.e., a box of chocolates) with a specific amount given to charity to represent the impure public good and produced results similar to those discussed in Munro's paper (Munro and Valente, 2016). The framed impure public good in Engelmann's paper (Engelmann et al., 2017), to some extent, was a self-interested impure public good as defined in Munro's paper (Munro and Valente, 2016) and the real product-based impure public good seemed to possess the identical characteristic of discouraging consumers' altruistic behavior. This implies that a self-interested impure public good needs to be discovered delicately. Nonetheless, both

papers mentioned above fixed an invariant proportion between private characteristic and public characteristic for a self-interested impure public good, which suggests the potential of investigating the influence of changes in the proportions of private and public characteristics of the impure public good on individuals' prosocial behavior.

In addition, moral licensing could be another implication for crowding out effect of donation. Mazar and Zhong (2010) implemented an experiment comprised purchasing conventional or green products and a dictator game to confirm the existence of the aforementioned issue. The results of their experiment were in line with Munro's (2016), but Mazar and Zhong suggested that their results were induced by a "moral licensing effect," which means that individuals behave less pro-environmentally after purchasing environmentally friendly products, as if they have obtained a green license. Brañas-Garza et al. (2013) conducted a sequence of dictator games and proved that previous donations would have impact on the present donations through the pattern of moral licensing (i.e., donate more in previous game but donate less in present game) and moral cleansing(i.e., donate less in previous game but donate more in present game). Momsen and Stoerk (2014) argued that the above phenomenon might be appropriate to interpret through mental accounting. They believed green products or services could be divided into two dimensions (i.e., consumption needs and ethical benefit), so that individuals will classify them into two mental accounts with distinct shadow prices (Thaler, 1985). Since consumers compare their choices between conventional and green products through the above two dimensions, their donations in a dictator game might decrease after ethical spending.

In the current study, a within-subject design was implemented in a dictator game experiment where participants were asked to allocate their endowments between a charity organization and themselves. We aim at investigating whether mental accounting exist when impure public goods appear in a dictator game. Our research makes contributes to previous literature in several way. First, we replaced the impure public goods in Munro's design (Munro and Valente, 2016) with a real product (i.e., a ball pen) and made an additional donation as part of the impure public good to a charity organization, as that in Engelmann et al. (2017). This change makes the experiment context closer to a real-world situation. Second, the proportion between private and public characteristics of the impure public good was designed to vary in the experiment. We attempt to

reveal whether this change in proportion will have an impact on participants' ethical choices. Moreover, it is worth noting that since the additional donation related to the impure public good was provided by the experimenter, every participant was confronted with the same amount of money when they made the allocation between the charity organization and themselves in each round of the experiment.

The remainder of this paper is organized as follows: The next section describes the methodology of impure public goods. Section 3.3 and 3.4 provide experiment design and implementation. Experimental results and discussions are presented in Sections 3.5 and 3.6, respectively. The final section offers conclusions and suggestions for further research.

3.2 Impure public goods theory

The theory foundation of this chapter is according to Kotchen's work(2006). There are $i = 1,2,\ldots n$ individuals in the market. We assume that they derive utility from the characteristics of the goods instead of the goods themselves. There are two characteristics, X (i.e. the private characteristic) and Y (i.e. the public characteristic). Here we could interpret the public characteristic Y as an environment quality. The preference of each individual could be captured by a strictly increasing and strictly quasi-concave utility function $U_i(X_i, Y)$, where X_i is the the consumption of private characteristic by individual i. Y is the aggregation provision of public characteristic and $Y = \sum_{i=1}^{n} Y_i$, where Y_i is the private provision of public characteristic by individual i. Specially, the provision of public characteristic by other individuals is noted $Y_{-i} = \sum_{j \neq i} Y_j$ and each individual takes the behaviour of others as exogenous.

Each individual has the exogenous endowment $w_i > 0$， which could be allocated by three market commodities: a conventional good c_i that simply generate X_i, a direct donation d_i that generate Y_i and a impure public good(or green good in this chapter) g_i which could generate X_i and Y_i jointly. For the sake of simplicity, c_i, d_i and g_i are set to normalize all price to unity which means one unit of c_i could generate one unit of X_i and one unit of d_i could generate one unit of Y_i. The green technology of green good are characterized by $\alpha > 0$ and $\beta > 0$ such that one unit of g_i could generate α unit of X_i and β unit of Y_i.

We could write the maximization of individual i's utility as follow[1]:

$$\begin{aligned} &max\ U_i(X_i, Y) = U_i(X_i, Y_i + Y_{-i}) \\ &s.t.\quad X_i = c_i + \alpha g_i\ , Y_i = d_i + \beta g_i\ , c_i + d_i + g_i \le w_i \end{aligned} \tag{6}$$

3.3 Experimental design

To explore the above issues, we applied a within-subject design of dictator games according to those used by Munro and Valente (2016) and Engelmann et al. (2017). There were six tasks, including two baseline tasks and four impure public good tasks in our design. The impure public good was specified as a bundle of a private good (i.e., a ball pen) and a public good (i.e., an additional donation to a charity organization), which mimics the setting in Engelmann et al. (2017). The chosen charity organization is Shanghai University Education Development Foundation (SHUEDF)[2] since it is a charity relevant to the participants in our experiments. Thus, participants might feel intense benefits if they donate to this charity. However, in the experiment instructions and during the implementation of the experiment, we did not use any environmental contents, which was an attempt to avoid a potential framing effect of green consumption on participants' choice behavior. Nevertheless, we could still obtain several general results regarding the impact of impure public goods from our specific setting.

Table 10. Features of tasks

Task	Order	Endowment	Impure public good	Constitution of impure public good
BL1	Round 1	60 RMB	No	
IPG1	Round 2	72 RMB	Yes (self-interested)	Private: a ball pen (12 RMB) Donation: to SHUEDF (3 RMB)
IPG2	Round 3	72 RMB	Yes (self-interested)	Private: a ball pen (12 RMB)

[1] In the experiment of this chapter, there are no provision of public characteristic by other individuals.(i.e. $Y_{-i} = 0$) and the consumption of conventional goods in the experiment are the amount of money which is allocated to the respondents themselves.

[2] SHUEDF was established in February 2014 and certified as a charity. This organization receives donations from either organizations or individuals for Shanghai University and the donations are applied to set up scholarships, educational funds, and to support university development, etc. The recipient in the dictator game is set as a charity in the current design, which follows the design of Eckel and Grossman (1996).

				Donation: to SHUEDF (6 RMB)
IPG3	Round 4	72 RMB	Yes (self-interested)	Private: a ball pen (12 RMB) Donation: to SHUEDF (9 RMB)
IPG4	Round 5	72 RMB	Yes (even-interested)	Private: a ball pen (12 RMB) Donation: to SHUEDF (12 RMB)
BL2	Round 6	60 RMB	No	

Notes: *BL1* and *BL2* refer to the two baseline tasks*; IPG1, IPG2, IPG3,* and *IPG4* refer to the four impure public good tasks.

The summary of the experimental tasks is presented in Table 10. Each participant was asked to complete six tasks during the experiment; the first and last task (i.e., *BL1* and *BL2*) were baseline tasks (i.e., traditional dictator game without impure public goods being introduced). In the baseline tasks, each participant was given 60 RMB (1 USD≈6.38 RMB) as his/her endowment for this task and was asked to allocate this amount between himself/herself and SHUEDF; the decision needed to be written on the recording sheet. The contents of the first and last task were the same. The purpose for which we included a baseline task at the beginning and one at the end of the experiments is first to eliminate the possible order effect of the baseline task (Moffatt, 2015) and second to examine subjects' possible behavioral changes after experiencing the impure public good tasks.

From the second to the fifth task (i.e., *IPG1* to *IPG4*), a specific impure public good was introduced into each task. The contents of the four impure public good tasks were similar. In *IPG1*, each participant received 72 RMB as the endowment and was asked to purchase a ball pen whose retail price is 12 RMB. When the participants purchased the ball pen with 12 RMB, 3 RMB out of the 12 RMB would be donated to SHUEDF by the experimenter. After that, the participants needed to determine how to allocate the remaining 60 RMB (72 RMB subtract 12 RMB) between themselves and SHUEDF, and the decision needed to be written on the recording sheet. The amount of the donation out of the 12 RMB (i.e., the fixed price of the ball pen in every impure public good task) in *IPG2*, *IPG3*, and *IPG4* increased successively; it was 6, 9, and 12 RMB, respectively.[3] In addition, the impure public good in *IPG1*, *IPG2,* and *IPG3* could be regarded as

[3] There are two reasons for not assigning the amounts of donation out of the 12 RMB in random order. First, we

a self-interested impure public good (i.e. $\frac{\alpha}{\beta} > 1$), since the amount of donations offered with the impure public good in these tasks was lower than the retail price of the ball pen. The impure public good in *IPG4* was set as an even-interested impure public good (i.e. $\frac{\alpha}{\beta} = 1$), in which the amount of donation equals the retail price of the ball pen.

3.4 Experiment implementation

Participants were recruited at Shanghai University (SHU) through advertisements posted on the internet, and 137 students (Female students account for 57.66%) took part in the experiment. The detailed demographic characteristics of participants are shown in Appendix 3. A total of eleven sessions took place in two classrooms (one for the experiment and the other for payment) at the School of Economics, Shanghai University, on May 19th and 20th, 2018.

In each session, we implemented the same six tasks. Each participant received written experimental instructions (Appendix 1) and a recording sheet (Appendix 2) at the beginning of the experiment. Before starting the experiment, one experimenter first read the instructions loudly to assure the participants understood the whole procedure. Then, each participant was asked to finish the above-explained six tasks in order (i.e., from round 1 to round 6) without any communication with other participants and was informed that their decisions and earnings would remain anonymous and private. The rewards of each task or round were the amount participants left for themselves in that task or round. The participants were asked to raise their hands to hand over their instructions and recording sheets when they finished their own tasks and one experimenter would approach them with an automatic dice machine containing one die. The participants pushed the button on the machine by themselves, and the number shown on the die (any number from 1 to 6) determined the number of the task or round they could acquire a reward for. When all the participants in this session finished their tasks as well as rolled the die on the machine, they were asked to answer a questionnaire[4], and then took this questionnaire to another classroom to receive

conducted the experiment in paper-and-pencil style and not via a computer, so perfect randomization was hard to achieved. Second, the participants might check or correct their decisions in previous tasks because all the decisions were written on the same recording sheet; thus, whether the order was random would not be a possible factor affecting participants' choices.

[4] The contents of the questionnaire were about choices for mobile payments. None of questions were relevant to the purpose of this study.

their rewards. The sessions lasted from 30 to 40 minutes, and the average earnings were 42.6 RMB, which is above the minimum hourly wage in Shanghai.

