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On Farmers' Participation in Decision-making of Ecological Protection of Drinking Water Resources

*Jie Lin, **Chao Yu

*School of economics and management, Zhejiang University of Water Resources and Electric Power, Xuelin Street. No.583, Jianggan District, Xiasha University Town, Hangzhou, PR China, 310018(linjielinjie1@163.com)

**Esc Rennes School of business, 2 Rue Robert d'Arbrissel, 35065, Rennes, France (yc526009040@gmail.com)

Abstract

Farmers' participation in ecological protection is the ultimate goal of the government's ecological compensation policy, and their willingness is a prerequisite for participation in ecological protection. This study mainly discusses the decision-making motive of farmers' participation in ecological protection, and seeks for effective measures to prevent non-point source pollution of chemical fertilizer in water source protection area. In a creative manner, the author makes the famers' willingness to cut back on fertilizer in the compensation scenario as the proxy variable of farmers' willingness to participate in ecological protection of drinking water environment, and choose the ordered Logit regression model to analyze the causes of farmers' differed willingness to cut back on fertilizer. The results show that income-related factors have a significant effect on farmers' willingness to participate in non-point source pollution control, and those with concurrent business, high household income, high personal income, and high production efficiency are more likely to cut back more on fertilizer. Although the farmers' awareness of fertilizer pollution is generally low, the farmers have a strong awareness of environmental issues and are very willing to participate in water environmental protection. In particular, farmers who have immediate family members living in the water supply areas pay more attention to water quality issues. In contrast, the farmers with higher willingness to receive

compensation are more dependent on agricultural income, and their willingness to participate is very low.

Keywords

Water source, ecological protection, farmers' participation, farmer's willingness, the ordered Logit regression model

1. Introduction

As a typical southern province of China, Zhejiang mainly relies on lakes and reservoirs for drinking water supply [1]. This type of water source is usually located in deep mountains. Limited by economic and geographical reasons, the farmers there mostly carry out decentralized management of their own farmlands and engage in concurrent business and non-agricultural sectors. The famers' household food consumption mainly depends on agricultural yield processed by traditional technology. There are many shortcomings of the current production mode and lifestyle of these famers. On the one hand, the fragmentation of land is not conducive to the implementation of unified environmental action; On the other hand, the engagement in concurrent business further diffuses the limited human, material and financial resources [2], leading to the neglection of precision farmland management. Under the joint effect of these factors, agricultural non-point source pollution has become one of the most serious problems of drinking water quality.

Agricultural non-point source pollution is a byproduct of human activities. So far, the Chinese governments at all levels have formed a consensus that the protection of the environment requires the establishment of the cooperation between government and farmers, which solves the agricultural non-point source pollution of water in the downstream by regulating the behavior of microcosmic entities at the water source.

Based on the consensus, some scholars further suggest that if the government wants farmers to take environmental-friendly farming measures, it should make reasonable compensation to farmers for the social benefits brought by their adoption of environmental protection measures [3, 4] because mandatory measures would invoke negative emotions among the farmers [5].

Recognized and supported by many governments in the world [6], this suggestion has promoted the construction of water source ecological compensation mechanism. At present, the research of ecological compensation at home and abroad has yielded fruitful results, covering the aspects of the construction of compensation system [7, 8], compensation standard [9,10], compensation method [11], etc. However, the research still focuses on the construction of the compensation system [12], and rarely talks about the reasons for farmers to change their behavior. The problem is particularly prominent in China.

From the general procedure of the compensation, it is clear that the farmers' participation in the ecological protection and their receipt of ecological compensation do not happen simultaneously. Instead, the two steps take place one after the other. The farmers' participation in ecological protection is the prerequisite for compensation and the basis for the design of compensation standards. Thus, the government must find out the behavior and attitude of farmers before the negotiation on compensation. The amount and mode of compensation should be determined in consideration of the famers' willingness. Likewise, it is an important content of the compensation policy to accurately grasp the famers' willingness.

The farmers' willingness is a psychological index difficult to quantify. In reference to research on the adoption of agricultural technology [13-15], the author view the ecological compensation policy as a tool to survey the farmers' willingness. The tool is most commonly use in the discussion of the adoption of new agricultural technologies. However, as the farmers' tendency to adopt a technology is normally recorded as "yes" or "no", it is impossible to measure the intensity of their willingness. Considering that the farmers' decisions are mostly result-oriented, i.e., decision-making based on whether the behavioral results are favorable, this paper decides to use fertilizer as the carrier because it is easy to control the input/output and estimate the results of fertilizer, and creatively makes the famers' willingness to cut back on fertilizer in the compensation scenario as the proxy variable of farmers' willingness to participate in ecological protection. In this way, the author can find out how willing the famers are to participate in ecological protection of drinking water resources by determining their willingness to cut back on fertilizer, and thereby discuss the specific influencing factors and impact mechanism.

