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Land Certification, Adjustment Experience, and Green Production Technology Acceptance of Farmers: Evidence from Sichuan Province, China

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Abstract: Land certification and adjustment experience, which are of great significance to strengthen farmers' acceptance of the green production technologies (the GPTs), are important factors that affect the stability of land property. Based on the research data of 540 farmers in Sichuan, China, the probit model is used in this research to explore the effect of the land certification upon the GPTs acceptance of farmers and discuss the moderation effect of land adjustment experience (large-scale adjustment and small-scale adjustment). The results show the following. (1) Overall, 10% of the farmers have not obtained the certificates, 17% of the farmers have experienced small-scale land adjustment, and 3% of the farmers have experienced large-scale land adjustment. Meanwhile, 15% of the farmers have not adopted any the green production technologies (the GPTs), and the rest have adopted at least one green production technology. (2) Land certification affects farmers' acceptance of the GPTs in a significant way. (3) Small-scale land adjustment will weaken the role of land certification in promoting farmers' acceptance of the green production technologies (the GPTs), while large-scale land adjustment will not. (4) For farmers with large scale of land, low extent of land fragmentation, and high extent of dependence on agricultural income, land certification will positively promote farmers' decision making on whether to accept the GPTs.

Keywords: land certification; land adjustment; green production technology; acceptance behavior; China

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1. Introduction

The fifteenth global development objective in the United Nations Sustainable Development Goals calls for the restoration of degrading land and soil. It puts forward that the sustainable development of agro ecosystem should be emphasized. Ever since China started economic reform and opening up, achievements of agriculture in the past 40 years have attracted worldwide attention. However, the rapid development in exchange for extensive agricultural production has seriously overdrawn the ecological dividend [1,2]. According to the official data of China Rural Statistical Yearbook, from 1990 to 2020, China's agricultural output value rose from 71.17 billion USD to 1030.70 billion USD. It has increased 14 times. At the same time, in the past 30 years, the amount of chemical fertilizer rose from 25.903 million tons to 52.507 million tons. The amount of pesticide rose from 733 thousand tons to 1.131 million tons and has increased twice. Because of the excessive consumption of chemical fertilizers, pesticides, and other extensive agricultural production practices, non-point source pollution in agriculture is aggravated. Moreover, the quality of agricultural products is not high, which has seriously affected the sustainable development of agriculture [3,4]. Thus, boosting the green transformation of agricultural production mode and the green development of agriculture in rural areas has important implications for reducing rural environmental pollution. It improves resource utilization efficiency and

promotes the implementation of the Rural Revitalization Strategy [5]. During the 12th Five-Year Plan period, China's agricultural department clearly defined the basic objectives. They are "one control, two reductions, and three basics". China's No. 1 central document of 2022 points out that it is necessary to strengthen the comprehensive treatment of non-point source pollution in agriculture. Then, promoting the reduction of agricultural inputs and the recycling of waste to promote the green development of agriculture in rural areas is important. This is the only way to promote the green development of agricultural production for future agriculture.

The research on green production technology was mainly put forward by Western countries in order to explore the environmental pollution problems encountered in the process of industrialization. Scholars in Western countries have discussed the ecological environment and ecological crisis caused by traditional technologies. As Carline Brenner pointed out, in the past 50 years or more, developed countries have relied on a large number of mechanical technologies, irrigation technologies, fertilizers, and pesticides to improve their agricultural productivity, which has paid a huge environmental cost [6]. Agricultural green production technology has become a hot topic in academic circles. Some scholars believe that the green production technologies (the GPTs) are a series of technologies that give consideration to both increasing output and reducing energy [7]. It is a sustainable development model committed to achieving the unity of economic and ecological benefits [8,9]. However, agricultural green production technology is difficult to completely modularize. In other words, no specific technology can have a clear boundary to completely decompose this behavior. The United Nations Environment Programme summarized the GPTs into three categories: (1) technologies to improve soil fertility through organic fertilizer input, optimization of planting structure, integration of livestock and planting, etc.; (2) techniques for reducing soil erosion and pest management through natural methods; and (3) technologies to reduce food deterioration by strengthening the management of agricultural product storage and sales. In view of this, our paper studies the GPTs in the production link and refers to the first and second definitions of the GPTs by the United Nations. Common studies on green production technologies by domestic scholars include farmland quality protection [3,10,11], reduction of pesticides and fertilizers [5,12], straw return [13,14], etc. Unlike domestic scholars, foreign scholars love exploration more, such as studies on the use of the electrolyte principle to degrade pollutants and improve soil fertility [15], using the characteristics of nanoparticles to synthesize nanofertilizer to replace chemical fertilizer and improve soil fertility [16], green technology using vetiver to maintain soil and water nutrient balance to mitigate subsequent changes [17], and so on.

Farmers are the actual decision makers and implementers of the GPTs. Their acceptance of the green production technologies (the GPTs) is not high [18]. For example, Liu's study of the research data of 1115 rice farmers in Hubei and Xuan Wang's study of the research data samples of 944 farmers in Hubei show that the acceptance rates of soil testing formula fertilizer and commercial organic fertilizer by farmers are very low, which are only about 20% [10,19]. So, what exactly restricts farmers to adopt green production technology?

The research on the farmers' acceptance of green production technology and its influencing factors have always been the focus of agricultural economics and development economics. Many scholars have done a lot of research on the influencing factors of farmers' acceptance of the GPTs. They can be summarized into the following two categories. From the perspective of internal factors, farmers' own capital endowment is an important reason that prevents farmers from accepting the GPTs. Previous studies have shown that farmers' age [20–22], education level [23–26], and other personal characteristics, as well as income, land area [27], and other family characteristics, play an significant role in the farmers' acceptance of the GPTs. From the perspective of external factors, environmental regulations like government regulation [28–30], government subsidies [31], and cooperative participation [32–34] play a guiding or restrictive role in farmers' acceptance of the GPTs. However, unlike the previous study, this study paid close attention to the impact of land property rights on the farmers' acceptance of the GPTs.

