Research on farmers' green production behavior from the perspective of environmental regulation

Dong Yubing[1,a*], Lei Zhiying[1,b]

[1]College of Management, Sichuan Agricultural University, Chengdu 611830, China

*Corresponding author: [a]2025279938@qq.com, [b]205350049@qq.com

Abstract. Based on the field investigation data of 263 citrus growers in Jianyang, Meishan, Pujiang and Jintang, Sichuan Province, this paper discusses the factors influencing farmers' willingness to produce green production technology and their behavior from the perspective of environmental regulation, and uses binary logit model to analyze the reasons for the deviation between farmers' willingness and behavior.

Keywords: Environmental regulation; Institutional norms; Green production

1 Introduction and literature review

The realization of agricultural green production is of great significance to improve agricultural production efficiency, reduce resource waste and environmental pollution in the production process, and promote the high-quality development of agriculture[1].In February 2022, The State Council promulgated the "14th Five-Year Plan for Promoting Agricultural and Rural Modernization", emphasizing the important role of developing and promoting agricultural green production technology and building an agricultural green production system in the new historical period. Farmers are the key subjects to adopt green production technology, and their green production willingness and behavior directly affect the application effect of green production technology in China. The research shows that the current situation of agricultural green production is not optimistic, many farmers have a high willingness to adopt green production technology, but not much use in actual production behavior, and the contradiction between willingness and behavior seriously hinders the green development of agriculture[2].It is of great practical significance to explore the internal reasons and mechanism of the deviation between farmers' green production intention and behavior for promoting agricultural green production and accelerating agricultural modernization.

Domestic and foreign research on the green production intention and behavior deviation of farmers has made some achievements. Based on the perspective of resource endowment, some scholars believe that the difference in farmers' perception of value brought by different production modes greatly affects farmers' willingness to green production, and the actual resource endowment is a key factor restricting farmers' green

B. K. Kandel et al. (eds.), *Proceedings of the 2023 3rd International Conference on Business Administration and Data Science (BADS 2023)*, Atlantis Highlights in Computer Sciences 19,
https://doi.org/10.2991/978-94-6463-326-9_31

production behavior [3-5]. Therefore, policy suggestions are put forward to strengthen capital accumulation and optimize resource endowment structure to promote farmers' green production behavior [6]. With the deepening of cognitive research, green cognition has gradually evolved into a new research perspective. Scholars have proposed that farmers' green cognition has a positive impact on their green production intention [7], and the difference in farmers' green cognition is one of the important reasons leading to the deviation between their intention and behavior. Therefore, suggestions are put forward to optimize the combination of traditional green production mode and modern science and technology [8]. In addition, based on the development of informal institutions, scholars have explored the internal reasons for the deviation between farmers' green production intention and behavior under the influence of social norms [9-10], environmental awareness [11-13] and social network [14-15].

The previous studies of scholars provide reference value for this paper, but there is still room for expansion. There are many studies on farmers' green production intention and behavior deviation, but few studies have been conducted from the perspective of environmental regulation. On the one hand, most of the existing studies on environmental regulation focus on the will of farmers, and few focus on the contradiction between the will and behavior. On the other hand, the measurement of environmental regulation by scholars mainly focuses on the government policy level, and rarely considers the environmental awareness of farmers themselves, and the selection of indicators is one-sided and lack of systematical.

This paper takes 263 citrus growers in Jianyang, Meishan, Pujiang and Jintang of Sichuan Province as the main research objects, takes the test soil formula technology as an example, uses the binary regression model to empirically analyze the influencing factors of farmers' green production intention and behavior deviation, explores the key role of environmental regulation in the deviation process, and expand the composition of influencing factors of farmers' green production. It provides a wealth of theoretical support and practical experience for improving agricultural green production efficiency.

2 Analysis and hypothesis

Environmental regulation is the regulation of various behaviors that pollute the public environment for the purpose of protecting the environment. Environmental pollution is a kind of negative externality behavior, and to regulate such behavior is to transform the cost borne by the whole society into the private cost borne by itself. Environmental regulation, as an external factor, profoundly affects the behavior of farmers. On the one hand, as the main body of balancing agricultural economic development and environmental protection, government departments can influence the willingness and behavior of farmers to adopt green production technologies from the aspects of environmental protection policy formulation, environmental protection system constraints, pollution monitoring and punishment [16]. On the other hand, under the long-term historical accumulation, environmental protection has gradually become the common customs, behavior norms and value standards of rural households, and the impact of

individual behaviors on the environment has been more considered in the process of production and life of rural households. In order to protect the environment, farmers may make positive choices in the adoption of green production technologies such as soil testing formulas [17].