2. Farmers’ willingness in cut back on fertilizer

2.1Sample characteristics

Table 1. Sample characteristics

Variable	Options	Total	Qiaodun	Siminghu	Variable	Options	Total	Qiaodun	Siminghu
Gender	Female	21	8	13	Education	Illiterate	264	201	63
	Male	520	315	205		Primary school dropout	29	12	17
Family population	Fewer than 3	138	68	70		Primary school	146	79	67
	3 to 5	245	131	114		Junior high school	71	29	42
	More than 5	158	124	34		Senior high school	28	2	28
Family income	Less than RMB 10,000 yuan	13	13	0		Junior college and above	3	0	3
	Between RMB 10,000 and 20,000 yuan	39	31	8	Age	Younger than 40	25	10	15
	Between RMB 20,000 and 30,000 yuan	31	13	18		Between 40 and 50	76	25	51
	Between RMB 30,000 and 50,000 yuan	137	92	45		Between 50 and 60	149	86	63
	Between RMB 50,000 and 70,000 yuan	114	90	24		Between 60 and 70	210	137	73
	More than RMB 70,000 yuan	178	84	94		Older than 70	81	65	16

To obtain reliable conclusions through comparison, the author chooses to collect samples for the study from two places in Zhejiang Province with similar sizes: the 138km2 Qiaodun Reservoir Water Source Area (Qiaodun Town) and the 103.1 km2 Siminghu Reservoir Water Source Area (Yuyao, Ningbo). The former location has inferior economic and geographical environment than the latter. See Table 1 for the sample characteristics of the respondents. Using the stratified sampling method, the survey focuses on collecting the information of the farmers from five aspects, including the individual characteristics, employment, environmental awareness, policy awareness and willingness to participate.

2.2 Environmental awareness of respondents

In the questionnaire, the question on environmental awareness goes like this: “What do you think of the excessive use of fertilizer on surface water?” The options are: 1=no idea; 2=no effect;

3=insignificant effect; 4=normal effect; 5=significant effect. The answers from the respondents are as follows (Figure 1): most of the famers speak negatively of the water pollution of fertilizer. Nearly 5.6% of the farmers do not know that fertilizer would pollute the water source; nearly 37.1% of the farmers think fertilizer has no effect on the water source; 33.1% of the farmers believe that fertilizer has no effect; 14.5% of the farmers consider the effect to be very small; 9.7% of the farmers regard the effect as significant.

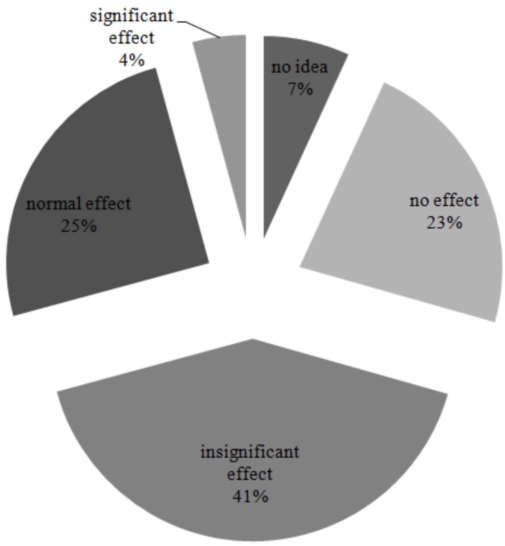


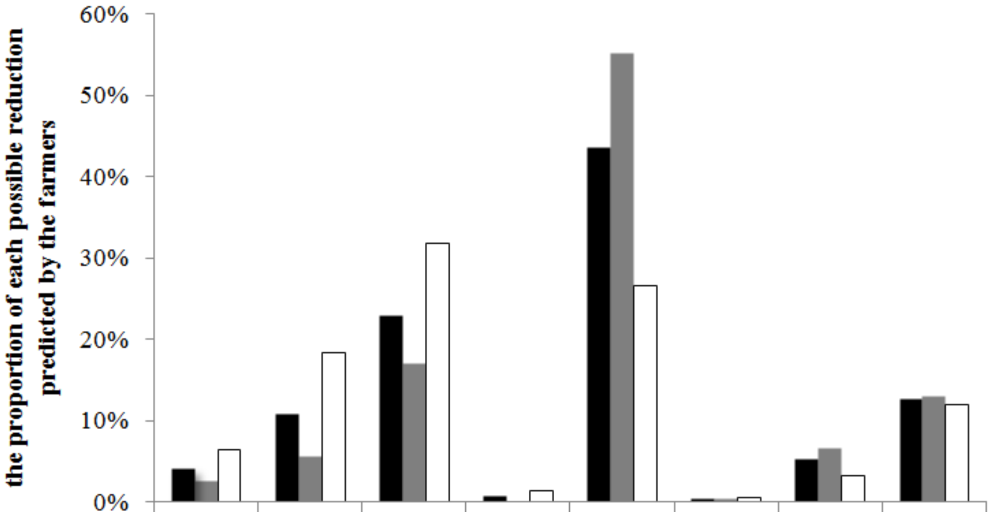
Fig. 1 Farmer's comments on the fertilizer's pollution of water environment

2.3 Famers' understanding of the relationship between the reduction of fertilizer and the crop yield

2.3.1 Farmers' risk assessment of crop failure without the application of fertilizer

Aiming at how farmers comment on the importance of fertilizer in crop yield, the questionnaire asks the farmers about the possible consequences of non-application of fertilizer. Figure 2 shows the proportion of all possible reductions predicted by the farmers if fertilizer is not applied. The farmers' responses indicate that the yield would be cut by half if all the other inputs are not constrained. Among all respondents, most farmers believe the yield would drop by 70% (22.90% of the total respondents) or 80% (43.68% of the total respondents); 12.60% of the farmers reply that nothing would be reaped at the harvest. The proportion is basically the same in the two research areas.