Some studies have found that the stability of land ownership can affect farmers' long-term investment behaviors [11,35]. The acceptance of green production technologies (the GPTs) by farmers is just a long-term investment behavior. Land certification may have an impact on the adoption of the GPTs by farmers. Land certification refers to the confirmation of agricultural land ownership through land registration procedures, such as land registration application, cadastral survey, ownership verification, registration, and issuance of land certificates to enhance the stability of rural land property rights. The specific analysis is as follows. As rational decision makers, farmers will decide whether to accept the GPTs according to the relative number of costs and benefits. The certainty of investment expectation is also an important factor affecting investment. Land certification and adjustment experience are two important factors affecting the stability of land rights. On the one hand, land certification can improve the certainty of farmers' investment expectations by stabilizing land ownership [36]. When the right has not been confirmed, due to the poor stability of the land right, the farmers' expectation for future investment is uncertain. They usually focus on short-term benefits and carry out predatory management [37]. The incentive for the GPTs is low. Land certification can effectively promote the acceptance of the GPTs, such as farmland quality protection [38] and reduction of pesticide and fertilizer [12]. On the other hand, land adjustment is also an important factor. Land adjustment is the main way to deal with the land redistribution caused by population changes, so as to ensure the fair possession and management of land by collective members. China's agricultural land adjustment includes two basic ways: large-scale adjustment and small-scale adjustment. Large-scale adjustment means that the land in the whole village is recovered by the collective and redistributed to households according to the family population after grading. Small-scale adjustment refers to the partial adjustment among the farmers whose family population has increased or decreased. The land of the farmers whose family population has not changed is not moved. Due to the widespread existence of land adjustment in practice [39], even if farmers have obtained land certificates with legal benefits, they cannot ensure that the land ownership are stable and safe. Therefore, when analyzing the policy effect of the new round land certification, it is necessary to examine the possible impact of the heterogeneity of farmers' land adjustment experience.

In view of this, this research uses the probit model to delve into the effect of the new round certification upon the acceptance of green production technologies (the GPTs) acceptance by farmers and to discuss the moderation effect of land adjustment experience (large-scale adjustment and small-scale adjustment). It can offer a useful reference point for the research of the policy effect on land certification.

2. China's Land Certification and Land Adjustment

In China, according to the constitution, rural land ownership pertains to the village collective. Farmers only have rights to contract and manage the land. In order to stabilize farmers' land contractual management rights and ensure the security and stability of land ownership, the Chinese government has introduced a whole string of policies. In 1998, the land administration law required the government to issue land management right certificates to farmers at the legal level for the first time. Since 2008, Chinese governments at all levels have been effectively promoting the work of rural land ownership and certification. In 2009, China's No. 1 central document of the central government clearly proposed to carry out the pilot of land contractual management right registration for the first time. In 2013, the No. 1 central document of the central government stipulated that land certification should be basically completed in five years. Since then, from 2014 to 2018, five consecutive No. 1 central documents have proposed that we should think highly of land certification. In 2019, the No. 1 central document stressed that. on the basis of basically completing the registration and certification of contracted land, we should "look back" to finish up the work and properly resolve the remaining problems to give out the certificate of land contractual management right to farmers.

The Chinese government has been discouraging rural land adjustment. The law of the People's Republic of China on rural land contracting, as amended in 2002, stipulates at the legal level that no land shall be increased by increasing the number of people and no land shall be reduced by reducing the number of people. It also stipulates the employer shall not adjust the contracted land during the contract period. In 2008, the No. 1 central document stressed that the legal provisions upon which farmers' contracted land shall not be adjusted or recovered during the land contract period shall be strictly implemented. However, in practice, rural land adjustment has not been stopped despite repeated prohibition. China's rural land adjustment can be divided into two types: large-scale adjustment and small-scale adjustment [40]. Large-scale adjustment means that the village collective takes back all the land and redistributes it among the existing farmers. It may lead to significant changes and inconsistencies in some farmers' cultivated land. Small-scale adjustment refers to the partial adjustment among the farmers whose family population has increased or decreased. The land of the farmers whose family population has not changed is not moved [41,42]. Large-scale adjustment requires the village committee to take back the land and redistribute it. This is not only a complicated process, but also a costly one. Small-scale adjustment is a private adjustment between farmers, which is relatively easy. Therefore, in reality, the number of farmers who have experienced large-scale adjustment is relatively small, while the number of farmers who have experienced small-scale adjustment is relatively large.

3. Theoretical Analysis and Research Hypothesis

According to the theory of property rights, as long as the property rights are not clear, external problems will arise and public resources will be overused. Only clarifying property rights can eliminate or reduce the harm caused by the externalities [43]. Therefore, unclear property rights tend to lead to short-term production behavior of farmers, which goes against the long-term investment [44]. Stable land ownership is conducive to long-term investment. In essence, the farmers' acceptance of green production technologies (the GPTs) is a kind of long-term investment behavior. Therefore, from the perspective of the cost–benefit theory, only when the benefits of adopting the GPTs are larger than the costs will farmers accept the GPTs [45,46]. The long-term stable land ownership will make farmers have more stable investment expectations and increase their expected income. Therefore, clear and stable property rights are more conducive to farmers' acceptance of the GPTs [47]. Land certification and land adjustment experience are two important elements that influence the stability of land ownership. This is shown in Figure 1, and the following Sections 3.1–3.3 provide specific analysis.

3.1. The Effect of Land Certification on Green Production Technology Acceptance of Farmers

Land certification affects farmers' acceptance of the green production technologies (the GPTs) through legal protection and farmers' perceptions. On the one hand, the nation has gradually carried out the work of confirming and issuing certificates for agricultural land. In fact, it has made it clear that agricultural land ownership is recognized and protected by law by perfecting the registration institution. After land certification, the legal and institutional guarantees mean farmers do not have to worry about losing their land and the short operation period. It is also beneficial to alleviate land ownership disputes [48] so that farmers have more stable expectations and are more willing to invest in land [49,50]. At the same time, because land certification ensures the long-term nature of land ownership, farmers will not be limited to short-term benefits and are unlikely to make extensive or even destructive use of land. Instead, they will consider adopting the GPTs for long-term benefits. On the other hand, land certification helps to enhance farmers' subjective property security awareness [51]. Whether farmers adopt the GPTs depends on the implementation of the land certification policy. More importantly, it depends on whether the land certification effectively improves farmers' perception of property rights security. Since 2011, when the Chinese central government launched the land certification policy, which expanded from pilot to comprehensive coverage, the central government, provinces, and municipalities

have increased financial investment to ensure the effective promotion of land certification. Many studies on land certification have also confirmed that land certification does improve the security and stability of farmers' land ownership [52]. As land is an important livelihood capital for farmers, farmers trust that the security of land property rights has been improved from the perspective of perception, including farmers' expectation of longer land holding period and lower risk of losing land. So, farmers are willing to adopt the GPTs.

