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Abstract

In this study, a stated choice survey was conducted in Anhui Province, China. The best-worst scaling method, an alternative method to the discrete choice experiment, was used to value rural residents' attitude toward agri-environmental policy. Using the multinomial logit and random parameter logit model, the results showed that respondents thought the best policy included protecting underground water quality as the objective, straw recycling as the method, technological support provided by the government, a supervision level of 30% of farmers, and a 6,000 RMB subsidy directly disbursed by the government. Conversely, respondents thought the worst policy included protecting biodiversity as the objective, purchasing pesticides and fertilizers from the prescribed list as the method, no technological support provided by the government, an increased supervision level of 50% of farmers, and a 4,500 RMB subsidy requiring a contract with the government. 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.

Keywords: Agri-environmental policy; Best-worst scaling; Latent class model; Random parameter logit model; Multinomial logit model.

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 2 describes the status of agri-environmental policy. Section 3 covers the methodology of BWS. Survey design and data collection is presented in Section 4. Section 5 provides the results of regressions. Finally, Section 6 offers discussions and conclusions.

2. Status of agri-environmental policy

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).

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 1 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.

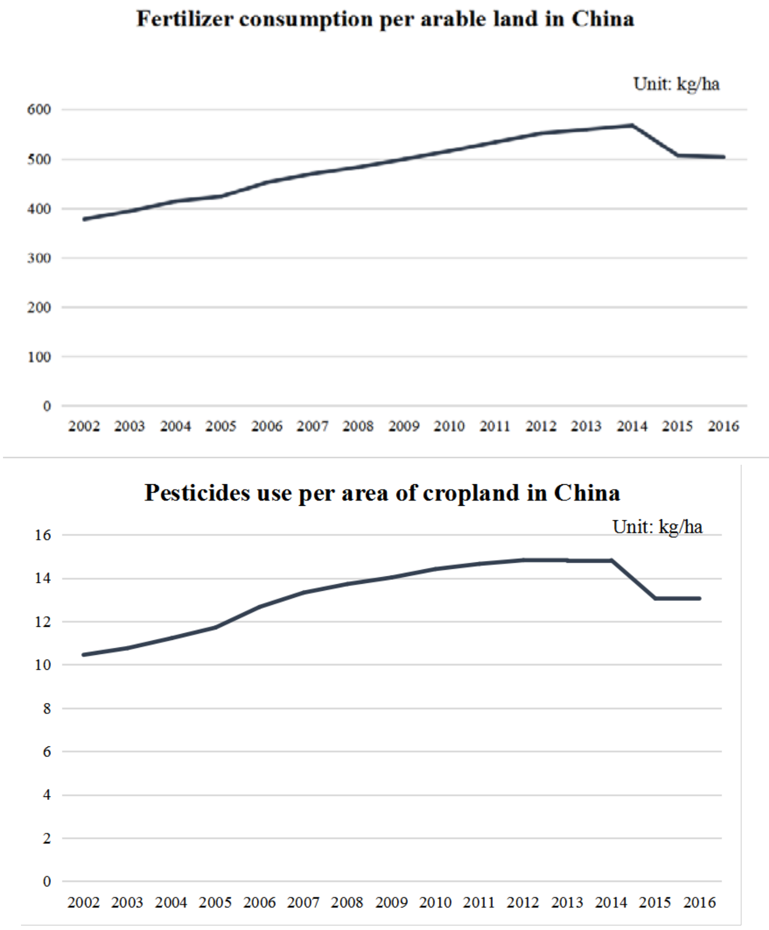

Figure 1. Fertilizer consumption and pesticide use in China

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.

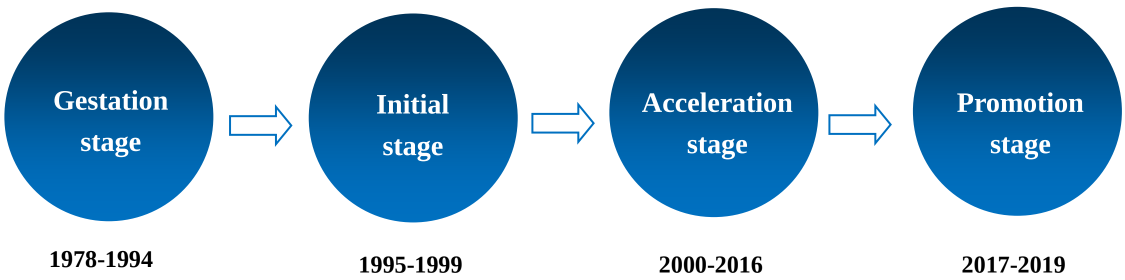

Figure 2. Four stages of agri-environmental policy development in China

As presented in Figure 2, 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 1 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 1. 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.

3 Methodology

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).