The farmers' risk assessment of crop failure basically reflects their attitudes towards the feasibility of fertilizer reduction. Based on the above statistics, the author makes the preliminary judgment that it is feasible and likely for the farmers to voluntarily cut back on the quantity of fertilizer.



	50%	60%	70%	75%	80%	85%	90%	100%
■ In total	4.10%	10.70%	22.90%	0.60%	43.60%	0.40%	5.20%	12.60%
■ Qiaodun	2.50%	5.60%	17%	0%	55.10%	0.30%	6.50%	13%
□ Siminghu	6.40%	18.30%	31.70%	1.40%	26.60%	0.50%	3.20%	11.90%

Fig. 2 Predicted extent of crop loss without application of fertilizer

2.3.2 The quantity of fertilizer reduction accepted by the farmers

For the sake of simplicity, this paper divides the quantity of fertilizer reduction accepted by the farmers into five ranges: (0,10%], (10%, 20%], (20%, 30%], (30%, 50%], and (50%, 100%], which are respectively expressed as 10%, 20%, 30%,50% and 100%. Figure 3 is the stacked graph on the quantity of fertilizer reduction accepted by the farmers.

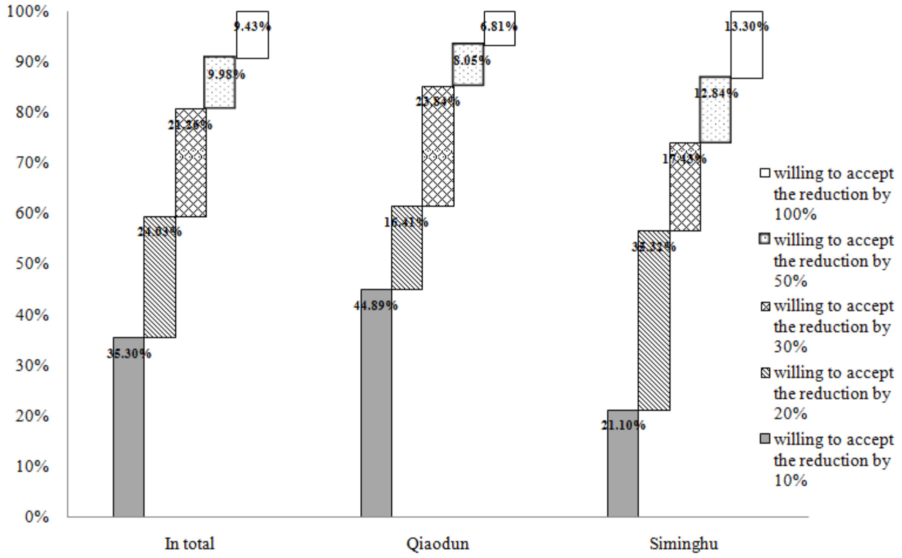


Fig. 3 The quantity of fertilizer reduction accepted by the farmers

Among all respondents, about 80.59% of the farmers choose to reduce the quantity of fertilizer by 30% or less, of which 35.30% are willing to accept the reduction by 10%, 24.03% are willing to accept the reduction by 20%, and 21.26% are willing to accept the reduction by 30%. Therefore, the farmers do not show a particular preference when the reduction ratio stays on a low level. This means the risk of crop loss is relatively insignificant and affordable, and the farmers are less sensitive to the possible reduction in crop yield. This is also demonstrated by the randomness of the farmers in reporting the acceptable quantity of fertilizer reduction.

2.3.3 Forecast on crop failure under different quantity of fertilizer reduction

Generally speaking, a certain reduction in fertilizer quantity would not result in a sharp decrease in crop yield (See Table 2). Cumulatively speaking, more than 70% of the farmers believe that the crop yield would drop by the same rate of the reduction in fertilizer quantity, indicating that most farmers agree that the drop in crop yield would not exceed the reduction in fertilizer quantity. This is particularly true among the farmers who are willing to cut back on fertilizer by 10%, 20% and 30%. Among both total respondents and Qiaodun respondents, the majority of farmers willing to cut back on fertilizer by 10%, 20% and 30% believe that the crop yield would reduce proportionally to the reduction in fertilizer quantity. Among the total respondents, these farmers take up 63.87% of those willing to cut back on fertilizer by 10%, 37.69% of those willing to cut back on fertilizer by 20%, 45.22% of those willing to cut back on fertilizer by 30%; among the Qiandun respondents, these farmers take up 66.21% of those willing to cut back on fertilizer by 10%, 62.26% of those willing to cut back on fertilizer by 20%, and 57.14% of those willing to cut back on fertilizer by 30%. In comparison, the farmers in Siminghu are more optimistic about the reduction of fertilizer. They believe that the crop yield would reduce proportionally to the reduction in fertilizer quantity when the latter is 10%. Most of them predict less crop loss when the reduction in fertilizer quantity stays at other levels.

On average, when the farmers accept a small reduction in crop yield, they tend to believe that the crop loss is more likely to exceed the reduction in fertilizer quantity. The tendency is fully demonstrated by the group of farmers who accept 10% of reduction in fertilizer quantity. Those willing to cut back on fertilizer by 50% or 100% tend to expect a less significant crop loss. The trend is further proved by the cumulative increase in the proportion of farmers believing in that the crop yield would reduce proportionally to the reduction in fertilizer quantity, regardless of the exact level of reduction. The survey reveals that most of the farmers who accept lower reduction in fertilizer quantity attach more importance to the role of fertilizer in production. They generally overestimate the risk of crop loss caused by the reduction in fertilizer. In contrast, the farmers who accept higher reduction in fertilizer quantity are more willing to demand compensation for the production loss, particularly those choosing to cut back on fertilizer by 100%.