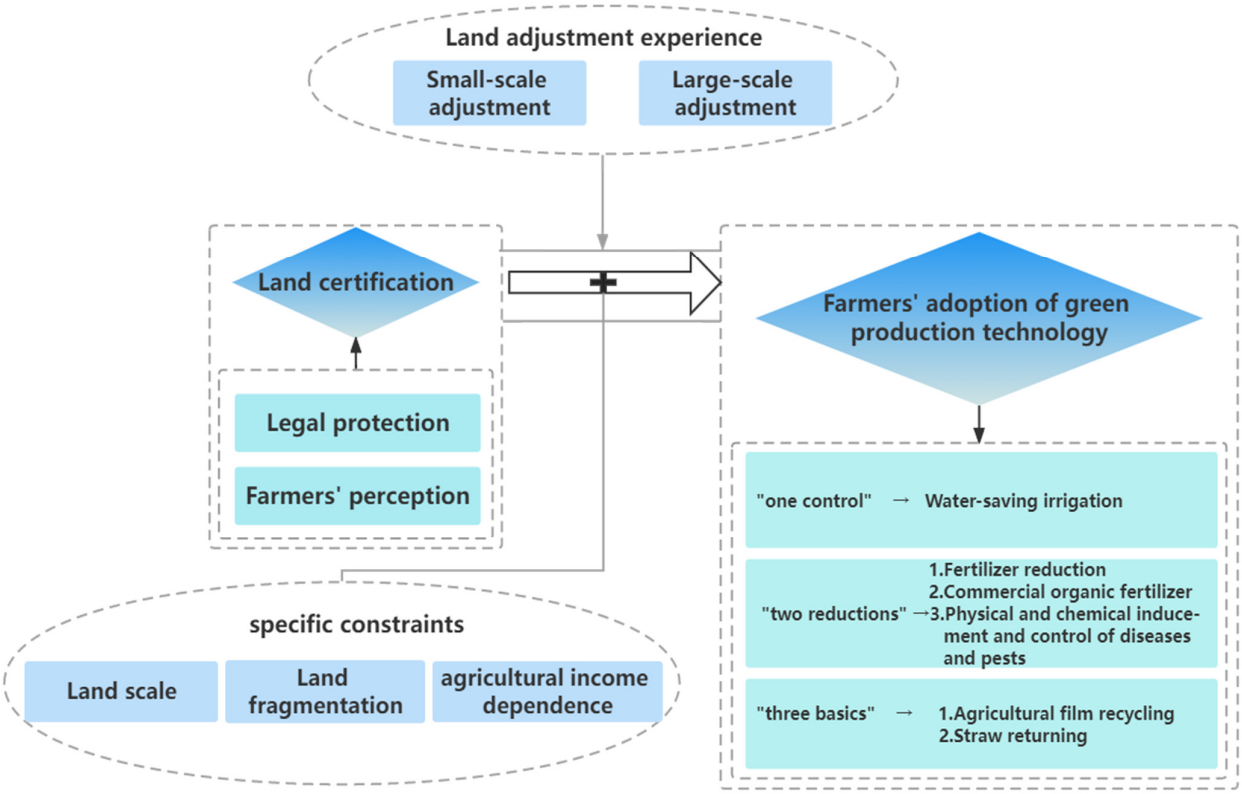

Figure 1. Theoretical analysis frame diagram.

Since the "No. 1 Document" of the central government in 2013 proposed that it would take five years to complete land certification of rural contracted land nationwide, 31 provinces have successively carried out pilot projects throughout the province. The new round of land certification in China is to effectively improve the security of agricultural land property rights, and then bring about Pareto improvement in economic, social, ecological, and other dimensions. Although it is not aimed at the adoption of the green production technologies (the GPTs) by farmers, the research findings of the new round of land certification have confirmed that the issuance of rights confirmation has effectively improved the security of agricultural land property rights [53,54], including the legal level of property rights security and farmers' perception level of property rights security. Based on the above analysis, this study proposes the following hypothesis:

Hypothesis 1. *Compared with the farmers who have not obtained a new round of land certificates, the farmers who have a new round of land certificates are more likely to accept the GPTs.*

3.2. Moderation Mechanism of Land Adjustment Experience upon the Green Production Technology Acceptance of Farmers

The classical literature of new institutional economics points out that the role of previous similar systems cannot be ignored when evaluating the possible policy effects of a system. Only when the system wins people's trust will people consciously abide by the system. The formation of such trust is closely related to the implementation effect of previous systems and people's historical experience. Only those systems that are strictly

implemented and can protect individual rights can enable individuals to form the expectation of institutional credibility and institutional identity, and thus become a real system. That is to say, the implementation effect of the system will strengthen or weaken people's expectations of the credibility of the system, thus leading to the differentiation of policy effects. In view of the fact that the farmers' experience of land adjustment can better show the implementation effect of the previous agricultural land property rights system and is a direct reflection of the security of land property rights, this paper focuses on how the experience of land adjustment affects the policy effect of land certification.

Even though the Chinese government does not approve of land adjustment [55], the experience of land adjustment is relatively common among farmers in practice [56]. During the second round of contracting, the farmers who have experienced land adjustment are neutral to the fact that the policy of land certification has not been fully implemented. Their trust in the policy of land certification will be greatly weakened [57]. They also do not agree that land certification will improve the stability and security of land ownership [58]. During the second round of contracting, farmers who have not experienced land adjustment will think that land certification has stabilized the land property rights [59] and that the relevant rights and interests have been protected. So, the trust in the policy of land certification will be relatively high. That is to say, whether farmers have land adjustment experience or not makes farmers' trust in land certification different. It may also have a different effect upon farmers' acceptance of the green production technologies (the GPTs).

Therefore, this study argues that the experience of land adjustment has a moderation effects in the way that land certification impacts the acceptance of the green production technologies (the GPTs) by farmers. If farmers have no experience of land adjustment during the second round of contracting, they will have a relatively high extent of trust in land certification. Then, they will think that the law can ensure the stability and security of land property rights and have a high extent of land property rights security. So, they will be more willing to adopt the GPTs. However, if farmers have experiences of land adjustment during the second round of contracting, the opposite will be true [60]. Based on the above consideration, this study proposes the following hypothesis:

Hypothesis 2. *The experience of land adjustment has a negative moderation effect on the policy impact of the new round land certification on the acceptance of the green production technologies (the GPTs) by farmers.*

3.3. Impact of Land Certification on Farmers' Acceptance of Green Production Technology under Different Constraints

In reality, the impact of land certification on farmers' acceptance of green production technologies (the GPTs) will be limited by specific constraints. First, land management scale has an impact [27,61]. Even though land certification can stabilize the expected income of farmers' investment by stabilizing the land ownership, the large-scale operation is difficult, and the cost of adopting the GPTs is relatively high for small-scale farmers. Therefore, based on the cost–benefit theory, for such farmers, the promotion effect of land certification on the acceptance of the GPTs by farmers will be weaker. However, for large-scale farmers, the acceptance of the GPTs is easy to produce scale benefits and reduce costs. Meantime, land certification will play a stronger role in boosting the GPTs acceptance of farmers [62]. Based on the above analysis, this study proposes the following hypothesis:

Hypothesis 3. *Compared to the farmers with small-scale land, when the farmers' land management scale is large, land certification of the new round will have a stronger impact on boosting the acceptance of green production technologies (the GPTs) by farmers.*

Second, land fragmentation has an impact [63]. Specifically, the theoretical logic lies in the following: land fragmentation will increase labor intensity, road costs, and other costs [64]. For farmers with a high extent of land fragmentation, even though land certification can stabilize the expected income of farmers' investment by stabilizing land

rights, the existence of redundant and unnecessary monetary and nonmonetary costs caused by land fragmentation will hinder the promotion of the acceptance of GPTs by farmers because of the high extent of land fragmentation [65]. Based on the above analysis, this study proposes the following hypothesis:

Hypothesis 4. *Compared with the farmers with a small extent of land fragmentation, when the extent of land fragmentation of farmers is large, the promotion of the new round land certification on farmers' acceptance of the green production technologies (the GPTs) is weaker.*

Third, agricultural income dependence has the effect [66]. The specific analysis is as follows: the heterogeneity of farmers' agricultural income dependence means that the agricultural labor input time and energy of family members are differentiated [67]. For farmers with a low level of agricultural income dependence, their willingness to invest in the green production technologies (the GPTs) will be reduced due to the lack of time, energy, and attention to agriculture and land, resulting in a weaker role of land certification in promoting the acceptance of GPTs by farmers even if the income expectation of farmers' investment is stable through land certification. For high agricultural income-dependent farmers, the opposite is true. Based on the above analysis, this study proposes the following hypothesis:

Hypothesis 5. *Compared with low agricultural income-dependent farmers, when farmers are more dependent on agricultural income, the new round land certification has a stronger effect in promoting farmers' acceptance of the green production technologies (the GPTs).*

4. Data Source, Variable Setting, and Model Setting

4.1. Data Source

Sichuan Province is the research area. As shown in Figure 2, Sichuan Province is located in the southwest of China. It is a large agricultural province. The rural population of Sichuan is about 36.20 million and the proportion of rural population is 43.27%, which are both in the top-ranked China. Rice is the main food crop in Sichuan. The sown area of rice is about 2 million hectares, accounting for about 30% of the total sown area of Sichuan's crops. Thus, Sichuan is a significant rice planting base in China. Thus, it is representative to choose Sichuan as the sample province.

The sample districts of the study are Jiajiang County, Yuechi County, and Gao County. Figure 2 shows the location and landform of the three counties. Jiajiang County, Yuechi County, and Gao County are located in the southwest, south, and east of Sichuan Province, respectively, covering a total area of 748.47 square kilometers. The main landforms of the three districts are plain county, hilly county, and mountainous county, respectively.

The data employed in the paper are from the questionnaire survey carried out by the research group in Jiajiang County, Gao County, and Yuechi County, Sichuan, China in July 2021. To ensure the quality and representativeness of the data, we selected Shengli Village and Liujiang Village in Wenjiang, Chengdu, to conduct a pre survey of 50 questionnaires before the survey, so as to revise the questionnaire. Secondly, the investigators are all postgraduates and doctoral students majoring in agriculture and forestry economic management who have received strict training. Then, the survey was docked with the local agricultural and rural bureau. The research mainly uses the method of stratified equal probability random sampling to determine the survey samples. The specific implementation steps are as follows: First, we selected the sample counties. According to the landform and the per capita gross industrial output value, the 183 counties in Sichuan were split into three groups by using the method of cluster analysis. Then, one county was selected from each group at random. Three sample districts were obtained. Jiajiang County, Yuechi County, and Gao County represent a plain county, hilly county, and mountainous county, respectively. The second is to choose the sample town. Considering the basic conditions, such as the economic development extent of each township in the sample county and the

distance from the center of the county, three sample townships were chosen from each sample county at random. In all, nine sample townships were obtained. Thirdly, the sample villages were chosen. Considering the basic conditions, such as the economic development extent of each village in the township and the distance from the township center, three sample villages were selected from each sample township at random. In all, 27 sample villages were acquired. Finally, the sample farmers were identified. In light of the register furnished by the village cadres, 20 farmers were selected as the sample farmers on the basis of the random number table. Ultimately, 540 valid farmers' questionnaires were obtained from 27 villages, nine towns, and three counties. Finally, after the completion of data collection, a "three checks" mechanism is required to ensure the quality of data. Because before the formal interview, we connected with the staff of the village committee to ensure that farmers can accept the interview. If one farmer refused to be interviewed during the formal questionnaire survey, we selected one from other farmers in the same village according to the principle of randomization. As a result, 540 questionnaires were collected in total.