Based on this, the following research hypotheses are proposed:

H1: Environmental protection regulations negatively affect the deviation between farmers' willingness to adopt soil testing formula and their behavior;

H2: Environmental awareness norms negatively affect the deviation between farmers' willingness to adopt soil testing formulas and their behavior.

Farmers' behavior is essentially the result of individual internal cognition and multiple external environment, which is influenced by the interaction of internal and external factors, and cannot be analyzed from unilateral factors. For example, mandatory government requirements or penalties will positively promote farmers' willingness to adopt green production technologies, but under the economic orientation, farmers may still give up the adoption of such technologies due to their weak environmental awareness and reluctance to invest more costs, resulting in a contradiction between their willingness and behavior. It can be seen that the deviation between farmers' willingness and behavior is jointly influenced by government policy norms and environmental awareness norms. Based on this, the following research hypotheses are proposed:

H3: The interaction of Environmental protection system standard and environmental awareness norms affects the deviation between farmers' willingness to adopt soil testing formulas and their behaviors.

3 Research data and research model

3.1 Data sources and descriptive statistics

The research data were obtained from field research on citrus growers in Jianyang, Meishan, Pujiang and Jintang of Sichuan Province in December 2021, covering a total of 8 townships and 16 villages. The survey adopts random sampling method, mainly in the form of one-to-one interviews between investigators and farmers. The questionnaire includes the basic situation of farmers' families, their intention and behavior of green production, and relevant policy demands. A total of 311 questionnaires were collected, of which 298 were valid, with an effective rate of 95.8%. According to the actual research content, 35 questionnaires that farmers were unwilling to adopt the soil testing formula were excluded, and the final sample number was 263.

The descriptive statistical results show that the respondents in this survey are mainly male farmers aged between 35 and 55 with an education level of junior high school or below. The scale of individual farming is concentrated within 10-20 mu, and most of the farmers have concurrent business behaviors. New agricultural operators account for a relatively small proportion in this survey. The basic information of the samples accords with the actual situation of citrus planting in Sichuan Province and is representative to a certain extent(As shown in Table 1).

Table 1. Basic characteristics of samples

Index	Options	Sample size	percent/%
Sex	Male	194	73.8
	Female	69	26.2
Age	Below 35	19	7.2
	35 and 55	198	75.4
	55-75	23	8.7
	Over 75	19	7.2
Educational level	Primary and below	107	40.7
	Junior high school	131	49.8
	High school and technical secondary school	18	6.8
	College or above	7	2.7
Planting scale	10 acres or less	88	33.5
	10-20 acres	139	52.9
	20 acres and above	36	13.6
Quantity of labor force	1-2 people	92	35.0
	3-5 people	147	55.9
	More than 5 people	24	9.1
Part-time employment	Pure cultivation	86	32.7
	Culture and cultivation	10	3.8
	Work and planting	152	57.8
	Others	15	5.7

3.2 Variable selection and description

In this paper, we assign "0" to the samples that are willing and have adopted the soil testing formula technology in agricultural production, indicating that there is no deviation between farmers' green production intention and behavior, and "1" to the samples that are willing but have not adopted the soil testing formula technology in agricultural production, indicating that there is a deviation between farmers' green production intention and behavior. The individual characteristics of farmers, family characteristics and production characteristics are taken as control variables, and 10 secondary indexes are subdivided. The results show that the mean value of deviation variable between farmers' willingness and behavior is 0.519, that is, 51.9% of farmers have deviation between their willingness and behavior in adopting soil testing formula technology. The mean value of environmental protection system standard variable is 2.703, indicating that the vast majority of farmers' adoption of green production technologies such as soil testing and formulation technology is affected by the government's environmental protection policies and systems. The mean value of environmental awareness standard variable is 3.587, indicating that the adoption of green production technology such as soil testing formula is the result of the improvement of farmers' green production awareness. The obvious difference of variables indicates that the key variables affecting the deviation between farmers' willingness and behavior are government institutional norms and environmental awareness norms. In other words, whether

farmers' green production willingness can be translated into behavior depends more on the comparison between traditional production technology and green production technology on environmental protection. The will and behavior of farmers will further converge. (As shown in Table 2).