Table 2. The famers' expected crop loss corresponding to the acceptable reduction in fertilizer quantity

Acceptable reduction in fertilizer quantity		10%	20%	30%	50%	100%
In total	Frequency (time)	191	130	115	54	51
	Average value (%)	13.17	17.50	25.09	32.87	87.94
	Minimum value (%)	0.00	0.00	0.00	10.00	50.00
	Maximum value (%)	50.00	50.00	50.00	50.00	100.00
	The value of the most expected crop loss (%)	10.00	20.00	30.00	30.00	100.00
	The proportion of the most expected crop loss (%)	63.87	37.69	45.22	33.33	60.78
Qiaodun	Frequency (time)	145	53	77	20	23
	Average value (%)	12.69	19.06	25.58	32.69	94.35
	Minimum value (%)	0	0	0	20.00	10.00
	Maximum value (%)	30	30	50	50.00	100.00
	The value of the most expected crop loss (%)	10	20	30	30.00	100.00
	The proportion of the most expected crop loss (%)	66.21	62.26	57.14	49.40	86.96

Siminghu	Frequency (time)	46	75	38	21	29
	Average value (%)	14.67	16.6	24.08	33.04	80.17
	Minimum value (%)	0	0	10	10.00	50.00
	Maximum value (%)	50	50	40	50.00	100.00
	The value of the most expected crop loss (%)	10	10	20	20.00	100.00
	The proportion of the most expected crop loss (%)	56.52	58.67	34.21	28.57	37.93

3. Model and variables

3.1 Modeling

Table 3. The values of dependent variables and descriptive statistics

Range	Sequence class of dependent variables	Frequency	Effective percentage	Cumulative percetage
（0，10%]	1	191	35.3	35.3
（10%，20%]	2	130	24.0	59.3
（20%，30%]	3	115	21.3	80.6
（30%，50%]	4	54	10.0	90.6
（50%，100%]	5	51	9.4	100
	In total	541	100.0	

In the survey of the farmers' willingness to cut back on fertilizer, this paper combines the open questionnaire method and the payment card method. The combination of the two methods guarantees that the results reflect the farmer's willingness on a voluntary basis. According to the farmers' report, it is known that the reduction accepted by them mostly falls on six points: 10%, 20%, 30%, 40%, 50% and 100%. In view of the continuity of dependent variables and their similarity to discrete variable, the author divides the accepted reduction quantity into five ranges: (0,10%], (10%, 20%], (20%, 30%], (30%, 50%], and (50%, 100%]. Since the accepted values are in a sequential order, the author assigns five values in turn from 1 to 5 to represent the increasing willingness to participate(See Table 3). The higher the assigned value, the higher the level of willingness is to cut back on fertilizer. According to the characteristics of the dependent variables, this chapter adopts the Logit regression model to analyze the determinants of farmers' willingness to participate.

The ordered Logit model can be simply expressed as:

$$L_i\left(X\right)=Logit\left[F_i\left(X\right)\right],\ (i=1,\ \ldots,\ I-1)$$

$$= Logit\left[P\left(Y \le i|X\right)/P\left(Y > i|X\right)\right]$$

$$= Logit\left\{P\left(Y \le i|X\right)/\left[1 - P\left(Y \le i|X\right)\right]\right\}$$

$$= \alpha_i - \beta X$$

Where Y (Y=1,..., I) is the cumulative probability function of the class order i. If Y is independent of X, then $L_i\left(X\right) = \alpha_i$; Otherwise, $L_i\left(X\right) = \alpha_i - \beta X$.

$L_i\left(X\right)$ estimates the effect of each "$-\beta$" unit of the X change on the change of Logit unit (the logarithm of the cumulative occurrence ratio) for ($Y \le i$).

3.2 Selection of variables

According to the relevant literature [16-20] and accumulated experience, this paper selects 14 influencing factors of farmers' participation in water resources protection, which fall into eight categories: individual characteristics, family characteristics, farmland management ability, farmland management characteristics, policy cognition, environmental awareness, willingness to accept compensation, and regional variable.

Specifically speaking, the individual characteristics include:

The age of the farmer(age)—As for the age variable, those between 50 and 70 are deemed as middle aged farmers, those younger than 50 as young farmers, and those older than 70 as old farmers;

The education level of the farmer (edu)—Farmer' education level;

The concurrent business of the farmer(ccb)—Whether the farmer has concurrent business.

The family characteristics include:

The income of the family(inc)—The variable is divided into six ranges based on the mean income (RMB 80,000 yuan) and median income (RMB 50,000 yuan);

The accessibility to drinking water(atw)—Whether a farmer has family members who live in the water supply area.

The farmland management characteristics include:

The acreage (ara)—The actual farmland area reported by the farmer;

The land fragmentation(ldf)—The farmland is regarded as low fragmentation farmland if the variable is below the average value (equal to or fewer than 2), as medium fragmentation farmland if the variable falls between 3 and 5, and as high fragmentation farmland if the variable exceeds 5;

The proportion for sale(pfs)—The ratio of the actual sales reported by the farmer to the production.