3.5 Results

3.5.1 Descriptive evidence of donation in each task

Table 11 presents the percentage of voluntary donation of five specific contributors in six tasks. In the baseline tasks (i.e., *BL1* and *BL2*), participants simply needed to make a choice on how to allocate the 60 RMB between themselves and SHUEDF; thus, the participants' voluntary donations equal the total donations, since impure public goods were not involved in these two tasks. In the impure public good tasks (i.e., *IPG1*, *IPG2*, *IPG3*, and *IPG4*), participants were compelled to purchase a symbolical impure public good consisting of a ball pen at a fixed price of 12 RMB and a donation to SHUEDF at a varying amount (i.e., 3 RMB, 6 RMB, 9 RMB, and 12 RMB in *IPG1*, *IPG2*, *IPG3*, and *IPG4*, respectively) donated by the experimenter. The value of the ball pen was then excluded from the endowment of 72 RMB and the participants could make their own determinations on how to allocate the remaining 60 RMB between themselves and SHUEDF. Due to this design, the total donations are larger than the voluntary donations of participants in the tasks with an impure public good.

Table 11. The percentage of voluntary donation of five specific contributors in six tasks

	Zero contributor	**10 RMB contributor**	**20 RMB contributor**	**30 RMB contributor**	**Full contributor**
BL1	3.7%	27.0%	21.9%	24.1%	1.5%
IPG1	4.4%	20.4%	10.2%	12.4%	2.2%
IPG2	5.1%	16.8%	8.8%	10.2%	2.2%
IPG3	8.0%	17.5%	11.7%	6.6%	2.9%
IPG4	16.8%	19.7%	13.1%	8.0%	2.9%
BL2	7.3%	27.0%	17.5%	21.2%	1.5%

In Table 11, we first look at the two baseline tasks. Five out of the 137 participants (3.7%) shared nothing with SHUEDF in *BL1* task, whereas 10 out of the 137 participants (7.3%) donated nothing in the *BL2* task. Two participants donated all their endowments (i.e., 60 RMB) in both the *BL1* and *BL2* tasks. About 27% of participants donated 10 RMB out of the 60 RMB in both the baseline tasks, which accounts for the highest proportion of participants. The second highest proportion of participants in *BL1* and *BL2* appears at 30 RMB donations, which account for 24.1% and 21.2%, respectively. Nearly 21.9% and 17.5% of participants in the *BL1* and *BL2* tasks, respectively, account for the third highest proportion of participants, who shared 20 RMB to SHUEDF. More participants shared nothing with SHUEDF in the impure public good tasks than in baseline tasks, except for *IPG1* and *IPG2,* in which the number of zero-contributors in these two tasks is less than that in the *BL2* task. The number of full-contributors (i.e., those who donated 60 RMB) in each impure public good task is more than that in the baseline tasks. In addition, Table 11 shows that the 10 RMB, 20 RMB, and 30 RMB donations are still three critical values in the impure public good tasks. The proportions of participants who donated 10 RMB are 20.4%, 16.8%, 17.5%, and 19.7% in *IPG1*, *IPG2*, *IPG3*, and *IPG4*, respectively. Participants who donated 20 RMB account for 10.2%, 8.8%, 11.7%, and 13.1% in *IPG1*, *IPG2*, *IPG3*, and *IPG4*, respectively. With respect to the participants who donated half of their endowment after purchasing the impure public good, the proportions are 12.4%, 10.2%, 6.6%, and 8.0% for *IPG1*, *IPG2*, *IPG3*, and *IPG4*, respectively.

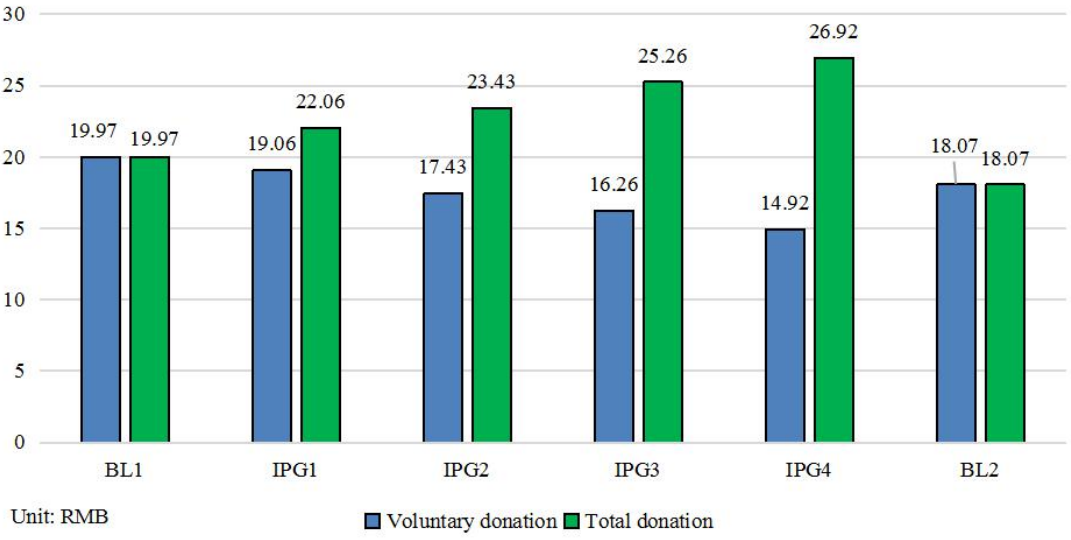

Fig 4. Mean of voluntary donations and total donations

The mean of the voluntary donations and total donations in the six tasks are shown in Figure 4. With respect to voluntary donations, the mean in *BL1* is higher than that in *BL2* (19.97 versus 18.07 RMB). When comparing to those in the baseline tasks, the mean donations in the impure public good tasks are almost always lower. Moreover, the mean voluntary donations seem to decrease as the donations provided by experimenter in the impure public good tasks increase (i.e., as the public characteristic in the impure public good increases). Nevertheless, the mean total donations presented in Figure 4 follow the opposite trend, showing a positive relation with the experimenter's donations. The reason for this might be that the increase of the experimenter's donations does not crowd out participants' voluntary donations completely. For instance, the decrease of the mean voluntary donations between *IPG1* and *IPG2* is 1.627 RMB, which is less than the 3 RMB increase in the experimenter's donation. The opposite trend in the mean voluntary donation and mean total donation to some extent probably reflects the participants' specific mind process when they make donations. This issue will be further discussed later.

Table 12. Panel Tobit regression estimation results of voluntary donation

	Voluntary donation	
Constant	47.203	(4.19)**
IPG1	-0.951	(-1.47)
IPG2	-2.677	(-4.14)**
IPG3	-3.991	(-6.16)**
IPG4	-5.717	(-8.75)**
BL2	-2.049	(-3.18)**
Female	2.254	(1.02)
Age	-0.378	(-0.91)
Hometown	1.531	(0.61)
Living expenses	-5.386	(-2.72)**
Majoring in economics	-4.674	(-2.15)*
Wald-test		
IPG1 and *IPG2*	$\chi^2(1) = 7.12,\ p = 0.008$	
IPG2 and *IPG3*	$\chi^2(1) = 4.10,\ p = 0.043$	
IPG3 and *IPG4*	$\chi^2(1) = 6.91,\ p = 0.009$	
Log likelihood	-2571.10	
Sample size	137	

Notes: ** and * indicate statistical significance at the 1% and 5% levels of confidence, respectively. Z-statistics are reported in parentheses. *IPG1, IPG2, IPG3, IPG4,* and *BL2* are dummy variables of the *IPG1, IPG2, IPG3, IPG4,*

and *BL2* tasks. *Female* is dummy variable referring to the female participants. *Age* is a continuous variable referring to the age of participants. *Hometown* is a dummy variable that equals to 1 if the participant came from rural area, and 0 if not. *Living expenses* is a continuous variable referring to the living expense per month of participants. *Majoring in economics* is a dummy variable that equals to 1 if the participant majors in economics, and 0 if not.

3.5.2 Regression analysis of voluntary donation

Table 12 presents the results of panel Tobit regression treating the amount of voluntary donation as dependent variables[5]. The left-censored and right-censored values in the regression were 0 and 60, respectively. Individual characteristics of participants and the task dummy variables as independent variables are also included in the regression. Of five individual characteristics variables, *Female* (i.e., male=0, female=1), *Hometown* (i.e. urban area=0, rural area=1), and *Majoring in economics* (not majoring in economics=0, majoring in economics=1) were set as dummy variables, whereas *Age* and *Living expenses* were continuous variables. As regards the tasks, we defined six dummy variables that equal 1 if participants took part in the task and 0 otherwise. The dummy variable for the first baseline task (i.e., *BL1*) was regarded as the reference of the other five task variables.

As shown in the second column of Table 12, all the estimated parameters of the task dummy variables except that of *IPG1* are statistically significant and have negative signs, implying that the voluntary donations in the latter four tasks are significantly less than those in the reference task (i.e., *BL1*). Furthermore, the magnitudes of *IPG1*, *IPG2*, *IPG*3, and *IPG4*—although *IPG1* is not significant— decrease extras the experimenter's donations increase and the Wald test in Table 12 demonstrates the voluntary donations in *IPG1*, *IPG2*, *IPG*3, and *IPG4* are statistically different from each other. This result is consistent with the mean voluntary donation trend shown in Figure 4, which implies participants prefer to donate less if the impure public good contains more public characteristics (i.e., a higher donation from the experimenter). The statistically insignificant parameter of *IPG1* suggests that the participants may consider *IPG1* to be substantially the same as *BL1*, possibly because the public characteristic part in this task is smaller than those in other impure public good tasks. It is unexpected that the donation in *BL2* is significantly less than that in *BL1*, whereas the smaller parameter in absolute value of *BL2* than those of *IPG2*, *IPG3*, and *IPG4*

[5] The Tobit regression estimation results of total donation are shown in the Appendix 4.

suggests the donation in *BL2* is still larger than those in these three impure public good tasks. In addition, the incomplete crowding out effect of donations provided by the experimenter, to some extent, could also be captured by these results. For instance, the parameters of *IPG2* and *IPG3* are -2.677 and -3.991, respectively. The difference is 1.314 (=3.991-2.677) RMB, which means the donation in *IPG3* is 1.314 RMB less than that in *IPG2*. This amount is less than the increase of 3 RMB in the experimenter's donation; therefore, it seems that the increase in the public characteristic of the impure public good does not completely crowd out participants' voluntary donations.

With respect to individual characteristics, the parameters of *Female*, *Age*, and *Hometown* are statistically insignificant, which indicates these characteristics do not affect the donation behaviors in our experiment. The parameters of *Living expenses* and *Majoring in economics* are both statistically significant and have a negative sign, suggesting that participants who spend more on living expenses per month or who major in economics would behave less altruistically and donate less. The result that students majoring in economics are inclined to behave less prosocially is consistent with that found in Marwell and Ames (1981) and Cadsby and Maynes (1998).