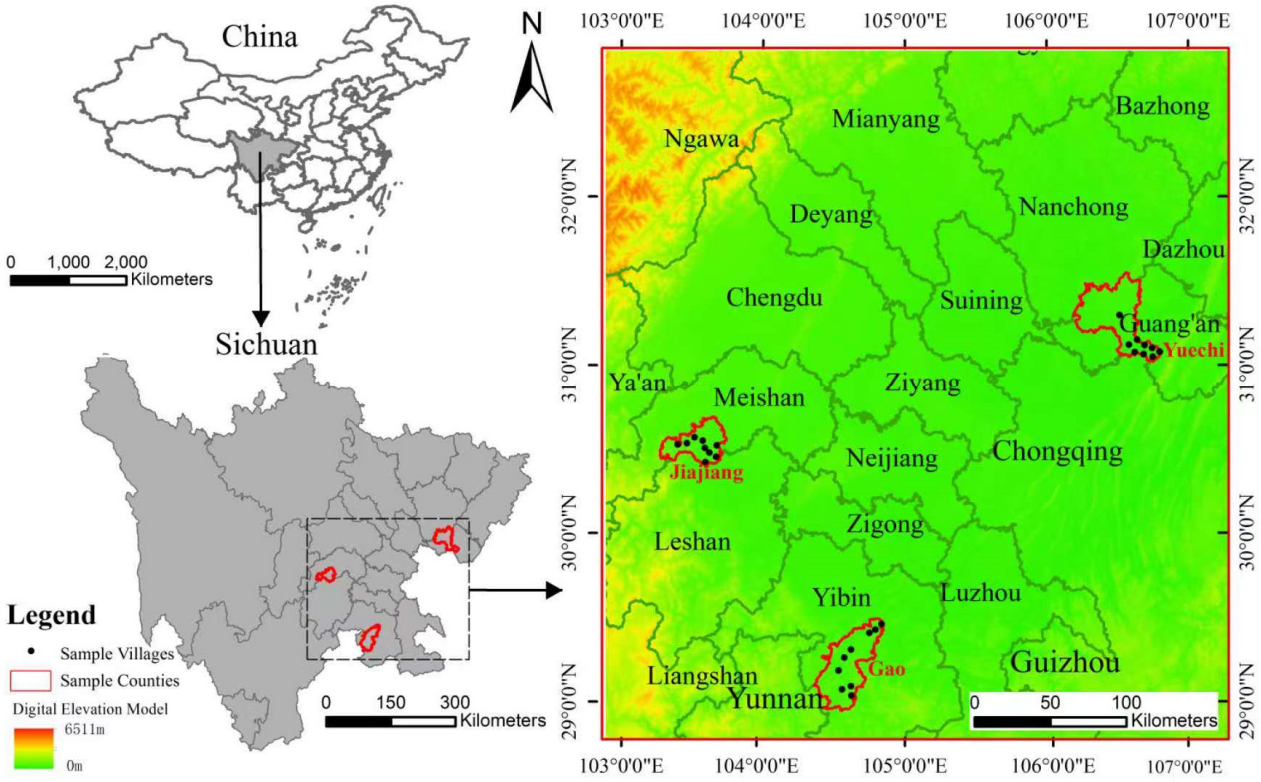

Figure 2. Location map of Sichuan Province and distribution map of the sample districts.

4.2. Model Setting

The acceptance of the green production technologies (the GPTs) by farmers as a dependent variable is a two-category variable. Therefore, the binary probit model was chosen to estimate in this paper. The specific model is as follows:

$$Y_1 = \alpha_0 + \alpha_1 cer + \alpha_2 \mathrm{l} - \mathrm{adu} + \alpha_3 \mathrm{s} - adu + \sum \beta_i X_i + \mu_1 \quad (1)$$

$$Y_2 = \lambda_0 + \lambda_1 cer + \lambda_2 \mathrm{l} - adu + \lambda_3 \mathrm{s} - adu + \lambda_4 cer \times \mathrm{l} - adu + \lambda_5 cer \times \mathrm{s} - adu + \sum \gamma_i X_i + \mu_2 \quad (2)$$

$$Y3 = \omega 0 + \omega 1 cer + \omega 2 \mathrm{l} - \text{management scale} + \omega 3 cer \times \mathrm{l} - \text{management scale} + \sum \varepsilon \mathrm{i} \mathrm{Xi} + \mu 3 \quad (3)$$

$$Y4 = \phi 0 + \phi 1\text{cer} + \phi 2l - \text{fragmentation} + \phi 3cer \times \text{l} - \text{fragmentation} + \sum \rho \text{i} Xi + \mu 4 \quad (4)$$

$$Y5 = \eta 0 + \eta 1\text{cer} + \eta 2\text{agri} - \text{income dependence} + \eta 3\text{cer} \times \text{agri} - \text{income dependence} + \sum \theta \text{i} Xi + \mu 5 \quad (5)$$

$$\begin{aligned} Y6 = {} & \xi 0 + \xi 1\text{cer} + \xi 2\text{l} - \text{management scale} + \xi 3\text{l} - \text{fragmentation} + \xi 4\text{agri} - \text{income dependence} \\ & + \xi 5cer \times \text{l} - \text{management scale} + \xi 6cer \times \text{l} - \text{fragmentation} + \xi 7cer \times \text{agri} - \text{income dependence} \\ & + \sum \nu \text{i} Xi + \mu 6 \end{aligned} \quad (6)$$

Among them, $Y1$, $Y2$, $Y3$, $Y4$, and $Y5$ are farmers' acceptance of the green production technologies (the GPTs). Cer is the new round of land certification as a core explanatory variable. L-adu refers to the farmers' large-scale land adjustment experience during the second round of contracting. S-adu refers to the farmers' small-scale land adjustment experience during the second round of contracting. Cer × l-adu refers to the cross-term between land certification and the farmers' large-scale land adjustment experience. Cer × s-adu refers to the cross-term between land certification and the farmers' land small-scale adjustment experience. L-management scale refers to the management scale of the household's land scale. Cer × l-management scale refers to the cross-term between land certification and the land management scale. L-fragmentation refers to the extent of the land fragmentation. Cer × l-fragmentation refers to the cross-term between land certification and the land fragmentation. Agri-income dependence refers to the proportion of income in agriculture. Cer × agri-income dependence scale refers to the cross-term between land certification and the agriculture income dependence. Xi is the three dimensions of control variables that represent the farmers' individual characteristics, family characteristics, and land management characteristics. This paper measures the effect of land certification in the new round on the acceptance of the GPTs by farmers through Formula (1). Through Formula (2), it is verified whether the experience of land adjustment plays a moderation effect between land certification and the green production technology acceptance of farmers. To demonstrate the effect of land certification on farmers' acceptance of the green production technologies (the GPTs) under different constraints, Formulas (3)–(6) are applied.

4.3. Variable Setting

4.3.1. Green Production Technology Acceptance

Farmers' green production technology acceptance is the dependent variable of this study. In 2015, the Chinese Ministry of Agriculture formulated and issued the implementation opinions of the Ministry of Agriculture on combating non-point source pollution in agriculture. It put forward the objective of "one control, two reductions, and three basics" by 2020. Among them, "one control" refers to dominating the total amount of agricultural water and agricultural water environmental pollution. "Two reductions" refers to the reduction in the application of chemical fertilizers and pesticides. "Three basics" refers to the recycling, comprehensive recovery, and harmless treatment of livestock and poultry manure, agricultural film, and crop straw. Based on this and referring to the existing research on the measurement of farmers' acceptance of the green production technologies (the GPTs), this study introduces six green production technologies including whether to adopt water-saving irrigation technology [68,69], whether to adopt physical and chemical inducement and control of pests and diseases [70,71], whether to reduce the application of chemical fertilizer [72,73], whether to apply commercial organic fertilizer [42,74], whether to return straw to the field [75,76], and whether to recycle agricultural film [77], to reflect the connotation of the objective of "one control, two reductions, and three basics". Water-saving irrigation technology corresponds to the goal of "one control". Physical and chemical inducement and control of pests and diseases, reduction of chemical fertilizer application, and application of commercial organic fertilizer correspond to the objective of "two reductions". Straw returning and agricultural film recycling correspond to the goal of "three basics". Specifically, if farmers adopt at least one of the green production

technologies, they are considered to have adopted the GPTs and the value is 1. If the farmer does not participate in any the GPTs, it is considered that the farmer has not adopted the GPTs, and the value is 0. From the results of the descriptive statistical analysis, 15% of the farmers have not adopted any of the GPTs. The rest of the farmers adopted at least one of the GPTs. Among them, the proportion of farmers who have adopted technologies, such as fertilizer reduction, agricultural film recycling, and straw returning to the field, is relatively high (Table 1).