The production efficiency (eff) stands for the farmland management ability. It should be noted that the existing literature generally uses the "time devoted to agriculture" to illustrate farmers' production experience and farmland management ability [21]. However, as most farmers in the survey have been involved in rice planting for many years, it is very difficult to measure the farmers' ability to manage and restore the farmland. Considering that the farmland management ability is eventually converted to real income, it is possible to measure the ability by the input-output efficiency. This paper expresses the actual production capacity of the year with the farmers' production efficiency obtained on the basis of the output and input data in the year of the survey. The farmers' production efficiency is measured by the popular data envelopment analysis (DEA). The estimation of the famers' production efficiency are based on input indices like the net quantity of nitrogen fertilizer, the net quantity of phosphate fertilizer, the net quantity of potash fertilizer, the cost of pesticide, the cost of land and the cost of machinery. The output index is the rice yield of the farmers.

The policy cognition (wpa) describes whether the farmer knows that himself/herself lies in the water protection area.

The environmental awareness (iof) describes the environmental assessment of the impact of fertilizer.

The willingness to accept compensation (eci) variable stands for the expected compensation intensity of the farmer, which describes the compensation for each 1% of reduction accepted by the farmer.

The public willingness to accept compensation (aeci) is the instrumental variable of the "expected compensation intensity", which derived from the mean expected willingness to receive compensation of the other farmers who share the same accepted reduction quantity with the respondent.

The relative economic level of the village (rev) is used to compare the economic development between each village and the other villages of the same town. This index is divided into four levels based on the mean value and the quartiles.

The regional variable (qdt) describes whether the water protection area is located in Qiaodun town or not.

Table 4 has listed the meaning and basic statistics of each variable.

Table 4. The names, meanings and descriptive statistics of the variables introduced to the model

Type	Name of variable	Description	Mean value	Standard deviation
Individual characteristics	age	1=younger than 50; 2=between 50 and 70; 3=older than 70	1.9630	0.5794
	edu	1=illiterate; 2=literate, primary school level; 3=literature, above primary school level	1.8226	0.7441
	ccb	1=yes; 0=no	0.7357	0.4659
Family characteristics	inc	1=less than RMB 10,000 yuan; 2=between RMB 10,000 and 30,000 yuan; 3=between RMB 30,000 and 50,000 yuan; 4=between RMB 50,000 and 80,000 yuan; 5=between RMB 80,000 and 100,000 yuan; 6=more than RMB 100,000 yuan	3.4861	0.8915
	atw	1=yes; 0=no	0.6100	0.4882
Farmland management characteristics	ara	Unit: mu	2.3950	1.6339
	ldf	1=fewer than 3; 2=between 3 and 5; 3=more than 5	2.3272	0.8290
	pfs	The ratio of the actual sales reported by the farmer to the production	0.1388	0.1851
Farmland management ability	eff	The production efficiency of the year of the survey calculated by DEA	0.6143	0.1719
Policy cognition	wpa	1=yes; 0=no	0.5564	0.4973
Environmental awareness	iof	1=not sure; 2=there is no impact; 3=there is impact	2.6377	0.6070
Willingness to accept compensation	eci	The compensation for each 1% of reduction accepted by the farmer	16.9077	10.8280

The public willingness to accept compensation	aeci	The mean value of compensations accepted by other farmers	16.8369	9.0015
Regional variable	rev	1=weak; 2=sub-weak; 3=sub-strong; 4=strong	1.7874	0.8867
	qdt	1=Qiaodun reservoir; 0=Siminghu reservoir	0.5970	0.4910

4 Model estimation results

4.1 Selection and verification of instrumental variable

Due to the mutual influence between the farmers' accepted reduction quantity and the willingness to receive compensation, the willingness to receive compensation is likely to be endogenous, which might bias the estimation of model parameters. This paper addresses the issue with instrumental variable. In this method, the estimation is made by two-stage regressions.

Stage 1: Regressing the endogenous variable—the "expected compensation intensity"—against all exogenous and instrumental variables:

$$eci_i = \gamma_i aeci_i + \delta_{ij} \sum x_{ij} + \mu_i \tag{1}$$

Stage 2: Based on the "accepted reduction quantity", fit the willingness to receive compensation obtained in Stage 1 (ecihat) and estimate all exogenous variables:

$$wtr_i = \alpha_i ecihat_i + \beta_{ij} \sum x_{ij} + \varepsilon_i \tag{2}$$

Where $aeci_i$ (public willingness to receive compensation) is the instrumental variable of the "expected compensation intensity"; $ecihat_i$ is the fitted value of the regression result in Stage 1. Formula (2) reflects the relationship between instrumental variable and the expected compensation intensity. There are two reasons that the author sets the "public willingness to receive compensation" as the instrumental variable:

(1)Relevance, i.e. the correlation between the instrumental variable and the endogenous variable: Normally, the joint significance of the instrumental variable and the endogenous variable is judged by the F-test of the first stage of the two-stage estimation. According to the rule of thumb of Staiger and Stock (1994) [22], when there is only one endogenous variable and the F value of the stage 1 regression is greater than 10, there is no weak instrumental variable problem. The F value of the fertilizer control model is 97.85, and the F value of the pesticide control model is 151.69. (See Model A-I and Model B-I in Table 3 and Table 4 respectively) Besides, coefficient of the instrumental variable also passes the t-test at the significance level of 1%. The results show that acri is a strong instrumental variable.