3.6 Discussion

The impure public good tasks of our experiment involved impure public goods with specific public characteristics. The impure public goods in *IPG1*, *IPG2*, and *IPG3* could be treated as self-interested impure public goods, since the amounts donated by the experimenter are less than the value of the private characteristic (i.e., the 12 RMB cost of the ball pen), whereas the impure public good in *IPG4* could be treated as an even-interested impure public good because the amount donated by the experimenter is equal to the value of the private characteristic. From the results described in Section 3.5, we could deduce that the voluntary donations of participants in the impure public good tasks will obviously decrease as the experimenter's donations increase; in other words, participants will behave less altruistically when they face an impure public good with more public characteristics or their voluntary donation will be affected by crowding out effect of impure public good, regardless if it is a self-interested or even-interested impure public good.

3.6.1 Mental accounting

The interpretation of participants' voluntary donations showing a negative correlation with the experimenter's donations may be that participants set a specific amount for donations to SHUEDF (based on the expectation of the participants) and the experimenter's donations crowd out their voluntary donations. If this is true, the total donations among impure public good tasks should not be statistically different. However, we find out that total donations statistically increase along with the experimenter's donations[6], but the magnitudes of this increase are less than the increase in the experimenter's donations. We might interpret this behavior as a phenomenon of incomplete "mental accounting," since the participants indeed decreased their voluntary donations to allow room for the experimenter's donations, as shown in the regression results of voluntary donations. Participants might treat the two types of donations as one mental account (i.e., donations to SHUEDF) instead of separating these two donations into distinct mental accounts. This implies that the experimenter's donations might be regarded by participants as their own donations to SHUEDF, since it is their purchases of the impure public goods that induce these donations by the experimenter. This interpretation is to some extent consistent with that of Momsen and Stoerk (2014). Nonetheless, this mental accounting is incomplete because participants' voluntary donations cannot completely crowd out those by the experimenter. The possible implication might be that the participants behave slightly more altruistically to offset the crowding out effect, which results in the mental accounting being incomplete. Moreover, the recent studies on expectation in donation issues (e.g., Brañas-Garza et al., 2017; Pereda et al., 2017) might be utilized to partly interpret why the participants behaved slightly more altruistically. Since the purpose of the SHUEDF is to help students and support university development, the participants might set an expectation of how much they could benefit from the SHUEDF, which possibly serves as a potential factor affecting participants' voluntary donations.

[6] It should be noted that the increase of total donation is caused by the increase of mandatory contributions from the experimenter.

3.6.2 *BL1* vs. *BL2*

The donations in *BL2* are significantly lower than those in *BL1*, which indicates participants behave more selfishly after experiencing the impure public good tasks. For the sake of determining how individuals donated in *BL1* and *BL2*, we have a closer look at the donations in both *BL1* and *BL2.* About 24.8% (34 out of 137) participants donated less in *BL2* than in *BL1* and the mean difference of these donations is 9.32 RMB. Of the 34 participants, 13 donated 5 RMB less in *BL2,* and 11 donated 10 RMB less in *BL2.* The maximum and minimum difference is 40 RMB and 1 RMB, respectively, and 85.3% of the 34 participants' differences in their donations between *BL1* and *BL2* are at least 5 RMB. We check the voluntary donations in the four impure public good tasks prior to *BL2* to seek a reasonable explanation. We find out that 23 out of these 34 participants' donations decreased continuously, which led us to suspect that their decreased donations in *BL2* might be influenced by the previous tasks. The selfish behavior seemingly exists as a mental inertia that causes participants to act less altruistically even when the experimenter's donations were excluded in *BL2.* Nevertheless, the crowding out effect vanished in *BL2;* therefore, the participants' voluntary donations were more or less higher in *BL2* than those in the impure public good tasks.

3.7 Conclusions

In the current study, we applied a within-subject design in the dictator game experiment in accordance with that in Munro and Valente (2016) and Engelmann et al. (2017). Our results suggest that an incomplete mental accounting effect could be captured through our experiment. The effect of the impure public good on participants' prosocial behavior shown in our study demonstrates the importance of the public characteristic in the impure public good and suggests that the donations by a third party (e.g., the experimenter in the current study) might be a vital factor affecting individuals' voluntary donations.

Moreover, an impure public good is considered as an alternative path to encourage consumers to contribute more to the public good without being mandatorily required. However, our research offer evidence that impure public good consumption alone might not be a sustainable measure to induce consumers to behave more prosocially. Hence, we should be prudent when

promoting impure public goods as an instrument to aid contributions to public goods. We need to construct an appropriate institution for the impure public goods market that could cultivate consumers to behave in alignment with sustaining prosocial actions. Therefore, producers of impure public goods, as the main participants in the market, should also be considered in future research on impure public goods.

Finally, we designed two baseline tasks, one at the beginning and another at the end of the experiment. The results indicate that participants' behaviors in the impure public good tasks, which took place between the two baseline tasks, might impact their behaviors in the second baseline task. Participants became more selfish as the experimenter's donation increased, and this trend decreased their donations in the last baseline task. This inertia influence should be delicately checked through exploring how opposite settings related to the impure public good tasks (i.e., the continuous decrease of the experimenter's donations) affect participants' voluntary donations and whether this influence has an inertia affecting their behaviors when the impure public good is removed. In addition, in the current paper we only consider the case that the mandatory donation is lower than or equal to the private one in impure public good treatments, the effect of impure public goods with which the mandatory donation is higher than the private one would be also interesting and need to be explored. We leave these issues open and welcome any efforts to further explore them at a much deeper level.

Chapter IV

Valuing rural residents' attitude regarding agri-environment policy: A best-worst scaling analysis

4.1 Introduction

When we examine environmental pollution, industrial pollution is usually considered to be the main topic of study. However, agricultural intensification, the main characteristic of modern agriculture, can also cause serious environmental problems such as soil erosion, water pollution, and biodiversity loss in rural areas. Agri-environmental public goods, which provide efficient ways to promote agri-environmental protection, can be defined as environmental externalities from agricultural activities that have characteristics of non-rivalry and non-excludability (Jones et al., 2015). There are nine targeted agri-environmental public goods, including water quality, soil quality, and biodiversity. The provision of agri-environmental public goods has positive externality which should be subsidized by the government. Consequently, the common resolution of agri-environmental problems is for the government to offer an additional subsidy to farmers (i.e., the source of agri-environmental pollution) to encourage them to provide agri-environmental public goods during the production process.

The research regarding agri-environmental policies mainly covers cases in developed countries like the US and member countries of the EU. Some research focuses on the evaluation of policy and the comparison between different policies implemented in different countries (Baylis et al., 2008; Dobbs and Pretty, 2008). Regarding the various types of agri-environmental policies, Payments for Environmental Services (PES) is the most appealing, and quite a bit of research focuses on its theory and practice (Engel et al., 2008; Wunder, 2015; Dedeurwaerdere et al., 2015). Other research centers on specific topics concerning agri-environmental policies. In one example,

Brady et al. (2009) evaluated the long-term impact of the 2003 EU reform on farm structure, landscape, and biodiversity. The result indicated that the reform may have had negative effects on the landscape by eliminating the link between government support and production. In another example, Mettepenningen et al. (2011) defined factors influenced by public transaction costs of agricultural environmental policies. The research showed that the factors perceived to be important included the frequency of information exchange with the farmers' association, environmental managers trusting the farmers, and mitigating the adverse effects of agriculture.

Instead of focusing on the top-down impact of agri-environmental policies, some research considered the attitudes of agri-environmental protection stakeholders in agri-environmental policies through stated preference methods such as the Discrete Choice Experiment (DCE). Ruto and Garrod (2009) investigated the effect that scheme design can have on encouraging participation. Farmers were found to require greater financial incentives to join schemes with longer contracts, less flexibility, or higher levels of paperwork. Broch and Vedel (2012) investigated preference heterogeneity for agri-environmental contracts (e.g., afforestation contracts) among farmers in Denmark, and found that having the option to cancel the contract decreased farmers' required compensation level, whereas monitoring increased it. Moran et al. (2007) investigated the Scottish public's preferences for future agri-environmental reform. They suggest that the public has defined preferences and a willingness to pay (using general income taxation) to affect changes beyond the status quo.

Agri-environmental policies in China did not start until recently; thus, the research on this issue is scarce. There are two descriptive studies in the literature. In one study, Zhu et al. (2018) conducted a comparative study of three agricultural environmental policy models. The results indicated that agri-environmental schemes in China have significantly enhanced farmer enthusiasm toward farmland protection and enhanced their satisfaction with the policy. In another study, Zhang et al. (2015) investigated farmers' attitudes towards agricultural infrastructure projects and perceptions of agri-environmental issues in Beijing and Changsha. The results indicated that farmers were generally dissatisfied with the top-down implementation process of agricultural infrastructure projects. However, these descriptive studies have not investigated how and to what extent Chinese farmers evaluate the factors of agri-environmental schemes in China.

Therefore, in the current study, we would like to fill this gap by providing empirical analysis on agri-environmental policies.

An alternative method called best-worst scaling (BWS) could elicit more information than DCE (Guo and Shen, 2019). The multi-profile case in BWS includes an extra question asking which profile respondents like least for each choice set of DCE. Analysis of these results could provide additional ranking information of attribute levels. For this reason, we use the BWS multi-profile case in the following analysis to further analyze the attitude of rural residents on agri-environmental policies in China.

The remainder of this paper is organized as follows: Section 4.2 describes the status of agri-environmental policy. Section 4.3 covers the methodology of BWS. Survey design and data collection is presented in Section 4.4. Section 4.5 provides the results of regressions. Finally, Section 4.6 offers discussions and conclusions.

4.2 Status of agri-environmental policy

4.2.1 Status of agri-environmental policy in developed countries

EU: The EU mainly targets what constitutes an agricultural externality (i.e., the agri-environmental public goods). Since the agri-environmental public goods are being supplied privately by farmers, EU member states consider it legitimate to offer compensation in return for their provision (MAFF, 2000). Agri-environmental schemes (AES) provide financial support for member states to design and implement agri-environmental measures (AEM). The governments are inclined to offer compensation to farmers who provide public goods if they commit to using environmentally friendly agricultural inputs or technologies, regardless of whether those techniques are used on specific land and how the technology will have an impact on the environment (Baylis et al., 2008).

United States: The US administration tends to focus on the actual and potential negative relationship between agricultural and environmental goals as well as reducing agriculture's negative externalities (Baylis et al., 2008). Farmers in the United States are often paid specifically to return farmland to its native state. The US Conservation Reserve Program uses the

Environmental Benefits Index (EBI), which requires a significant amount of information. It is based on data such as the environmental characteristics of applicants' fields and the benefits produced by one or more actions, such as only retiring the land versus retiring the land and planting native grasses.