Table 2. Description and statistics of variables

Variable class	Variable name	Mean value	Standard deviation
Dependent variable	Deviation	0.519	0.478
Independent variable	Environmental protection system standard	2.703	0.876
	Environmental awareness norms	3.587	1.003
Control variable	sex	0.738	0.479
	Age (logarithmic treatment)	1.646	0.107
	Educational level	1.998	0.905
	Whether they are village cadres	0.372	0.311
	Whether it is a new type of agricultural business entity	0.080	0.279
	Family labor force	3.057	1.093
	Annual household income	5.179	4.304
	Farming years	4.632	1.202
	Scale of operation	16.141	2.509
	Whether to work part-time or not	0.632	0.503

3.3 Research model

Binary Logit regression model is widely used in the research of binary decision making, and can be used to solve the research problem of farmers' willingness to adopt green production technology and their behavior deviation.

$$logit(p)=ln\left(\frac{P}{1-P}\right)=b_0+b_1x_1+b_2x_2+\ldots+b_nx_n+\varepsilon \quad (1)$$

In equation (1), p is the probability of deviation between farmer's behavior and intention in adopting soil testing formula technology; b_0 Is a constant; b_1-b_n Is the binary Logit regression coefficient of the respective variables; x_1-x_n Is an independent variable; ε Is the constant error term.

The entropy method is used to study the interaction of many factors. It can judge the dispersion degree of each variable measurement index according to the size of the observed value of each index, and assign the weight of the index. This paper proposes that farmers' willingness to adopt green production technology and their behavior deviation are influenced by the interaction between government institutional norms and environmental awareness norms. It is necessary to use entropy method to synthesize the

corresponding comprehensive index by weighted average of each variable and assign weight.

$$X = \left(x_{ij}\right)_{m*n} \tag{2}$$

x_{ij} represents the j index of the i farmer; m is the number of farmers; n is the number of evaluation indicators, and the extreme value of equation (2) is standardized.

$$x_{ij}^{'} = \frac{(x_{ij} - minx_{ij})}{maxx_{ij} - minx_{ij}} \tag{3}$$

The specific gravity matrix is obtained by normalizing the column of the normalized matrix (3).

$$Y = \left(y_{ij}\right)_{m*n} \tag{4}$$

$$y_{ij} = \frac{x_{ij}^{'}}{\sum_{i=1}^{m} x_{ij}^{'}} \tag{5}$$

The information entropy (e_j) and information utility value (d_j) of item j are calculated by using matrix (5).

$$e_j = -\frac{1}{ln(m)} \sum_{i=1}^{m} y_{ij}\, lny_{ij} \tag{6}$$

$$d_j = 1 - e_j \tag{7}$$

According to the weight of j index$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$, the index weights of government policy norms and environmental awareness norms are obtained, and the comprehensive index is calculated.

$$F = \sum_{j=1}^{n} w_j * y_{ij} \tag{8}$$

4 Empirical Analysis

4.1 Reliability and validity test

In this study, SPSS22.0 was used for reliability analysis of the data, and the Klonbach coefficient value was 0.760, which was greater than the reference value 0.6, indicating that the reliability of the research data was high and the index measurement was relatively stable. The validity analysis of the data shows that the KMO value is 0.804, greater than the reference value 0.7, and the Bartlett spherical test value is 1803.455, and p=0.000. The 0.01 test indicates that there is a high correlation between the variable indicators and the validity of the research data is high.

4.2 Model checking

The binary Logit model was used for regression analysis of data samples. The result of model likelihood ratio test p<0.001 and the result of Hosmer test p=0.10, which was greater than 0.05, indicated that the model fit was good. Robustness test was carried out on the model, and 1000 repeated samples were taken by Bootstrap for regression. The results of model estimation show that the results of Logit regression under Bootstrap method are consistent with those of binary Logit regression, and the model robustness test passes (As shown in Table 3 and Table 4).