(2) Exogeneity, i.e. the instrumental variable is not related to the disturbance term: Currently, there is no way to measure whether the instrumental variable is related to the disturbance term under the conditions of exact recognition (the number of instrumental variables is the same with that of endogenous variables). Usually, the relevance is determined through qualitative discussion or by reference to expert opinions. Based on the following reasons, the author believes that the instrumental variable is not related to the disturbance term.

The farmers' willingness to accept compensation is mainly affected by four factors: (1) reducing the opportunity cost of fertilizer or pesticide application; (2) local farmland transfer price; (3) national farmland compensation standard; and (4) the implementation of compensation policy. The farmers' demands based on the opportunity cost reflect their own conditions and the production and economic conditions in the local region, which is subjected to obvious neighborhood effect. The use of "public willingness to accept compensation" as the instrumental variable not only reflects the compensation intensity demanded by the farmers, but also how the intensity and implementation of compensation by the local government affect the farmers' compensation requirements. In the same degree of participation, if other farmers have higher demand on average, a farmer may require a higher level of compensation. The individual willingness to participate of the farmer is not directly affected by the average compensation intensity expected by other farmers because the government compensation and the implementation are completely exogenous in the model, and the collective attitude of the other farmers is also an exogenous variable. Theoretically speaking, it is irrelevant to the disturbance term in Model (2). Therefore, the author considers that the average expectation compensation intensity of other farmers is an appropriate instrumental variable of farmers' expected compensation intensity.

4.2 The endogeneity test

As the premise of using the instrumental variable, the existence of endogenous variable should also be tested. In general, the endogeneity of the explanatory variable is tested by means of instrumental variable. This paper takes the residual-based two-step approach proposed by Wooldridge, J. M. (2001) [23]. The first step is to replace the Logit regression estimation in this paper with the OLS estimation, implement the OLS regression of the endogenous variable—"the accepted reduction quantity—against all the exogenous variables (including the instrumental variable), and to retain the resid. The second step is to estimate all variables and the resid on the basis of the "accepted reduction quantity". If the coefficient of the resid passes the significance test, the exogenous assumption cannot be rejected, making it an endogenous variable of the test variable. Please refer to Model A-I and Model A-II in Table 5 for step 1 and step 2 of the fertilizer control model. It can be seen that the resid passes the t-test at the significance level of 1%. Thus, in both of the models, eci is judged to be an endogenous variable.

Table 5. The test results of the instrumental variable and the endogeneity of the fertilizer control model

Variable	Model A-I		Model A-II	
	Coefficient	t value	Coefficient	t value
age	-1.4089***	-2.8433	-0.0557	-0.7313
edu	0.1633	0.4299	-0.0617	-1.0636
inc	0.1258	0.6330	0.0435	1.4363
ccb	-0.3354	-0.5443	-0.2113**	-2.2449
ara	0.0108	0.0637	-0.0066	-0.2537
ldf	0.3451	0.7571	0.2584***	3.7025
pfs	-2.1238	-1.4595	-0.8675***	-3.8843
eff	3.6732**	2.4669	1.1290***	4.9484
wpa	0.7879	1.4572	0.0057	0.0687
iof	0.1970	0.4601	0.0085	0.1294
atw	-0.5083	-0.9486	0.2661***	3.2488
rev	-0.0364	-0.1255	-0.0070	-0.1573
qdt	-0.1910	-0.2443	0.1015	0.8504
eci			-0.1069***	-23.0268
aeci	1.0200***	32.9462		
resid			0.1072***	13.1995
常数	-1.3243	-0.5533	3.0203***	8.2836
N	541		541	
R^2	0.7226		0.553	
F	97.85***		43.38***	

Note:"*" means p < 0.1, "**" means p < 0.05, and "***" means p < 0.01; resid is the residual term obtained by Model I.

4.3 Analysis of model results

As shown in Table 6, the overall goodness of fit of the two models and the significance of individual variables have improved after the endogenous problem of the models is resolved by using the public willingness to accept compensation as the instrumental variable. It is mentioned above that $L_i\left(X\right)$ estimates the effect of each "$-\beta$" unit of the X change on the change of Logit unit (the logarithm of the cumulative occurrence ratio) for (Y ≤ i). Although "$-\beta$" itself is interpretable, it is usually converted to odds ratio by the formula $OR = \exp^{(-\beta)}$ according to the principle of the $L_i\left(X\right)$ model. The odds ratio is easier to explain, and illustrates the influence of each unit of X change over the odds of Y. See the "Point Estimation" column in Table 6 for the specific results of the conversion.

Table 6. Estimated results of fertilizer reduction willingness model

Variable		Estimated value of the coefficient	Z value	Point estimation
Age	[age=2]	0.0810	0.2696	1.0844
	[age=3]	-0.6478	-1.6065	0.5232
Education level	[edu=2]	-0.1036	-0.4735	0.9016
	[edu=3]	-0.3390	-1.1058	0.7125
Family income	[inc=2]	0.6010	0.7301	1.8239
	[inc=3]	0.7430	0.9148	2.1022
	[inc=4]	0.6766	0.8410	1.9672
	[inc=5]	0.3081	0.3703	1.3608
	[inc=6]	1.0562	1.2767	2.8754
Concurrent business	[ccb=1]	-0.5578**	-2.4238	0.5725
Acreage	ara	-0.0129	-0.2048	0.9872
Land fragmentation	[ldf=2]	1.2872***	4.0160	3.6226
	[ldf=3]	1.5276***	4.3623	4.6071
Proportion for sale	pfs	-2.3909***	-4.2513	0.0915
Production efficiency	eff	3.5732***	6.1795	35.6304
Policy cognition	[wpa=1]	0.1946	0.9263	1.2148
Environmental awareness	[iof=2]	0.5911	1.3185	1.8060
	[iof=3]	0.7187*	1.7107	2.0518
Willingness to accept compensation	eci	-0.4207***	-15.9792	0.6566
Access to drinking water	[atw=1]	0.4598**	2.2339	1.5838
Relative economic level of the	[rev =2]	0.0122	0.0531	1.0123