Table 1. Variable definition and variable descriptive statistics.

Variable	Variable Measure	Mean	Standard Deviation
Green production technology acceptance	Do you adopt the AGPTs (one of the following)? [a]	0.85	0.36
Water-saving irrigation	Do you adopt water-saving irrigation? [a]	0.01	0.07
Fertilizer reduction	Do you adopt fertilizer reduction? [a]	0.57	0.50
Commercial organic fertilizer	Do you adopt commercial organic fertilizer? [a]	0.25	0.43
Physical and chemical inducement and control	Do you adopt physical and chemical inducement and control ? [a]	0.02	0.15
Agricultural film recycling	Do you adopt agricultural film recycling? [a]	0.55	0.50
Straw returning	Do you adopt straw returning? [a]	0.55	0.50
Land certification	Do you obtain land certification? [a]	0.90	0.30
Small-scale land adjustment	Do you experience small-scale land adjustment? [a]	0.17	0.37
Large-scale land adjustment	Do you experience large-scale land adjustment? [a]	0.03	0.17
Age	Your age (years)	58.45	11.84
Gender	Your gender (0 = male, 1 = female)	0.40	0.49
Education	Do you receive nine years education or above? [a]	0.34	0.47
Cognition of agricultural green production	Do you think the AGPTs is important? [b]	4.25	0.90
Family labor	The number of labor force aged 16–64 in your family [c]	2.58	1.45
Family income	The annual net income of the family [d]	0.15	0.36
Social capital	The number of frequent relatives and friends during the Spring Festival	7.29	7.42
Land scale	The scale of the land [e]	0.22	0.42
Land fragmentation	The number of land blocks [e]	0.32	0.47
Land fertility	The fertility condition of the cultivated land [b]	2.95	1.07
Cultivation convenience	The distance from home to the farthest land [f]	0.80	0.40

Note: [a] 1 = yes, 0 = no; [b] Likert 5-point scale, where 1 means strongly disagree and 5 means strongly agree; [c] Those who are students, soldiers, and who are unable to work due to serious illness are not included; [d] 1 = more than 100,000 Yuan, 0 = otherwise; [e] 1 = larger than the sample average, 0 = otherwise; [f] 1 = not exceed 1000 m, 0 = otherwise.

4.3.2. Land Certification

The core variable of this study is land certification. According to the relevant provisions of the newly revised detailed rules for the implementation of the provisional regulations on real estate registration, the main procedures for the land certification are the registration application of land rights applicants, cadastral investigation, ownership review, registration, and issuance or replacement of land certificates. Whether farmers hold a new round of certificates is the last and most critical step to complete the land certification [78]. Therefore, "whether farmers have obtained a new round of land certificates" can be used as the core explanatory variable of land certification [79]. According to the requirements of the No. 1 document of the central government, land certification of the contracted land shall be completed by the end of 2018. Therefore, when the research group conducted the research, most farmers should have obtained a new round of land certificate. However, due to the difference of work progress in different regions, there may be cases where certificates have not been issued yet. This has been confirmed by some scholars [38]. However, the "No. 1 document" of the Central Committee in 2019 once again emphasized looking back and finishing the work of land certification. Therefore, there are relatively few farmers who have not obtained a land certificate. According to the results of the descriptive statistical

analysis, 90% of farmers have obtained the certificate of ownership confirmation. This is in line with the actual situation, indicating that the sample data are representative.

4.3.3. Land Adjustment Experience

Land adjustment experience is the moderation variable of this study. China's rural land adjustment can be divided into two types: large-scale adjustment and small-scale adjustment [40]. This study introduces two moderation variables: whether farmers have experienced small-scale land adjustment and whether they have experienced large-scale land adjustment during the second round of contracting. Then, we assign a value in terms of the answer result. The answer "yes" is assigned a value of 1, which indicates that the land has experienced small-scale or large-scale adjustment. On the contrary, if the value is 0, it indicates that the land has not experienced a small-scale or large-scale adjustment [80]. According to the results of descriptive statistical analysis, 17% of the farmers have experienced a small-scale land adjustment and 3% have experienced a large-scale land adjustment.

4.3.4. Control Variable

There are many factors affecting farmers' acceptance of the green production technologies (the GPTs). In order to test the robustness of research variables and control relevant variables as much as possible, this study introduces three dimensions of control variables: individual characteristics of farmers, family characteristics, and land management characteristics [81]. Among them, the individual characteristics of farmers are reflected by age, gender, education level, and agricultural green production cognition [82]. Family characteristics are measured by the number of people in the family labor force, family income level, and social capital [33,83]. The characteristics of land management are measured by four control variables: management scale, extent of fragmentation, fertility condition of cultivated land, and the extent of cultivation convenience [84,85] (Table 1).

5. Results

5.1. Land Certification and Farmers' Acceptance of Green Production Technology

The estimated results of land certification and farmers' acceptance of the green production technologies (the GPTs) are shown in regression 1. The regression results show that land certification positively promotes farmers' acceptance of the GPTs at the 1% level. It shows that, compared with farmers who have not obtained a new round of certificates, having a new round of certificates can encourage farmers to adopt the GPTs. Hypothesis 1 is thus preliminarily confirmed. In terms of land adjustment experience, large-scale and small-scale land adjustment experiences have a differentiated impact on the green production technology acceptance of farmers. Among them, the experience of small-scale land adjustment negatively affects farmers' acceptance of the GPTs at the significance level of 1%. However, the large-scale land adjustment experience does not pass the significance test. It shows that the experience of land adjustment during the second round of contracting is indeed not conducive to the acceptance of the GPTs by farmers.

5.2. Land Certification, Adjustment Experience, and the Green Production Technology Acceptance of Farmers

In order to verify whether the experience of land adjustment has a negative moderation effect on the effect of land certification on the green production technology acceptance of farmers, the cross-items of small-scale land adjustment experience and land certification, the cross-items of large-scale land adjustment experience and land certification are introduced in regression 2.

The regression results in the Table 2 show that, for the acceptance of the green production technologies (the GPTs) by farmers, "cer" × "s-adu" passes the significance level test at 5% significance level and the impact direction is negative. "Cer" × "l-adu" does not pass the significance level test. Combined with the results of regression 2, it shows that, for

the green production technology acceptance of farmers, the experience of small-scale land adjustment will have a negative moderation effect on the influence of land certification. The experience of large-scale land adjustment has no such moderation effect. In other words, the experience of land adjustment will indeed weaken the incentive effect of land certification on farmers. That is, through weakening the credibility of the new round land certification, farmers' land adjustment experience has established a mechanism that results in a negative moderation effect between land certification and farmers' acceptance of the green production technologies (the GPTs). Hypothesis 2 is thus preliminarily confirmed. However, there are differences in the effects of large-scale land adjustment and small-scale land adjustment on farmers' acceptance of the GPTs. The reason why the cross-items of large-scale adjustment are not significant may be that there are fewer farmers who have experienced land adjustment in the sample, which affects the stability of the results. The concrete reason and logic we present here need to be supplemented by the follow-up study.