Table 3. Binary logit model regression results

Variable name	Logit regression		
	Regression coefficient	Standard error	$Exp(B)$
Environmental protection system standard	-0.670***	0.203	0.507
Environmental awareness norms	-0.628***	0.156	0.513
R^2	0.253		

Table 4. Regression results after repeated sampling

Variable name	After Bootstrap extraction, Logit regression is performed	
	Regression coefficient	Standard error
Environmental protection system standard	-0.670***	0.201
Environmental awareness norms	-0.628***	0.206

Note: ** and *** are statistically significant at 5% and 1%, respectively.

4.3 Interaction test

The entropy method was used to calculate the entropy and weight of each variable (As shown in Table 5 and Table 6).

Table 5. Independent variable index and weight

Variable name	Variable index	Entropy value	Weight
Environmental regulation	Environmental protection system standard	0.9907	0.5839
	Norms of collective consciousness	0.9286	0.3977

Table 6. Interaction analysis

Variable name	Model	
Environmental protection system standard	-0.786***	-0.972*** (0.368)
	(0.433)	
Environmental awareness norms	2.225**	
	(9.153)	

Note: ** and *** are statistically significant at 5% and 1%, respectively.
The values in parentheses are interpretation coefficients.

4.4 Result analysis

Environmental protection regulations and environmental awareness regulations have negative effects on farmers' willingness to adopt soil testing formula technology and their behavior deviation. And the impact of environmental protection system is greater than that of environmental awareness. The more strict the government's formulation and control of environmental protection system, the stronger the pollution punishment, and the willingness and behavior of farmers to change traditional production methods and adopt green production technology will not be inconsistent. At the same time, constantly improving farmers' environmental awareness and strengthening their understanding of the importance of green production behavior will also promote farmers to carry out green production. Therefore, hypothesis H1 and H2 are confirmed.

The results of interaction test show that the interaction terms of environmental protection policy norms and environmental protection awareness norms have a significant negative impact on the willingness to adopt green production technology and the deviation of behavior of farmers, that is, environmental protection policy norms and environmental protection awareness norms have complementary effects in the process of reducing the degree of deviation between willingness and behavior. First of all, farmers will adjust and change their perception of environmental pollution costs according to the government's environmental protection system, which will affect the actual willingness and behavior of green production technology adoption. Secondly, when farmers themselves have a high awareness of environmental protection, they will also take the initiative to respond to the relevant policies and systems of the government on adopting green production technologies and protecting the environment, and convert their willingness to adopt into actual behaviors. Therefore, hypothesis 3 is confirmed.

In the empirical process, it was found that the farming years of sample farmers had a significant negative effect on the willingness and behavior deviation of farmers to adopt soil testing formula technology. In this regard, existing studies have given a more reasonable explanation that the longer the farming years of farmers, the more dependent they are on their own production experience, the less likely they are to change the original production mode, and the more likely they are to deviate from their willingness to adopt the new green production mode and their behavior [18]. On this basis, combined with the field investigation, this paper proposes that the ability of farmers to learn new things decreases with the increase of age, and most of the young rural labor force choose to go out for work, and the remaining older labor force is difficult to bear the excessive production intensity, which leads to the negative impact of farming years on green production willingness and behavior.

5 Conclusions and enlightenments

Based on the field survey data of 263 citrus growers in Jianyang, Meishan, Pujiang and Jintang of Sichuan Province, this paper explores the influencing factors of farmers' willingness to adopt green production technology and their behavior deviation from the perspective of environmental regulation, and uses the binary logit model for empirical study. The empirical conclusion is as follows: Environmental regulation has a negative

impact on farmers' willingness to adopt green production technology and behavior deviation.

According to the above research conclusions, the following policy recommendations are put forward: First, strengthen the formulation and implementation of the government's environmental protection system, appropriately strengthen the investigation and punishment of environmental pollution behaviors, further formulate and improve the monitoring and supervision system of green production, and guide the formation and development of social norms of environmental protection. Second, through technical training, household propaganda and other ways to make the promotion of green production technology accurately landing, encourage technical talents to guide and teach in rural households, and comprehensively improve farmers' green technology cognition. Third, fully rely on modern Internet technology to strengthen the dissemination of environmental protection information such as green production, give play to the demonstration and promotion role of green production representatives, and create a good environment for environmental protection and green production.