village	[rev=3]	0.3983	1.4072	1.4893
	[rev=4]	-0.2032	-0.4400	0.8161
Local region	[qdz=1]	0.5840**	1.9711	1.7932
Point of tangency of the dependent variable	cut1	-3.9405***	-3.6344	0.0194
	cut2	-1.0397	-0.9935	0.3536
	cut3	0.8504	0.8110	2.3406
	cut4	2.0492*	1.9475	7.7617
Model fitting	N	541		
	pseudo R^2	0.381		
	Log likelihood	-499.8506		
	LR chi2(15)	614.66***		

Note:"*" means p < 0.1, "**" means p < 0.05, and "***" means p < 0.01. For all categorical variables, the low order values are taken as the reference.

In accordance with the estimated results of the parameters listed in Table 6, it is concluded that variables like age, concurrent business, acreage, land fragmentation, proportion for sale, production efficiency, environmental awareness, willingness to accept compensation and the local region all have significant impact on the willingness to cut back on fertilizer. The specific impacts are as follows:

(1) Concurrent business

The situation of concurrent business plays a significant role in the reduction of fertilizer quantity (P<0.05). The ratio of 0.5725 indicates that it is less likely for the farmers who have concurrent business to reduce fertilizer by high proportions than those who do not have concurrent business. For the farmers who have concurrent business, the mean family income is RMB 70,000 yuan/year, 70% of which is non-agricultural income. After completing the normal agricultural activities, they are more willing to spend time on non-agricultural activities, which can bring more individual benefits. Any extra labor resulted from reduction in fertilizer would incur significant opportunity costs.

(2) Land fragmentation

The ratio of farmlands in the category of "between 3 and 5" is 3.6226 (P<0.01), and that of farmlands in the category of "more than 5" is 4.6071(P<0.01). As both ratios exceed 1, the farmers who own "between 3 and 5" and "more than 5" pieces of farmland are more willing to cut back on fertilizer than those who own "fewer than 3" pieces of farmland. According to the possibility of accepting pesticide reduction, the farmlands are arranged in the following order: “more than 5” >”between 3 and 5” >“fewer than 3”. This shows that farmers with higher land fragmentation are more willing to reduce fertilizer by high proportions. A possible reason is that land fragmentation, as an important index to measure agriculture production conditions, is inextricably related to farmland quality. Among the respondents, the highly fragmented farmlands are often of low quality and low yield. The more fragmented the farmland, the more difficult and labor-intensive of the farmland management. This is especially true to the terraces in mountainous areas. Sometimes, the distance between the two separated blocks can be up to 5 km. Besides, many of high fragmentation farmlands are low yield ones. As a result, most of the owners of high fragmentation farmlands agree to give up some low quality farmlands and focus on high quality ones provided that they are properly compensated. What is more, the farmland consecutiveness is of paramount importance to the application of fertilizer. Contiguous land facilitates mechanized operation and significantly reduces the labor intensity and transportation costs.

(3) Proportion for sale

The ratio of the proportion for sale is 0.0915 ($P < 0.01$), which is lower than 1. This indicates that the probability of the farmers with high proportion for sale is 0.0915 times higher than that of those with low proportion for sale. The greater the proportion for sale, the more unlikely it is for the famers to reduce fertilizer by high proportions. This is probably because the farmers with high proportion for sale regard crop production as an economic activity rather than merely a family activity needed to meet household consumption. Therefore, they are more concerned about the stability of the harvest, and are reluctant to take many protective tillage measures which demand extra labor without bringing additional values to the goods.

(4) Production efficiency

The ratio of production efficiency is 35.6304($P<0.01$), indicating that the farmers of high production efficiency are more likely to cut back on fertilizer by high proportions than those of low production efficiency. On the basis of this finding, it is reasonable to deduct that the farmers who reduce fertilizer by high proportions normally boasts high production efficiency.

(5) Environmental awareness

The ratio of farmers who believe that excessive application of fertilizer affects water quality (iop= 3) is 2.0518 (P <0.01), indicating that the farmers with higher environmental awareness are more likely to reduce fertilizer by high proportions. This testifies the necessity to provide environmental education and spread environmental knowledge.

(6) The willingness to receive compensation

The ratio of the willingness to receive compensation stands at 0.6566 (P<0.1). The willingness exerts a significant effect and the ratio always stays below 1. This means the farmers with higher willingness to receive compensation are less likely to choose a high reduction proportion. A possible reason is: Such farmers expect higher risk of crop loss after fertilizer reduction. The compensation serves as an agricultural insurance against environmental protection measures because it ensures that agricultural incomes are not affected by the uncontrollable risk of crop loss.

(7) Access to drinking water

With a ratio of 1.5838 (P <0.05), the access to drinking water has a significant effect on farmers' willingness to cut back on fertilizer, indicating that a farmer tends to reduce fertilizer quantity by high proportions if his/her family members live in the water supply area. The farmers attach little importance to water quality because most of them rely on the rural drinking water projects rather than the two reservoirs.