Japan: Eco-friendly agriculture in Japan is defined as a sustainable method of farming to lower the environmental load by decreasing chemical fertilizers and pesticides through improving soil quality while taking advantage of agriculture's inherent material recycling power, with consideration for harmonization with productivity (Yamada, 2011). Recent agri-environmental policies in Japan include the New Policy for Food, Agriculture, and Rural Areas (New Policy), issued by the Ministry of Agriculture, Forestry and Fisheries (MAFF) in 1992, and the Food, Agriculture and Rural Areas Basic Act (New Basic Act), passed by the National Diet in 1999. The New Policy defined the concept and direction of eco-friendly agriculture but did not include details on how to implement it. The New Basic Act, however, provided more comprehensive coverage of agri-environmental issues based on the content put forth in the New Policy. The main concept of the New Basic Act is stated as "the sustainable development of agriculture by strengthening the natural recycling functions and the realization of the multifunctionality of agriculture." which addresses the multifunctionality of agriculture rather than just traditional food production (Yamada, 2011).

4.2.2 Status of agri-environmental policy in China

The Bulletin of the national survey on soil pollution released on 17 April 2014 acknowledged that overall, 16.1% of soil in China was polluted, consisting of 19.4% of farmland, 10.0% of forest land, 10.4% of grassland, and 11.4% of unused land (Wan et al., 2018). The overuse of fertilizer and pesticide contributed to 70% of farmland pollution and is the primary human cause of widespread soil pollution. Figure 5 shows fertilizer consumption and pesticide use in China, a trend that had been increasing until 2014. While fertilizer consumption and pesticide use decreased slightly after 2014, both levels were still elevated.

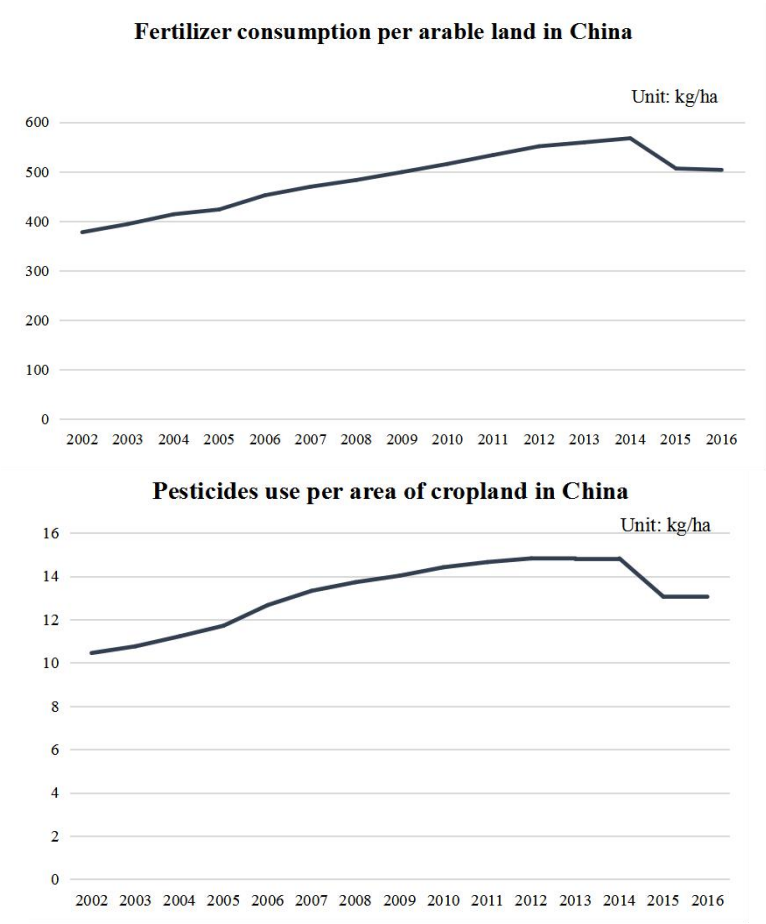

Figure 5. Fertilizer consumption and pesticide use in China

The agricultural policy in China focused mainly on agricultural production and farmers' income before 1978. In 1978, the government realized rural areas in China had become pollution shelters and started to take action.

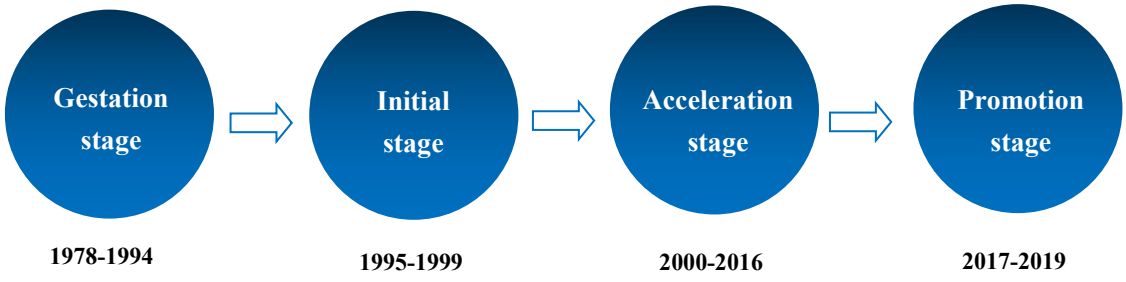

Figure 6. Four stages of agri-environmental policy development in China

As presented in Figure 6, agri-environmental policies in China have experienced four stages since 1978 (Han et al., 2019). In the gestation stage, from 1978 to 1994, the pollution problem in rural areas came mostly from the transfer of industrial pollution. However, the overuse of manure

and pesticide began having serious consequences during the transition from traditional agriculture to modern agriculture. The State Council released “Opinions on developing ecological agriculture and strengthening the protection of the agri-ecological environment” and “Decision on strengthening environmental protection“ to promote ecological agriculture (Han et al., 2019). Considerations regarding the prevention and control of agricultural non-point source pollution were still at a nascent and insignificant level in the overall environmental protection policy. There were only general targets and no specific or targeted policy actions.

During the initial stage, from 1995 to 1999, the use of fertilizer and pesticides increased rapidly, which had a huge impact on the environment in rural areas. For example, excessive use of nitrogen fertilizer led to serious nitrate pollution in groundwater (Liu, 1999). In 1998, rural environmental pollution began to exceed environmental capacity, and rural areas started to show obvious signs of deterioration. In 1999, the State Environmental Protection Administration released “Several opinions of the state environmental protection administration on strengthening ecological and environmental protection in rural areas,” which was the first policy aimed at agri-environmental protection in China (Han and Jin, 2016). In this stage, agricultural and environmental protection must be coordinated with economic development. Meanwhile, strengthening agricultural pollution prevention and control has become the overall policy goal of this stage.

The production and consumption of fertilizer and pesticides in China had become the largest in the world during the acceleration stage covering 2000 to 2016, while the use ratios of fertilizer and pesticides were so low that land fertility decreases apparently. In 2008, the central government set up a special fund for rural environmental protection to focus on improving the rural environment by “replacing subsidies with awards” and “promoting governance with awards” in order to increase the enthusiasm of local governments for improving the rural environment (Han and Jin, 2016). Influenced by the State’s policies, major cities such as Chengdu, Suzhou, Dongguan, Shanghai, Foshan, Guangzhou, Linhai, Haining, and Cixi have vigorously conducted policy experiments. Table 13 presents the details of agri-environmental policies in Suzhou and Shanghai. The basic contents of agri-environmental policies in Suzhou and Shanghai are similar to AES in that farmers can be subsidized if they complete assignments required by the government.

In this study, the acceleration stage will be the main period we focus on.

Table 13. The agri-environmental policies in Suzhou and Shanghai

Policy	**Details**
Farmland eco-compensation (Suzhou)	(i) Payment is based on farmland quality, location, and scale. Payment for prime farmland is 3,000 RMB per hectare per year where the area is between 66.667 and 666.667 hm^2, and 6,000 RMB per hectare per year where the area is above 666.667 hm^2. (ii) Participants receive the entire payment.
Agricultural ecology and security subsidies (Shanghai)	(i) The subjects of the subsidy are farmers, communities, and agriculture companies. (ii) The subsidy consists of planting winter green manure, purchasing organic fertilizer, and straw recycling.

The last stage, or promotion stage, covers 2017-2019, a time period of increased public concern about environmental protection, the safety of agricultural products, and the quality of drinking water. However, some mandatory environmental actions such as seed bans, livestock and poultry bans, and straw burning bans have also led to a certain degree of social controversy. It is critical to protect the environment while also keeping the best interests of farmers in mind. The end goal is to help ’farmers become the real beneficiaries of environmental protection. In 2018, the strategic plan for rural revitalization was released, defining specific action plans for implementing the strategy (Han et al., 2019). The strategy of rural revitalization goes beyond any single field of agricultural and rural development in the past. It covers many fields including society, ecology, culture, and the economy. It is a comprehensive promotion of the concept of sustainable agricultural and rural development.

4.3 Methodology

4.3.1 Best-worst scaling

Since the discrete choice experiment (DCE) was developed in the early 1980s (Louviere and Woodworth, 1983), it has become a workhorse in economics literature for evaluating the stated preferences for various issues in areas such as transportation economics, health economics, and environmental economics. The DCE was implemented within the random utility theory (Thurstone, 1927), which depicted the choice behavior from the perspective of economic theory relatively well. Hence, the DCE method surpassed other stated preference methods that were not derived from economic theory and became a popular analysis tool in economics literature. However, due to the absence of a ranking system of alternatives, DCE barely allowed us to know the "best choice" for respondents (Guo and Shen, 2019). Thus, scholars sought to further investigate and acquire more information about choice behavior.

There has been increasing interest in recent decades in an alternative method called best-worst scaling (BWS) to elicit more information based on DCE. Finn and Louviere (1992) first proposed the BWS method for a food safety case in which a person was asked to select both the best and worst items from a list of options in terms of food safety. Since the pilot research was published, a number of applications have been proposed and a complete theoretical system has been established. The BWS method basket includes three types of cases: object case, profile case, and multi-profile case (Flynn, 2010). In the object case, respondents choose the best and worst objects from a list of objects (or attributes without detailed levels). The profile case involves only one profile or alternative in a normal DCE choice set and respondents choose the best and worst levels from this profile. The multi-profile case adds questions asking which profile respondents like most and which profile respondents like least to each choice set of DCE. Namely, the respondents need to choose the best and worst profiles from each choice set in the BWS multi-profile case. In this study, we use the BWS multi-profile case to reveal the attitudes of rural residents on agri-environmental policy. The BWS multi-profile case, or best-worst DCE (BWDCE), is the closest method to DCE, since it is designed to ask the respondent to choose the best and worst profiles in every choice set based on the DCE choice set (Lancsar et al., 2013).