References

1. He K, Zhang J B, Zeng Y M, et al. (2016) Households' willingness to accept compensation for agricultural waste recycling：taking biogas production from livestock manure waste in Hubei, P. R. China as an example. Journal of Cleaner Production, 131(9): 410-420.
2. Wang S J, Wang Y Q. (2014) Research on Influencing factors of straw selling behavior and willingness choice difference: Based on survey data of 624 farmers in Jiangsu Province. Rural Economy, (06): 55-59.
3. Lu M Y, Wang K. (2008) Study on the influence of vegetable farmers' resource endowment on their planting pattern and planting scale selection behavior: Based on empirical analysis of vegetable farmers in Jiangsu Province. Agricultural Technical Economics, (02): 64-71.
4. Zhu W H, Chen M Y. (2021) Study on the influence of household resource endowment on farmers' green production behavior: Based on the survey data of 458 tea farmers in Fujian Province. Taiwan agriculture research, (01): 27-31.
5. Fu X H, Song W T. (2010) Analysis on the influencing factors of purchasing intention and purchasing behavior of farmers' biopesticides: A case study of Sichuan Province. Agricultural technology economy, (6): 120-128.
6. Zhang T C, Yan T W, He K, Zhang J B. (2017) Effect of capital endowment on farmers' investment intention in green production: A case study of straw returning to farmland. China Population, Resources and Environment, 27(08): 78-89.
7. Huang Y Z, Luo X F, Li R R, Zhang J B. (2018) Farmer cognition, external environment and green agricultural production intention: Based on the survey data of 632 farmers in Hubei Province. Resources and Environment in the Yangtze Basin, 27(03): 680-687.
8. Yu W Z, Luo X F, LI R R, Xue L F, Huang L. (2017) Study on farmers' green technology adoption intention and behavior deviation from the perspective of green cognition. Resources Science, 39(08): 1573-1583.
9. Shi Z H, Zhang K X. (2022) A re-examination of farmers' "strong will and weak behavior" in green production: from the perspective of resource constraints and social norms -- with individual norms as the mediating variable. Agricultural resources and Regionalization in China: 1-12.

10. Xia J Q, He K, Zhang J B. (2019) Effects of environmental regulations and village regulations on farmers' green production intention: A case study of resource utilization of breeding waste from large-scale pig farmers. Chinese Journal of Eco-Agriculture, 27(12): 1925-1936.
11. Xu J B, Wang Y, Li C X. (2021) The influence of farmers' cognition on agricultural green production intention in the context of environmental regulation policy: Verification of data from 698 farmers in Heilongjiang Province. Journal of China Agricultural University, 26(02): 164-176.
12. Zhou Z W, Ma Q, Hou Y L, Yue D Q, Yao X Y. (2021) Study on the influencing factors of cotton farmers' environmental protection intention and behavior under environmental regulation in Xinjiang. Resources and environment in arid areas, 35(02): 8-13.
13. Daniela L, A. C P, Marco C. Environmental regulation and green productivity growth: Evidence from Italian manufacturing industries[J]. Technological Forecasting & Social Change,2022,184.
14. Gao M. (2020) Research on farmers' green production technology adoption behavior from the perspective of "dual network". Northwest A&F University.
15. Jimena A, Domingo F, Adoración M, et al. Popularity in Social Networks. The Case of Argentine Beekeeping Production Entities[J]. Agriculture,2021,11(8).
16. Cheng X Y. (2022) Effects of expected income and institutional environment on farmers' willingness to develop green agriculture: A case study of Quma Town, Yunyang County. Shanxi agricultural economy, (3): 19-21.
17. Yu Y H, Zhang Z J, Liu Y S. (2021) Farmer preference and ecological protection participation behavior of agricultural ecological protection policy objectives: Based on an experimental analysis of farmer selection in ten districts and counties in Chongqing. China Rural Observation, (01): 85-105.
18. Nie W, Zuo T D, Chen J. (2019) Analysis on influencing factors of farmers' cognition of agricultural green development and adoption of green production behavior. Journal of Northeast Agricultural University (Social Science Edition), 18(03): 1-9.