Table 2. Model estimation results of the influence of land certification and adjustment experience on the acceptance of green production technology.

Variable	Regression 1		Regression 2	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Cer	0.976 ***	0.205	0.987 ***	0.209
S-adu	−1.118 ***	0.177	−3.874 ***	1.130
L-adu	−0.519	0.388	−3.199 *	1.803
Cer×s-adu	—	—	−1.476 **	0.603
Cer×l-adu	—	—	−1.324	0.877
Age	−0.007	0.007	−0.008	0.007
Gender	−0.312	0.171	−0.335	0.173
Education	−0.113	0.164	−0.128	0.167
Cognition of agricultural green production	0.025	0.084	0.029	0.085
Family labor	0.049	0.056	0.043	0.057
Family income	0.016	0.013	0.017	0.013
Social capital	0.104	0.223	0.180	0.228
Land scale	0.752 ***	0.215	0.706	0.218
Land fragmentation	−0.482 ***	0.170	−0.424	0.174
Land fertility	0.142 *	0.074	0.154	0.076
Cultivation convenience	−0.317	0.198	−0.299	0.201
Constant	0.554	0.709	3.087	0.802
Sample size	540		540	
Pseudo R^2	0.1990		0.2167	

Note: *, **, *** respectively represent 10%, 5%, and 1% significance levels.

5.3. Effect of Land Certification on Farmers' Acceptance of the Green Production Technologies (the GPTs) under Different Constraints

Table 3 reports four results. In regression 3, the cross-term coefficient of land certification and management scale is the difference of the effect of land certification on the green production technology acceptance of farmers under different land management scales. In regression 4, the cross-term coefficient of land certification and land fragmentation extent is the difference of the effect of land certification on the green production technology acceptance of farmers under different land fragmentation extents. In regression 5, the cross-term coefficient of land certification and agricultural income dependence is the difference of the impact of land certification on the green production technology acceptance of farmers under different agricultural income dependence levels. Regression 6 simultaneously controls the above three cross-terms to test the robustness of the estimation results.

Table 3. Model estimation results of the effects of different constraints on land certification.

Variable	Farmers' Acceptance of Green Production Technology			
	Regression 3	**Regression 4**	**Regression 5**	**Regression 6**
Cer	0.925 *** (0.203)	0.804 *** (0.213)	0.841 *** (0.204)	0.690 *** (0.228)
Cer × Land management scale	1.114 ** (0.488)	—	—	1.460 *** (0.515)
Cer × Land fragmentation	—	−0.966 * (0.507)	—	−1.411 ** (0.563)
Cer × Agriculture income dependence	—	—	0.398 * (0.233)	0.357 * (0.236)
Control variable	controlled	controlled	controlled	controlled
Sample size	540	540	540	540
Pseudo R^2	0.1225	0.1194	0.1179	0.1439

Note: *, **, *** respectively represent 10%, 5%, and 1% significance levels.

The estimation results of regression 3 confirm hypothesis 3; that is, the scale of land management will significantly affect the role of land certification on farmers' acceptance of the green production technologies (the GPTs). From the estimation results of regression 3 in Table 3, the coefficient of the cross-term of the virtual variables of land certification and management scale is positive. The cross-item is significant at the 5% significance level. This shows that, for large-scale farmers, adopting the GPTs is an easy way to produce economies of scale and reduce costs. For small-scale farmers, large-scale operation is difficult, and the cost of adopting the GPTs is relatively high. Therefore, land certification will promote farmers to adopt the GPTs, but this process goes hand in hand with the scale of land management. The larger the scale of management is, the stronger the positive influence of land certification on the acceptance of the GPTs by farmers is.

The estimation results of regression 4 confirm hypothesis 4; that is, the extent of land fragmentation will significantly affect the role of land certification on the green production technology acceptance of farmers. According to the estimation results of regression 4 in Table 3, the coefficient of the cross-term of the virtual variables of land certification and land fragmentation is negative. The cross-term is significant at the level of 10%. This shows that, due to the existence of redundant and unnecessary monetary and nonmonetary costs caused by land fragmentation, a high extent of land fragmentation will become an obstacle to the promotion of farmers' acceptance of the green production technologies (the GPTs) for farmers with a high extent of land fragmentation.

The above results show that the extent of land fragmentation has a negative impact on the process of land certification and farmers' acceptance of the green production technologies (the GPTs). The higher the extent of land fragmentation, the weaker the positive effect of land certification on the acceptance of the GPTs by farmers.

According to the proportion of agricultural income in total household income, the sample farmers are divided into low agricultural income dependence (the proportion of income in agriculture is less than or equal to 0.50) and high agricultural income dependence (the proportion of income in agriculture is higher than 0.50). Based on this, regression 5 is obtained. The estimated results of regression 5 confirm hypothesis 5 of this study. That is, the extent of agricultural income dependence will significantly affect the role of land certification on the green production technology acceptance of farmers. On the basis of the estimation results of regression 5 in Table 3, the coefficient of the cross-term of the virtual variable of land certification and agricultural income dependence is positive. The cross-term is significant at the level of 10%. This shows that, for low-income farmers who depend on agriculture, even if the income expectation of farmers' investment is stable through the land certification, the willingness of farmers to invest in the green production technologies (the GPTs) will be reduced due to the lack of time, energy, and attention to agriculture and land. As a result, the promotion influence of land certification on the green production technology acceptance of farmers is weakened. For high agricultural

income-dependent farmers, the opposite is true. The above results show that the extent of agricultural income dependence has a positive impact on the process of land certification and the green production technology acceptance of farmers. The greater the extent of agricultural income dependence is, the stronger the positive influence of land certification on the green production technology acceptance of farmers is. Regression 6 reports the estimated results of simultaneously controlling the above three cross-terms. The three cross-terms are significant at the level of 1%, 5%, and 10%, respectively, and the coefficients are positive, negative, and positive, respectively. It shows that the constraints considered in this study have a relatively stable impact on the green production technology acceptance of farmers.