4.3.2 Econometric models in BWS multi-profile case

4.3.2.1 Multinomial logit model

The BWS multi-profile case choice model in this study is based on random utility theory. The basic assumption in the random utility approach to choice modeling is that decision makers are utility maximizers; that is, given a set of alternatives, the decision maker will choose the alternative that maximizes his/her utility (Shen, 2006). However, the decision maker needs to choose not only the alternative that maximizes his/her utility (i.e., the best alternative), but also choose the alternative that minimizes his/her utility (i.e., the worst alternative) in a BWS multi-profile case. Since the utility U of an alternative for an individual cannot be observed, it is assumed to consist of a deterministic component V and a random error term $\varepsilon_{kk'}$ for every alternative pair of kk'.

Formally, the utility difference of choosing the best alternative i and the worst alternative i' for individual q can be expressed as:

$$U_{iq} - U_{i'q} = V_{iq} - V_{i'q} + \varepsilon_{ii'q} \tag{7}$$

Hence the probability that individual q chooses alternative i as the best alternative and alternative $i' \neq i$ as the worst alternative from a particular set X can be written as:

$$\begin{aligned} P_{BW}(ii' \mid X) &= P(U_{iq} - U_{i'q} > U_{jq} - U_{j'q}; \forall \quad j \neq j' \in X) \\ &= P(\varepsilon_{jj'q} < \varepsilon_{ii'q} + (V_{iq} - V_{i'q}) - (V_{jq} - V_{j'q}); \forall \quad j \neq j' \in X) \end{aligned} \tag{8}$$

To transform the random utility model into a choice model, certain assumptions about the joint distribution of the vector of random error terms are required. If the random error terms are assumed to follow the extreme value type I distribution and are assumed to be independently and identically distributed (IID) across alternatives and cases (or observations), the multinomial (or conditional) logit (MNL) model is obtained (McFadden, 1974). In the MNL model, the choice probability in Equation (8) is expressed as:

$$P_{BW}(ii' \mid X) = \exp(\mu(V_{iq} - V_{i'q})) / \sum_{\substack{j,j' \in X \\ j \neq j'}} \exp(\mu(V_{jq} - V_{j'q})) \tag{9}$$

If we make the further assumption that the deterministic component of utility is linear in its parameters, then Equation (9) can be given as:

$$P_{BW}(ii' \mid X) = \exp(\mu\beta'(X_{iq} - X_{i'q})) / \sum_{\substack{j,j' \in X \\ j \neq j'}} \exp(\mu\beta'(X_{jq} - X_{j'q})) \tag{10}$$

where μ represents a scale parameter that determines the scale of the utilities which is

proportional to the inverse of the distribution of the error terms. Typically, it is normalized to 1 in the MNL model. X_{iq} and $X_{i'q}$ are the explanatory variables of V_{iq} and $V_{i'q}$, , the attributes of alternative i and alternative i'. β' is the parameter vector associated with vector X_{iq} and $X_{i'q}$.

In this study, we applied the sequential model as in the profile case and leveraged both the opposite selection orders in the analysis. The sequential model is defined as follows:

$$P_{BW}(ii' \mid X) = \frac{\exp(\mu\beta' X_{iq})}{\sum_{j \in X} \exp(\mu\beta' X_{jq})} \times \frac{\exp(-\mu\beta' X_{i'q})}{\sum_{j' \in X \setminus i} \exp(-\mu\beta' X_{j'q})}$$

or (11)

$$P_{WB}(i'i \mid X) = \frac{\exp(-\mu\beta' X_{i'q})}{\sum_{j' \in X} \exp(-\mu\beta' X_{j'q})} \times \frac{\exp(\mu\beta' X_{iq})}{\sum_{j \in X \setminus i'} \exp(\mu\beta' X_{jq})}$$

The sequential model assumes that decision makers might abandon the best (resp. the worst) option they initially chose from the alternatives and afterwards choose the worst (resp. the best) from the remaining alternatives.

It is well known that heterogeneity among individuals is extremely difficult to examine in the MNL model (Shen, 2006; Louviere et al., 2000). This limitation can be relaxed to some extent by interaction terms between individual-specific characteristics and the various choices. However, there is a limit to this method since it requires a priori selection of key individual characteristics and attributes and involves a limited selection of individual-specific variables (Boxall et al., 2002).

4.3.2.2 Random parameter logit model

One approach that can account for individual heterogeneity is the Random Parameter Logit (RPL) (or Mixed Logit) model, which allows model parameters to vary randomly through assumed distributions (normal, log-normal, triangular, etc.). This model is a generalization of the MNL model and the form in BWS multi-profile cases is summarized below:

$$P_{BW}(ii' \mid X) = \frac{\exp(\beta'(X_{iqt} - X_{i'qt}) + \varphi'(F_{iqt} - F_{i'qt}))}{\sum_{\substack{j, j \in X \\ j \neq j'}} \exp(\beta'(X_{jqt} - X_{j'qt}) + \varphi'(F_{jqt} - F_{j'qt}))} \quad (12)$$

where β' is a parameter vector that is randomly distributed across individuals. φ' is a vector of non-random parameters. X_{iqt} and $X_{i'qt}$ are vectors of individual-specific characteristics and alternative-specific attributes at observation t and are estimated with random parameters. F_{iqt} and $F_{i'qt}$ are vectors of individual-specific characteristics and alternative-specific attributes at

observation *t* and are estimated with fixed parameters.

In this specification, a subset or all of the parameters in the β' vector can be assumed to be randomly distributed across individuals. These random parameters can also be defined as a function of the characteristics of individuals and/or other attributes that are choice invariant. Based on these defined attributes, the mean and standard deviations of the specified random parameters and contributions from these choice invariant attributes on random parameters are estimated by using the Maximum Simulated Likelihood (MSL) method. The RPL model is sufficiently flexible to provide the modeler a tremendous range within which to specify individual unobserved heterogeneity. To some extent, this flexibility offsets the specificity of the distributional assumptions (Greene and Hensher, 2003).

4.3.2.3 Latent class logit model

The Latent Class Logit (LCL) model, unlike the RPL model that specifies the random parameters to follow a continuous joint distribution, assumes that a discrete number of classes are sufficient to describe the joint function of the parameters. Therefore, the unobserved heterogeneity is captured by these latent classes in the population, each of which is associated with a different parameter vector in the corresponding utility. The LCL has often been used in marketing research instead of the RPL model, while there are few studies in other fields such as transportation and environmental valuation.

The choice probability of individual q of Class s in a BWS multi-profile case could be expressed as:

$$P_{BW}^{s}(ii' \mid X) = \exp(\mu\beta'(X_{iq}^{s} - X_{i'q}^{s})) / \sum_{\substack{j,j' \in X \\ j \neq j'}} \exp(\mu\beta'(X_{jq}^{s} - X_{j'q}^{s}))$$
$$s = 1, \ldots S \tag{13}$$

which is a simple MNL specification in class s. Additionally, one can construct a classification model as a function of some individual-specific attributes to explain the heterogeneity across classes. The LCL model simultaneously estimates Equation (13) for S classes and predicts the probability H_q^s as individual q in being in class s. Therefore, the unconditional probability of choosing the best alternative i and the worst alternative i' for individual q can be expressed as:

$$P_{BW}(ii' \mid X) = \sum_{s=1}^{S} P_{BW}^{s}(ii' \mid X) H_q^s \tag{14}$$

4.4 Survey design and data collection

4.4.1 Questionnaire

The questionnaire regarding agri-environmental policy that was used in this study has two parts: In the first part, respondents are presented with the DCE choice set plus an additional question (the worst choice question) to obtain the BWS multi-profile data. In each choice set, we presented three unlabeled profiles or alternatives: Policy A, Policy B, and Policy C. As presented in Table 14, each profile includes six attributes: *policy objective*, *agri-environmental protection assignment*, *whether the government provides free technical support*, *monitoring*, *form of additional payment*, and *additional payment per hectare*. Each attribute has three levels except for *whether the government provides free technical support* and *form of additional payment*, which have two levels. Most attributes were based on the studies of Ruto and Garrod (2009), Broch and Vedel (2012), and the agri-environmental policies being implemented in Suzhou and Shanghai. Moreover, we used Design-Expert Version 9 to create twenty-four valid choice sets by employing the D-optimal design. Since it would have been too cumbersome for respondents to answer all the choice sets, we further divided these choice sets randomly into three versions of questionnaires, and the respondents were only asked to answer the one version that was randomly assigned to them. Table 15 presents an example of the BWS multi-profile case choice sets in which the respondents would choose the policy they think is the best and the policy they think is the worst for all eight choice sets.

Table 14. Attributes and their levels regarding agri-environmental policy

Agri-environmental Policy Attributes	Levels of Attributes

Policy objective	Protection of soil quality Protection of underground water quality Protection of biodiversity
Agri-environmental protection assignment	Plant winter green manure Purchase pesticides and fertilizers from the prescribed list Straw recycling
Whether the government provides free technical support	Yes No
Monitoring	10% of farmers will be supervised 30% of farmers will be supervised 50% of farmers will be supervised
Form of additional payment	Direct subsidy Require contract with government
Additional payment per hectare	3,000 RMB 4,500 RMB 6,000 RMB

Table 15. An example of BWS multi-profile case choice sets

	Policy A	**Policy B**	**Policy C**
Policy objective	Protection of soil quality	Protection of underground water quality	Protection of soil quality
Agri-environmental protection assignment	Plant winter green manure	Purchase pesticides and fertilizers from the prescribed list	Purchase pesticides and fertilizers from the prescribed list
Whether the government provides free technical support	Yes	Yes	Yes
Monitoring	30% of farmers will be supervised	30% of farmers will be supervised	10% of farmers will be supervised
Form of additional payment	Require contract with government	Direct subsidy	Require contract with government
Additional payment per hectare	6,000 RMB	6,000 RMB	4,500 RMB
Please choose the policy you like the ***most***	□	□	□
Please choose the policy you like ***the least***	□	□	□

Questions in the second section of the questionnaire are related to demographic characteristics such as gender, age, education level, household size, number of children below middle school age, farmland area, household annual income, and household annual income from agriculture production. We also asked respondents five 5-point Likert scale questions that are related to agri-environmental protection and agri-environmental policy. Table 16 presents the 5-point Likert scale questions. The first two questions are related to satisfaction with the rural environment and the impact of the rural environment on agricultural production. The next question is related to the responsibility of farmers for agri-environmental protection, and the last two questions are related to knowledge of agri-environmental protection and agri-environmental policy.