(8) Regional factor

The regional variable has a significant effect on the reduction of chemical fertilizers, and the ratio is 1.7932, which is greater than 1. This shows that Qiaodun farmers are more likely to cut back on fertilizer by high proportions than Siminghu farmers. The difference is determined by the agricultural conditions of the two places. The farmlands owned by most Qiaodun farmers are long, narrow and fragmented terraces. As it is inconvenient to use farm cattle or machines, most of the production activities are carried out manually by the farmers. Thus, they are more aspired to receive compensation. Psychologically, they hope to guarantee the compensation by expressing absolute support to government policies. Many of Qiaodun farmers claim that they are willing to give up agricultural production if the compensation is in place.

(9) Insignificant variables

The age factor does not affect the participation of farmers in decision-making. A possible reason is that the farmers adopt basically the same techniques. Besides, as the risk of fertilizer is easily controlled, the farmers' attitude towards the reduction of fertilizer does not change with age. Similarly, the farmers' willingness to cut back on fertilizer is not affected by education level, indicating that farmers of different education backgrounds have little difference on compensation-based ecological protection. That is because education does not necessarily reflect the professional knowledge of the farmers. Neither is the farmers' willingness to reduce fertilizer quantity affected by family income, because it is easy to identify and control the risk of fertilizer reduction. Despite varied levels of family income, the farmers differ little on the willingness as long as their income is guaranteed by the compensation mechanism. Besides, policy cognition does not have any obvious impact to the farmers' willingness, probably because the government policies have not been effectively implemented. In short, the farmers' willingness to cut back on fertilizer is not much affected by the education, environmental awareness and policy cognition. In contrast, the accessibility to drinking water is a prominent influencing factor. This indicates that the awareness of environmental responsibility is still not a motive for farmers to take actions to protect water resources, and showcases the urgency of constructing and improving an incentive mechanism to guide the farmers to shoulder their environmental responsibilities. Moreover, the farmers' decision-making process is not easily affected by the relative economic level of the village. The conclusion confirms that the farmers' behaviors and decision-making are easily swayed by neighbors, and tend to have similar patterns.

5. Conclusion and Implications

5.1 Research conclusions

In order to subdivide and sort the intensity of farmers' willingness to participate, the author creatively makes the famers' willingness to cut back on fertilizer as the proxy variable of farmers' willingness to participate in ecological protection of drinking water environment, and divides the reduction quantity of fertilizer and pesticide accepted by the farmers into five intervals assigned in turn from 1 to 5. Since the values are in a sequential order, this paper chooses the ordered Logit regression model, which applies to the data feature, to analyze the causes of farmers' differed willingness to cut back on fertilizer. The results are as follows: farmers of all age groups share similar willingness to cut back on fertilizer. When they decide to reduce the use of fertilizer, they only consider the personal income (the farmers' concurrent business), irrespective of family income. The more fragmented the farmland, the more willing the farmer is to reduce fertilizer. Since the farmers with high crop commercialization rate pay more attention to agricultural income, those boasting high proportion for sale are less likely to reduce the use of fertilizer by high proportions. In contrast, the farmers with strong ability to management farmland and control the risk of crop loss are more likely to slash on the fertilizer quantity. Paradoxically, the famers more willing to receive compensation are less willing to participate. Of course, the trend is also affected by the local economy. For example, farmers living in Qiaodun, where the natural and economic conditions are poorer, are more willing to reduce the use of fertilizer by high proportions than those living in Siminghu. They have a stronger desire to make more money and change the farmland environment. Generally speaking, the farmers' willingness to cut back on fertilizer is not much affected by the education, environmental awareness and policy cognition, but greatly influenced by the accessibility to drinking water.

5.2 Research implications

To improve the farmers' awareness of scientific farming, the government departments in the water protection area should take the lead in building a technical exchange platform for the farmers. For instance, the departments can set up a fund to encourage innovative agricultural models and organize commendation meetings, aiming at creating a good learning atmosphere, strengthening the interaction and exchanges between farmers, and boosting their enthusiasm for innovation and exploration. Of course, the improvement of resource utilization not only relies on farmers but also on land. Under the prerequisite of sustainable use of farmland, the government departments ought to implement a nutrition promotion plan, make rational arrangement of cropping system, and prepare a land transformation plan in light of local conditions to improve low-yielding farmlands.

In addition to farmers and land, the government should also coordinate the relation between farmers and the market. This requires the government to give guidance to the farmers from production, circulation and consumption, so that they could change the long-established production habits to meet the green food standard. In particular, it is necessary to give technical support to the farmers during the production process. For example, the government should encourage the farmers to shift to the production of pollution-free, safe and quality green foods by helping them build local eco-agriculture brands and even promoting the certification of green trademarks.

To sum up, the key to solving the lack of coordination and the uncheck use of fertilizer lies in the gradual unification of the farming methods of the farmers, i.e. taking collective actions. If the farmers learn to take actions collectively, it is conductive to the unified planning of the government and the farmers' adoption of protective tillage measures. As long as the compensation is in place, any kind of protective tillage measures can spread to all areas by drawing upon the experience gained on key points. Nevertheless, the policies must be flexible enough to arouse the farmers' interests in participation. To some extent, policy flexibility equals the diversity of cooperation patterns between the farmers and the implementing agencies. Therefore, the government should provide personalized options when it establishes a cooperation model based on voluntary participation in the water protection area.

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