3.2 Econometric models in BWS multi-profile case

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:

$$U_{iq} - U_{i'q} = V_{iq} - V_{i'q} + \varepsilon_{ii'q} \quad (1)$$

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:

$$P_{BW}(ii' \mid X) = P(U_{iq} - U_{i'q} > U_{jq} - U_{j'q}; \forall \quad j \neq j' \in X) \\ = P(\varepsilon_{jj'q} < \varepsilon_{ii'q} + (V_{iq} - V_{i'q}) - (V_{jq} - V_{j'q}); \forall \quad j \neq j' \in X) \tag{2}$$

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:

$$P_{BW}(ii' \mid X) = \exp(\mu(V_{iq} - V_{i'q})) / \sum_{\substack{j,j' \in X \\ j \neq j'}} \exp(\mu(V_{jq} - V_{j'q})) \tag{3}$$

If we make the further assumption that the deterministic component of utility is linear in its parameters, then Equation (3) can be given as:

$$P_{BW}(ii' \mid X) = \exp(\mu\beta'(X_{iq} - X_{i'q})) / \sum_{\substack{j,j' \in X \\ j \neq j'}} \exp(\mu\beta'(X_{jq} - X_{j'q})) \tag{4}$$

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. V_{iq} and $V_{i'q}$ are the explanatory variables of X_{iq} and $X_{i'q}$, normally including alternative-specific constants (ASCs), the attributes of alternative i and alternative i', and the social-economic characteristics of individual q. 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

$$P_{WB}(i'i \mid X) = \frac{\exp(-\mu\beta' X_{i'q})}{\sum_{j' \in X} \exp(-\mu\beta' X_{j'q})} \times \frac{\exp(\mu\beta' X_{iq})}{\sum_{j \in X \setminus i'} \exp(\mu\beta' X_{jq})} \tag{5}$$

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).

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:

$$P_{BW}(ii' \mid X) = \exp(\alpha' + \beta'(X_{iqt} - X_{i'qt}) + \varphi'(F_{iqt} - F_{i'qt})) / \sum_{\substack{j, j \in X \\ j \neq j'}} \exp(\alpha' + \beta'(X_{jqt} - X_{j'qt}) + \varphi'(F_{jqt} - F_{j'qt})) \tag{6}$$

where α' is a vector of fixed or random alternative-specific constants (ASCs) in which one of the ASCs should be identified as 0. 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 α' and 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).

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:

$$P^s_{BW}(ii' \mid X) = \exp(\mu\beta'(X^s_{iq} - X^s_{i'q})) / \sum_{\substack{j,j' \in X \\ j \neq j'}} \exp(\mu\beta'(X^s_{jq} - X^s_{j'q}))$$
$$s = 1, \ldots S \qquad (6)$$

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 (6) for S classes and predicts the probability H^s_q 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:

$$P_{BW}(ii' \mid X) = \sum_{s=1}^{S} P^s_{BW}(ii' \mid X) H^s_q \qquad (7)$$

4. Survey design and data collection

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 2, 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 3 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 2. 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	Yes

technical support	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 3. 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 4 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 4. 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)

4.2 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 5. 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 5. 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%

5. Results

5.1 Results of MNL and RPL regression

Table 6 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 6. 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*** (-6.65)	-0.329*** (-8.22)	-0.322*** (-6.30)	0.300*** (4.48)	-0.391*** (-7.26)	0.336*** (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*** (4.34)	0.170*** (3.99)	0.194*** (3.87)	0.205** (2.47)	0.181*** (3.42)	0.240*** (3.08)
50% of farmers will be supervised	-0.102** (-2.38)	-0.099** (-2.33)	-0.114** (-2.21)	0.210*** (2.63)	-0.106** (-2.04)	0.202** (2.50)
Form of additional payment (Direct subsidy as base)						
Require contract with government	-0.149*** (-5.13)	-0.190*** (-6.48)	-0.178*** (-5.34)	0.015 (0.17)	-0.217*** (-6.25)	-0.034 (-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 6. 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[1].

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 6, 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.

5.2 Estimation results of latent class logit model

Table 7 and Table 8 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 7. 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

[1] 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 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.

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

Table 7. 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**	3.053**
	(2.10)	(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*	-6.823**
	(-1.94)	(-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 8 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 8. 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 (0.51)	1.082*** (12.03)	0.011 (0.24)	1.055*** (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

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.

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Appendix: Estimation results of MNL and RPL using DCE method

	MNL	RPL	S.D.
Policy objective			
(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)
Agri-environmental protection assignment (Plant winter green manure as base)			
Purchase pesticides and fertilizer from 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 the government provides free technical support (No as base)			
Yes	0.471***	0.627***	0.776***
	(5.87)	(5.32)	(4.57)
Monitoring by government (10% of farmers will be supervised as base)			
30% of farmers will be supervised	0.141	0.113	0.123
	(1.45)	(0.92)	(0.30)
50% of farmers will be supervised	-0.097	-0.169	-0.012
	(-1.03)	(-1.43)	(-0.04)
Form of additional payment (Direct subsidy as base)			
Require 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)	
Square of Additional payment per hectare	0.148***	0.203***	
	(3.48)	(3.69)	
Observations	4,032	4,032	
Log-likelihood	-1277.04	-1205.99	

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