Table 16. Questions regarding agri-environmental protection and policy

Question 1	How satisfied are you with the current environment in rural areas? (1=Very dissatisfied; 5=Very satisfied)
Question 2	Do you agree that the rural environment will have a large impact on agricultural production? (1=Totally disagree; 5=Totally agree)
Question 3	Do you agree that farmers should be responsible for the rural environment? (1=Totally disagree; 5=Totally agree)
Question 4	How much knowledge do you have about agricultural and environmental protection? (1=Have no idea; 5=Know exactly)
Question 5	How much do you know about current agricultural and environmental protection policies? (1=Have no idea; 5=Know exactly)

4.4.2 Data collection

We collected the data in Huainan City of Anhui Province by using paper and internet questionnaires. One hundred seventy valid questionnaires were returned, 70% of which were

paper questionnaires and 30% of which were internet questionnaires. The demographic characteristics of the participants are presented in Table 17. Respondents were 60% male and 40% female. The average age for respondents was 37, with 42.35% of respondents being 30 or younger. The proportion of respondents who graduated from junior high school was 42.35%, and 39.41% of the respondents have four people in the family. Respondents who have children under middle school age account for 71.77%. Regarding farmland area, 82.94% of respondents have less than 0.667 hectares, and 70.57% of respondents have an annual household income obtained from agricultural activity of less than 6,000 RMB.

Table 17. Demographic characteristics of the respondents (n=170)

Demographic characteristics	**% in sample**
Gender	
Male	60.00%
Female	40.00%
Age（mean=37）	
30 or younger	42.35%
Older than 30	57.65%
Highest education level	
Primary school	4.71%
Junior high school	42.35%
High school	19.41%
Junior college	9.43%
Bachelor's degree or above	22.93%
Household size	
1	1.18%
2	1.76%
3	25.28%
4	39.41%
5	22.37%
6 or above	9.41%
Children under middle school age	
0	27.65%
1	53.53%
2	16.47%
5	1.18%
7	0.59%
Farmland area (Hectares)	
Less than 0.667	82.94%
0.667 and above	17.06%

Annual household income (RMB)	
Less than 30,000	17.65%
30,000-50,000	42.37%
50,000-70,000	27.63%
70,000 and above	12.35%
Annual household income obtained from agriculture activity (RMB)	
Less than 6,000	70.57%
6,000-8,000	14.13%
8,000-10,000	7.65%
10,000 and above	6.47%

4.5 Results

4.5.1 Results of MNL and RPL regression

Table 18 presents the results of the MNL and RPL models. In both models, estimates are shown for both the best-worst order type (BW type) and the worst-best order type (WB type). The log-likelihood values in the MNL model in both types were slightly lower than those in the RPL model, which suggests that the RPL model is statistically superior. In addition, a number of the standard deviations of the assumed random parameters in the RPL model are significant**,** which provides supporting evidence that taking unobserved individual heterogeneity into account is necessary. In both the MNL and RPL regressions, all the policy attributes were treated as discrete variables.

Table 18. Estimation results of MNL and RPL model

	MNL (BW)	**MNL (WB)**	**RPL (BW)**	**S.D.**	**RPL (WB)**	**S.D.**
Policy objective (Protection of soil quality as base)						
Protection of underground water quality	0.226*** (6.04)	0.199*** (5.38)	0.299*** (5.94)	0.336*** (5.13)	0.280*** (5.28)	0.402*** (6.01)
Protection of biodiversity	-0.281*** (-7.50)	-0.323*** (-8.66)	-0.379*** (-6.82)	0.451*** (7.29)	-0.446*** (-7.06)	0.579*** (8.74)

Agri-environmental protection assignment (Plant winter green manure as base)						
Purchase pesticides and fertilizers from the prescribed list	-0.262***	-0.329***	-0.322***	0.300***	-0.391***	0.336***
	(-6.65)	(-8.22)	(-6.30)	(4.48)	(-7.26)	(5.07)
Straw recycling	0.568***	0.601***	0.694***	0.502***	0.746***	0.479***
	(12.54)	(13.17)	(10.37)	(6.99)	(11.09)	(6.42)
Whether the government provides free technical support (No as base)						
Yes	0.171***	0.168***	0.188***	0.211***	0.197***	0.243***
	(5.84)	(5.49)	(5.11)	(3.66)	(4.94)	(4.14)
Monitoring by government (10% of farmers will be supervised as base)						
30% of farmers will be supervised	0.185***	0.170***	0.194***	0.205**	0.181***	0.240***
	(4.34)	(3.99)	(3.87)	(2.47)	(3.42)	(3.08)
50% of farmers will be supervised	-0.102**	-0.099**	-0.114**	0.210***	-0.106**	0.202**
	(-2.38)	(-2.33)	(-2.21)	(2.63)	(-2.04)	(2.50)
Form of additional payment (Direct subsidy as base)						
Require contract with government	-0.149***	-0.190***	-0.178***	0.015	-0.217***	-0.034
	(-5.13)	(-6.48)	(-5.34)	(0.17)	(-6.25)	(-0.38)
Additional payment per hectare (3,000 RMB as base)						
4,500 RMB	-0.077*	-0.116***	-0.116**		-0.156***	
	(-1.79)	(-2.61)	(-2.37)		(-3.04)	
6,000 RMB	0.228***	0.282***	0.308***		0.390***	
	(5.57)	(6.77)	(6.50)		(7.76)	
Observations	6,720	6,719	6,720		6,719	
Log-likelihood	-2216.80	-2178.08	-2177.60		-2125.94	

Notes: z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Results of the MNL model for both types appear in the second and the third columns of Table 18. As shown, all the estimated parameters are statistically significant. Looking at policy objective, for example, the parameter of *protection of underground water quality* is statistically significant

and positive compared to the base (*protection of soil quality*), whereas the parameter of *protection of biodiversity* is statistically significant and negative. This implies that respondents prefer a policy aimed at protecting underground water quality the most and a policy aimed at protecting biodiversity the least. Regarding the agri-environmental protection assignment, the parameter of assignment *purchase pesticides and fertilizers from the prescribed list* is statistically significant and negative, while the parameter of *straw recycling* is statistically significant and positive. This indicates that respondents prefer a policy with straw recycling as the assignment over the base level assignment (*plant winter green manure).* However, it also indicates that respondents prefer a policy with the base level assignment *(plant winter green manure)* over the assignment of *purchase pesticides and fertilizers from the prescribed list*. For the attribute on government-provided free technical support, the parameter of the *Yes* parameter level (i.e., the government provides free technical support) is statistically significant and positive, which implies that the respondents prefer a policy with government-provided free technical support over a policy without it. Compared to the base level *10% of farmers will be supervised,* the parameter of *30% of farmers will be supervised* is statistically significant and positive, and the parameter of *50% of farmers will be supervised* is statistically significant and negative. This result suggests that the policy respondents prefer most calls for 30% of farmers being supervised, whereas the policy respondents prefer least calls for 50% of the farmers being supervised. In addition, the significantly negative sign of *require contract with government* indicates that the respondents prefer a policy with the direct subsidy provided by the government rather than a policy requiring a contract with the government. The estimation of the last attribute, *additional payment per hectare,* shows that the parameter of *4,500 RMB* level is significantly negative, whereas the parameter of *6,000 RMB* is significantly positive. This implies that respondents prefer a policy offering the additional subsidy of *6,000 RMB* per hectare the most and a policy offering *4,500 RMB* the least. The estimation results of this monetary attribute exhibit, to some extent, an unexpected U-shaped preference of respondents with regards to the subsidy. We further checked the frequencies of choosing *3,000 RMB*, *4,500 RMB*, and *6,000 RMB* among the choices of the best policy and found similar results that appeared (i.e., the proportion of choosing *3,000 RMB*, *4,500 RMB* and 6,000 *RMB* among the choices of the best policy are 33.93%, 30.28%, and

35.79%, respectively). However, the frequencies of choosing *3,000 RMB*, *4,500 RMB*, and *6,000 RMB* among the choices of the worst policy did not show this U-shaped result. Therefore, we infer that the unexpected estimation results of *additional payment per hectare* might be influenced by the respondents' choices of the best policy[7].

In the RPL model, we assumed that the parameters of all attributes follow a normal distribution except for *additional payment per hectare*. As shown in the fourth and sixth columns of Table 18, there appears to be little difference between the means of the parameters and the MNL estimates with respect to both signs and significance. However, the estimated standard deviations of policy o*bjectives, agri-environmental protection assignment, whether the government provides free technical support,* and *monitoring by the government* shown in the fifth and the seventh column are statistically significant, indicating that there exists heterogeneity among respondents in their preferences for these attributes.

4.5.2 Estimation results of latent class logit model

Table 19 and Table 20 present the results of class membership and the latent class logit model. We use six individual characteristics (i.e., *male*, *age*, *highest education level*, *household size*, *number of* c*hildren under middle school age,* and *farmland area*) and three questions regarding agri-environmental protection and policy to classify the latent classes for the BW type and the WB type. The values of CAIC and BIC suggest that the two classes are optimal and the results of class membership are shown in Table 19. From the table, we can find that *age*, *number of* c*hildren under middle school age*, *farmland area,* and the questions, "*Do you agree that the rural environment will have a large impact on agricultural production?"* and, "How much *do you know about current agricultural and environmental protection policies?"* are statistically significant to determine the latent classes in both types. Therefore, Class 1 can be viewed as the respondents who are younger, have more children under middle school age, have more farmland area, agree that the rural environment will have a large impact on agricultural production, and

[7] We also implemented the DCE method (*Additional payment per hectare* is set as a continuous variable and its quadratic term is also included) in the Appendix 5 to check the results. The same U- shaped preference is also shown in the DCE estimation. In addition, the reason for this U-shaped preference on *additional payment per hectare* is ambiguous and worthy of investigating more deeply in the future.

have less knowledge of current agricultural and environmental protection policies than Class 2.

Table 19. Results of class membership

	Latent class (BW) (Class 2 as base)	**Latent class (WB) (Class 2 as base)**
	Class 1	**Class 1**
Male	-0.477	-0.593
	(-0.30)	(-0.39)
Age	-0.196*	-0.191*
	(-1.80)	(-1.82)
Highest education level	1.905	1.884
	(1.53)	(1.59)
Household size	-1.846	-1.915
	(-1.06)	(-1.15)
Number of children under middle school age	2.343*	2.378*
	(1.73)	(1.82)
Farmland area (Hectare)	2.439**	2.444**
	(1.99)	(2.07)
Do you agree that the rural environment will have a large impact on agricultural production?	3.081** (2.10)	3.053** (2.20)
Do you agree that farmers should be responsible for the rural environment?	-0.967	-0.983
	(-0.91)	(-0.95)
How much do you know about current agricultural and environmental protection policies?	-6.817* (-1.94)	-6.823** (-2.04)
Constant	22.689	23.048
	(1.51)	(1.59)

Notes: z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 20 presents the results of the latent class logit model for the BW type and the WB type. There is little difference in the significance and signs of parameters for both types, but the magnitudes of parameters. For both types, Class 2 appears to be more sensitive to the attributes of agri-environmental policy. In Class 1, the parameters of *whether the government provides free technical support*, *form of additional payment,* and *additional payment per hectare* present the same significance and sign with the results of MNL and RPL, whereas other attributes show some differences. The parameters of *protection of underground water quality* and *protection of biodiversity* are statistically insignificant compared with the base level *protection of soil quality* in

Class 1, which means the respondents in Class 1 consider *protection of underground water quality* and *protection of biodiversity* to be essentially the same as *protection of soil quality*. For the *agri-environmental protection assignment* attribute, the parameter of *straw recycling* is statistically significant and has a positive sign, which implies that the respondents in Class 1 prefer *straw recycling* over the base level *plant winter green manure*. However, the parameter of *purchase pesticides and fertilizer from the prescribed list* is insignificant, which suggests that the respondents in Class 1 consider *purchase pesticides and fertilizer from the prescribed list* to be essentially the same as *plant winter green manure.* The parameters of *30% of farmers will be supervised* and 5*0% of farmers will be supervised* are both statistically insignificant, which means both the above levels are considered by the respondents in Class 1 to be essentially the same as the base level *10% of farmers will be supervised.* In Class 2, most of the parameters show the same significance and sign with the results of MNL and RPL except for the attribute *additional payment per hectare.* The parameter of *4,500 RMB* is still negatively significant, but the parameter of *6,000 RMB* is statistically insignificant. The latter result implies that the respondents in Class 2 regard receiving the subsidy of *6,000 RMB* to be the same as receiving *3,000 RMB.*

Table 20. Estimation results of LCL model

	Latent class clogit (BW)		**Latent class clogit (WB)**	
	Class1	**Class2**	**Class1**	**Class2**
Policy objective (Protection of soil quality as base)				
Protection of underground water quality	0.025	1.082***	0.011	1.055***
	(0.51)	(12.03)	(0.24)	(11.67)
Protection of biodiversity	0.074	-1.355***	0.053	-1.489***
	(1.55)	(-14.25)	(1.11)	(-14.96)
Agri-environmental protection assignment (Plant winter green manure as base)				
Purchase pesticides and fertilizer from the prescribed list	0.010	-1.196***	-0.015	-1.240***
	(0.19)	(-11.74)	(-0.30)	(-11.61)
Straw recycling	0.135**	2.125***	0.125**	2.147***
	(2.40)	(15.23)	(2.25)	(15.22)

Whether the government provides free technical support (No as base)				
Yes	0.300***	0.221***	0.359***	0.123*
	(7.37)	(3.55)	(8.46)	(1.91)
Monitoring by government (10% of farmers will be supervised as base)				
30% of farmers will be supervised	0.059	0.551***	0.030	0.543***
	(1.07)	(5.78)	(0.54)	(5.50)
50% of farmers will be supervised	-0.037	-0.375***	-0.025	-0.356***
	(-0.67)	(-3.81)	(-0.47)	(-3.60)
Form of additional payment (Direct subsidy as base)				
Require contract with government	-0.131***	-0.219***	-0.173***	-0.242***
	(-3.38)	(-3.48)	(-4.43)	(-3.64)
Additional payment per hectare (3,000 RMB as base)				
4,500 RMB	-0.102*	-0.209**	-0.144**	-0.177*
	(-1.77)	(-2.39)	(-2.46)	(-1.90)
6,000 RMB	0.506***	-0.067	0.568***	0.066
	(9.09)	(-0.75)	(10.10)	(0.73)
Observations	6,490	6,490	6,490	6,490
Predicted percentage	0.629	0.371	0.630	0.370
Log-likelihood	-1878.76		-1827.69	

Notes: z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.6 Discussion and conclusion

In this study, we conducted a best-worst scaling method to investigate rural residents' attitudes toward agri-environmental policies in China and used MNL and RPL models to analyze the data. We found that respondents thought the best policy included protecting underground water quality as the objective, straw recycling as the assignment, technological support provided by the government, a supervision level of 30%, and a 6,000 RMB subsidy with no contract requirement. Conversely, respondents thought the worst policy included protecting biodiversity as the objective, purchasing pesticides and fertilizer from the prescribed list as the assignment, no technological support provided by the government, an increased supervision level of 50%, and a 4,500 RMB subsidy requiring a contract. The results of the latent class logit model suggested the respondents who are older, have fewer children under middle school age, less agree with the rural environment will have a large impact on agriculture production, have more knowledge of agricultural and environmental protection would show more sensitivity to the attributes of agri-environmental policies.

Our results imply that rural residents in Huainan City consider the most urgent agri-environmental protection to be protection of underground water quality, and that straw recycling should be the most efficient way to save the agri-environment. For the sake of encouraging farmers to contribute to a rural environment, the government should provide free technological support as well as pay a direct subsidy without requiring a contract. In addition, residents think a modest level of supervision is necessary but prefer the government not be overly strict about it. As for which group to target, promotion of this policy should begin with residents who are older and have more knowledge of agricultural and environmental protection.

Finally, two issues remain for continued research. First, the preference of respondents on the subsidy amount shows a U-shaped result. The reason is not clear in this study, so this issue should be investigated further. Second, considering the widespread variances among provinces in China, there may be significant regional differences in opinions regarding agri-environmental policies. Thus, the attitudes of rural residents in other provinces should also be investigated to determine the level of heterogeneity among different regions in China.

Chapter V

Concluding Remarks

This chapter concludes the thesis. A summary of main conclusions is presented in Section 5.1, and Section 5.2 gives the suggestions for future research.

5.1 Summary of the main conclusions

This thesis discussed the specific issues of sustainable consumption and production from the perspective of private good, impure public good, and the public good. The main conclusions in the previous three chapters except Chapter 1 are summarized in this section.

Chapter 2 examined the electric vehicle preferences of Shanghai residents by conducting a stated choice survey in Shanghai. MNL and RPL models were used to analyze data for three samples(i.e. the full sample, a subsample of potential EV purchasers, and a subsample of non-EV purchasers). We found that most preferred EVs had the attributes with a longer driving range, a shorter charging time, a faster maximum speed, lower pollution emissions, lower fuel cost, and a lower price. Whilst the results of willingness to pay suggested potential EV purchasers were willing to pay more than their non-purchaser counterparts for enhancing each of the EV attributes presented to them. According to the results of chapter 2, the government should focus on not only subsidize driving range but also other attributes like reducing charging time, lowering pollution emissions, and increasing maximum speed. Moreover, potential EV purchasers more likely to be the people who are older males, highly educated residents with a degree at the master's level or higher, have higher individual annual income, members of the salariat, families without a car, pay attention to policies related to NEVs, have stronger green consumption consciousness, more acceptance of new products and new technology, and more intense environmental protection awareness.

Chapter 3 In the current study, we applied within-subject dictator games to investigate the influence of impure public good on participants' prosocial behavior shown in our study demonstrates the importance of the public characteristic in the impure public good. The phenomenon could be explained by an incomplete mental accounting mind process, and also suggests that the donations by a third party (e.g., the experimenter in the current study) might be a vital factor affecting individual' voluntary donations. The results of two baseline tasks indicate that participants' behaviors in the impure public good tasks, which took place between the two

baseline tasks, might impact their behaviors in the second baseline task. Participants became more selfish as the experimenter's donation increased, and this trend decreased their donations in the last baseline task. Furthermore, an impure public good is considered as an alternative path to encourage consumers to contribute more to the public good without being mandatorily required. However, our research offers evidence that impure public good consumption alone might not be a sustainable measure to induce consumers to behave more prosocially. Hence, we should be prudent when promoting impure public goods as an instrument to aid contributions to public goods.

In Chapter 4, we conducted a best-worst scaling survey to investigate rural residents' attitude of agri-environment policies by applying MNL and RPL models, and we found that the respondents who thought the policy which had the objective of protection of underground water quality, the assignment of straw recycling, technology provided by government, 30% farmers be supervised, 6000RMB subsidy directly given by the government is the best agri-environment policy. However, the respondents thought the policy which had the objective of protection of biodiversity, the assignment of purchase pesticides and fertilizers in the prescribed list, technology not provided by the government, 50% farmers be supervised, 4500RMB subsidy given by making a contract with the government is the worst agri-environment policy. The results of the latent class logit model suggested the older respondents, have fewer children under the middle school, less agree with the rural environment will have a large impact on agriculture production and have more knowledge of agriculture environment protection will show more sensitive to the attributes of agri-environment policy.

5.2 Direction for future research

In the study of electric vehicles, we did not include the number of charging stations in this study due to the reason that the charging mode in China was a controversial topic during the period of our survey, this factor needs to be a further investigation in the future research. In addition, offering free license plates for EVs should be very attractive to consumers and might be an important factor affecting their preference for an EV. Further research is needed to explore this issue. Moreover, the data used in this paper was collected in Shanghai, country-level data is needed to further explore our research question to acquire more information from other provinces and cities in China. Finally, it should also be noted that our results are based on a hypothetical choice survey that may have a hypothetical bias. Future research is highly encouraged in comparing our results with results estimated from actual purchase data. As for the research of Chapter 3, our research concluded that impure public good consumption alone might not be a sustainable measure to induce consumers to behave more prosocially. Hence, We need to construct an appropriate institution for the impure public goods market that could guide consumers to behave sustainable prosocial actions. Therefore, producers of impure public goods should also be

considered in future research on impure public goods. The inertia influence of selfish behavior should be checked through exploring how opposite settings related to the impure public good tasks affect participants' voluntary donations and whether this influence has inertia affecting their behaviors when the impure public good is removed. Furthermore, in the current paper, we only consider the mandatory donation is lower than or equal to the private one in impure public good treatments, the effect of impure public goods with which the mandatory donation is higher than the private one would be also interesting and need to be explored. We leave these issues open and welcome any efforts to further explore them at a much deeper level. The study of agri-environment demonstrated the preference of respondents on the subsidy amount shows the U-shape results, however, the reason is not clear in this study. This issue should be further discovered and any research on this issue is welcomed. Moreover, the data of the region which already implemented the agri-environment policy should be collected and compare the preference of the rural residents in these areas on agri-environment policy with the results in our current study.

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Appendix

Appendix 1: Task instructions

I would like to welcome all the participants in today's experiment. This experiment is divided into six rounds of tasks. In each round you will be rewarded based on your decision, whereas the final reward you receive in the experiment will be determined by randomly selecting one of these six rounds. The specific selection method will be explained in detail later. The procedure of the experiment is as follows: First, we introduce the processes of Rounds 1 to 6, and then you will be asked to do the tasks of Rounds 1 through 6. Remember that you cannot speak to other participants during the experiment. If this happens, the experiment will be aborted immediately. If you have any questions, please raise your hand.

We first introduce the process of the Round 1 task.

Instructions for Round 1 task

In Round 1, you will receive 60 RMB. Then, you need to decide how to allocate these between the "Shanghai University Education Development Foundation" (i.e., SHUEDF, a non-profit charity established in February 2014, accepting social donation funds for Shanghai University and utilizing these to support higher education) and yourself. The amount you leave for yourself will be your reward in this round.

In addition to the experiment instructions, you also have a "Recording sheet."

Please look at this sheet. It will be used to record the amount of money you allocate between SHUEDF and yourself. When you have decided how to distribute the money, please fill in the amount allocated to the SHUEDF in the "Donate to SHUEDF" column in the "Recording sheet" of the Round 1 task; the amount assigned to yourself should be recorded in the "Assign to yourself" column on the sheet of the Round 1 task.

Instructions for Round 2 task

Round 2 will be conducted after the Round 1. In this task, you will receive 72 RMB. You have to buy a 12 RMB ball pen we provide you, whereas we will donate 3 RMB to SHUEDF. Next, you will decide how to allocate the remaining 60 RMB (i.e., 72 RMB minus 12 RMB) between SHUEDF and yourself. The amount you leave for yourself will be your reward in this round.

When you have decided how to distribute the money, please fill in the amount allocated to SHUEDF in the "Donate to the SHUEDF" column in the "Recording sheet" of the Round 2 task; the amount assigned to yourself should be recorded in the "Assign to yourself" column on the sheet of the Round 2 task.

Instructions for Round 3 task

Round 3 will be conducted after Round 2. In this task, you will receive 72 RMB. You are asked to buy a 12 RMB ball pen we provide you, whereas we will donate 6 RMB to SHUEDF. Next, you will decide how to allocate the remaining 60 RMB (i.e., 72 RMB minus 12 RMB) between SHUEDF and yourself. The amount you leave for yourself will be your reward in this round.

When you have decided on how to distribute the money, please fill in the amount allocated to SHUEDF in the "Donate to the SHUEDF" column in the "Recording sheet" of the Round 3 task; the amount assigned to yourself should be recorded in the "Assign to yourself" column on the sheet of the Round 3 task.

Instructions for Round 4 task

Round 4 will be conducted following Round 3. In this task, you will receive 72 RMB. You have to buy a 12 RMB ball pen we provide you, whereas we will donate 9 RMB to SHUEDF. Next, you will decide how to allocate the remaining 60 RMB between SHUEDF and yourself. The amount you leave for yourself will be your reward in this round.

When you have decided how to distribute the money, please fill in the amount allocated to SHUEDF in the "Donate to the SHUEDF" column in the "Recording sheet" of the Round 4 task; the amount assigned to yourself should be recorded in the "Assign to yourself" column on the sheet of the Round 4 task.

Instructions for Round 5 task

Round 5 will be conducted after Round 4. In this task, you will receive 72 RMB. You have to buy a 12 RMB ball pen we provide you, whereas we will donate 12 RMB to SHUEDF. Next, you will decide how to allocate the remaining 60 RMB (i.e., 72 RMB minus 12 RMB) between SHUEDF and yourself. The amount you leave for yourself will be your reward in this round.

When you have made your decision on how to distribute the money, please fill in the amount allocated to SHUEDF in the "Donate to the SHUEDF" column in the "Recording sheet" of the Round 5 task; the amount assigned to yourself should be recorded in the "Assign to yourself" column on the sheet of the Round 5 task.

Instructions for Round 6 task

Round 6 will be conducted after that of Round 5. In this task, you will receive 60 RMB. Then, you need to decide how to allocate this amount between SHUEDF and yourself. The amount you leave for yourself will be your reward in this round. It should be noted that the task of this round is exactly the same as that of the first round.

When you have decided how to distribute the 60 RMB, please fill in the amount allocated to SHUEDF in the "Donate to the SHUEDF" column in the "Recording sheet" provided in Round 6 task; the amount assigned to yourself should be recorded in the "Assign to yourself" column on the sheet of the Round 6 task.

The above is the content of the six rounds of today's experiment. After making decisions in each round, you can make the next round of decisions on your own without waiting for our instructions.

When all the decisions for the six rounds have been completed, and the results have been recorded in the "recording sheet," please raise your hand. We will put an automatic dice machine in front of you, and you need to press the button to roll the dice. The number shown on the die will correspond to which round you will be paid for, namely, 1 corresponds to the first round, 2 to the second round, and so on. For example, if you roll the number 1, you will receive a reward based on your decision in the Round 1 task; if the number is 2, you will receive a reward based on your decision in the Round 2 task, and so on. Furthermore, if you roll a 2, 3, 4, or 5, you will also receive a ball pen with a market price of 12 RMB. At the same time, we will donate the corresponding amount to SHUEDF. In addition, when we prepare your reward, please complete a questionnaire for us.

Appendix 2: Recording sheet

Round 1 task

Now that you have received 60 RMB, you can assign it to yourself or donate it to the Shanghai University Education Development Foundation (i.e., SHUEDF). How will you divide the amount?

Assign to yourself: _____ RMB

Donate to SHUEDF: _____RMB

Round 2 task

Now you have received 72 RMB, with 12 of which you must purchase a ball pen we provide for you. At the same time, we will donate 3 RMB to SHUEDF. Next, you will decide how to allocate 60 RMB (i.e., RMB 72 minus 12 RMB) between yourself and SHUEDF. How will you divide the amount?

Assign to yourself: _____ RMB

Donate to SHUEDF: _____RMB

Round 3 task

Now you have received 72 RMB, with 12 of which you must purchase a ball pen we provide for you. At the same time, we will donate 6 RMB to SHUEDF. Next, you will decide how to allocate 60 RMB (i.e., RMB 72 minus 12 RMB) between yourself and SHUEDF. How will you divide the amount?

Assign to yourself:_____ RMB

Donate to SHUEDF:_____RMB

Round 4 task

Now you have received 72 RMB, out of which you must purchase a ball pen costing 12 RMB. At the same time, we will donate 9 RMB to SHUEDF. Next, you will decide how to allocate the remaining 60 RMB (i.e., RMB 72 minus 12 RMB) between yourself and SHUEDF. How will you divide the amount?

Assign to yourself:_ _____ RMB

Donate to SHUEDF: _____RMB

Round 5 task

Now you have received 72 RMB, out of which you must purchase a ball pen costing 12 RMB. At the same time, we will donate 12 RMB to SHUEDF. Next, you will decide how to allocate the remaining 60 RMB (i.e., RMB 72 minus 12 RMB) between yourself and SHUEDF. How will you divide the amount?

Assign to yourself:_____ RMB

Donate to SHUEDF:_____RMB

Round 6 task

Now you have received 60 RMB, you can either assign it to yourself or donate it to SHUEDF. How will you divide the amount?

Assign to yourself:_____ RMB

Donate to SHUEDF: _____RMB

Appendix 3: Demographic characteristics of the participants (n=137)

Demographic characteristics	% in sample
Gender	
Male	42.34%
Female	57.66%
Age（mean=22）	
18-21	36.62%
22-25	61.19%
26 and above	2.19%
Hometown	
Urban area	32.85%
Rural area	67.15%
Grade	
Undergraduate student	40.88%
Postgraduate student	59.12%
Major in economics?	
Yes	54.74%
No	45.26%
Living expenses per month (RMB)	
600-999	5.84%
1000-1499	29.93%
1500 and above	64.23%

Appendix 4: Panel Tobit regression estimation results of Total donation

	Total donation	
Constant	43.417	(4.22)**
IPG1	2.217	(3.65)**
IPG2	3.589	(5.91)**
IPG3	5.414	(8.91)**
IPG4	7.152	(11.75)**
BL2	-1.995	(-3.27)**
Female	2.418	(1.20)
Age	-0.340	(-0.89)
Hometown	1.516	(0.66)
Living expenses	-4.619	(-2.56)*
Majoring in economics	-4.303	(-2.17)*
Wald-test		
IPG1 and *IPG2*	$\chi^2(1) = 5.13, p = 0.024$	
IPG2 and *IPG3*	$\chi^2(1) = 9.07, p = 0.003$	
IPG3 and *IPG4*	$\chi^2(1) = 8.20, p = 0.004$	
Log likelihood	-2689.54	
Sample size	137	

Notes: ** and * indicate statistical significance at the 1% and 5% levels of confidence, respectively. Z-statistics are reported in parentheses. *IPG1, IPG2, IPG3, IPG4,* and *BL2* are dummy variables of the *IPG1, IPG2, IPG3, IPG4,* and *BL2* tasks. *Female* is dummy variable referring to the female participants. *Age* is a continuous variable referring to the age of participants. *Hometown* is a dummy variable that equals to 1 if the participant came from rural area, and 0 if not. *Living expenses* is a continuous variable referring to the living expense per month of participants. *Majoring in economics* is a dummy variable that equals to 1 if the participant majors in economics, and 0 if not.

Appendix 5: Estimation results of MNL and RPL using DCE method

	MNL	RPL	S.D.
Objectives of policy (Protection of soil quality as base)			
Protection of underground water quality	0.036	0.087	0.786***
	(0.42)	(0.72)	(4.48)
Protection of biodiversity	-0.615***	-0.999***	1.474***
	(-6.74)	(-5.83)	(8.43)
Assignments of agri-environment protection(Plant winter green manure as base)			
Purchase pesticides and fertilizers in the prescribed list	-0.105	-0.234*	0.928***
	(-1.13)	(-1.72)	(5.39)
Straw recycling	1.097***	1.490***	1.377***
	(11.50)	(8.63)	(7.13)
Whether free technical is provided by government(No as base)			
Yes	0.471***	0.627***	0.776***
	(5.87)	(5.32)	(4.57)
Monitoring by government(10% farmers will be supervised as base)			
30% farmers will be supervised	0.141	0.113	0.123
	(1.45)	(0.92)	(0.30)
50% farmers will be supervised	-0.097	-0.169	-0.012
	(-1.03)	(-1.43)	(-0.04)
Form of additional payment(Direct subsidy as base)			
Make contract with government	-0.551***	-0.698***	0.075
	(-7.13)	(-6.93)	(0.24)
Additional payment per hectare (thousands RMB)	-1.250***	-1.673***	
	(-3.21)	(-3.32)	
Additional payment per hectare×Additional payment per hectare	0.148***	0.203***	
	(3.48)	(3.69)	
Observations	4032	4,032	4,032
Log-likelihood	-1277.04	-1205.99	

z-statistics in parentheses *** p<0.01, * p<0.1