6. Robustness Tests

The above sets whether farmers have experienced small-scale land adjustment or large-scale land adjustment during the second round of contracting as the moderation variable. However, compared with the dichotomous variable of whether farmers have experienced land adjustment, it is more accurate to measure farmers' land adjustment experience by adjustment times. Therefore, the moderation variable of whether farmers have experienced land adjustment is replaced here. The times of large-scale land adjustment and small-scale land adjustment experienced by farmers during the second round of contracting are used as new moderation variables. From the fitting results in Table 4, land certification still significantly promotes farmers to adopt the green production technologies (the GPTs). In addition, as far as the moderation effect of land adjustment experience is concerned, "land certification" × "times of small-scale land adjustment" still passed the significance test. It shows that the experience of small-scale land adjustment will weaken the role of land certification in boosting the acceptance of the GPTs by farmers, which is consistent with Table 2. "Land certification" × "times of large-scale land adjustment" did not succeed in passing the significance test. That is, the experience of large-scale land adjustment does not moderate the effect of land certification on the acceptance of the GPTs by farmers. This can be mutually verified with Table 2.

Table 4. Robustness test of changing core explanatory variables.

Variable	Farmers' Acceptance of Green Production Technology	
	Coefficient	**Standard Error**
Land certification	0.950 ***	0.208
Times of small-scale land adjustment	−2.264 ***	0.709
Times of large-scale land adjustment	−1.978	1.615
Land certification × Times of small-scale land adjustment	−0.922 **	0.380
Land certification × Times of large-scale land adjustment	−0.871	0.829
Control variable	controlled	
Sample size	540	
Pseudo R^2	0.1805	

Note: **, *** respectively represent 5%, and 1% significance levels.

In addition, since this survey started in July 2021, the survey results cannot identify whether the farmers who obtained certificates in 2021 obtained the certificate of land certification first or adopted the green production technologies (the GPTs) first. This would contaminate the whole sample. In order to avoid this phenomenon, this study carried out fitting regression again after removing this type of farmer, as displayed in Table 5. The results show that the effect of land certification on the green production technology acceptance of farmers is still significant at the level of 1%. In addition, the experience of small-scale land adjustment negatively moderates the effect of land certification on the green production technology acceptance of farmers. However, the experience of large-scale land adjustment has no such moderation effect on land certification and acceptance of the GPTs. It shows that the conclusion of the above fitting regression is credible.

Table 5. Robustness test of subsample.

Variable	Farmers' Acceptance of Green Production Technology	
	Coefficient	**Standard Error**
Land certification	0.988 ***	0.210
Small-scale land adjustment	−3.939 ***	1.143
Large-scale land adjustment	−2.673	1.922
Land certification × Small-scale land adjustment	−1.493 **	0.602
Land certification × Large-scale land adjustment	−1.125	0.905
Control variable	controlled	
Sample size	540	
Pseudo R^2	0.2129	

Note: **, *** respectively represent 5%, and 1% significance levels.

In addition, because the new round of land certification is an institutional arrangement dominated by the national will, this study regards it as an exogenous policy impact and believes that there is no need to consider the endogenous issue.

7. Discussion

Compared with the existing research, the probable marginal contributions of this study are chiefly manifested in three sides. Firstly, this paper creatively structures the theoretical framework of "land certification–adjustment experience–green production technology acceptance of farmers". It explores the influence of land certification on the GPTs acceptance of farmers. At the same time, this study analyzes the effect of different constraints on it. It also discusses the heterogeneous effects in the context of differences in land management scale, land fragmentation, and farmers' dependence on agricultural income. Secondly, it reveals the mechanism of the effect of land certification on farmers' acceptance of the GPTs. It not only studies whether land certification has an impact on green production technology acceptance of farmers, but also focuses on the mechanism of the former on the latter, or the moderation effect of land adjustment experience (large-scale adjustment and small-scale adjustment). Third, it further enriches the theory of land property rights and the GPTs adoption. It provides reference for other developing countries like China to carry out land ownership reform and increase the acceptance of the GPTs.

The results of the study have some similarities and differences from existing studies. Although some papers found that land certification did not promote the adoption of the green production technologies (the GPTs) by farmers [44,86]. However, this paper is the reflects other studies, which show that land certification has reached the expected effect of the policy. It effectively improved the adoption rate of the GPTs by farmers [87], helped farmers adopt straw returning technology [88], applied more organic fertilizer [89], and reduced the amount of pesticides and fertilizers used [35]. Land tenure has been a significant topic in developing countries, such as Central and Eastern Europe, Africa, Asia, Latin America, and other regions. The research of scholars from these countries is similar to this study. Awudu Abdulai's research on Ghana illustrates that land tenure significantly influenced farmers, whether to invest in land-improving and conservation measures or not [90]. Studies of Ethiopia, belonging to West Africa, also show that land registration increased tenure security and land-related investment [49,91]. Research on Thailand, an Asian country, shows that land tenure security significantly affects land-improving investments [92]. Research on Peru shows land tenure security has a positive effect on the probability of making investments [93].

This study also has some shortcomings. Because the number of farmers in the sample who have experienced large-scale adjustment is small, the regression results are not significant. It is not enough to support the research on large-scale adjustment. This deficiency will be further explored by expanding the sample size and other methods in our future research.

8. Conclusions

Based on the survey of farmers in 27 villages, nine townships, and three counties in Sichuan Province, applying the probit model, this study draws the following conclusions: (1) Compared with the farmers who have not obtained the new round of certificates, the farmers with the new round of certificates are more likely to accept the green production technologies (the GPTs). Land certification has a significant positive effect on the green production technology acceptance of farmers. This shows that promoting the implementation of land certification can significantly encourage farmers to accept the GPTs [36,37,47]. (2) Land adjustment is a factor restricting farmers to accept the GPTs. Small-scale land adjustment plays a negative role in moderating the land certification and the acceptance of the GPTs by farmers. Large-scale land adjustment has no such moderation effect. (3) The effect of land certification on the acceptance of the GPTs by farmers will face constraints. For the farmers with a large scale of land, low extent of land fragmentation, and high extent of dependence on agricultural income, land certification has a positive role in promoting their decision making on whether to accept the GPTs.

This study offers some enlightenment on the following:

(1) The new round of land certification positively effects the acceptance of green production technologies (the GPTs) by farmers in a significant way. This study proves that land certification can effectively encourage farmers to accept the GPTs. It shows that land certification can enable farmers to engage in agricultural production based on long-term expectations, which undoubtedly has a positive impact on the sustainable development of agriculture. Therefore, we should pay more attention to the protection of the property rights of agricultural land. Meantime, we should seize the time to ensure the quality and quantity in doing a good job to land certification. Through land certification, it is obvious that agricultural land property rights are recognized and protected by law so as to solve the potentially unstable and unsafe problems of agricultural land property rights. It can also contribute to a positive role of land certification in improving the acceptance of GPTs by farmers.

(2) The influence of the implementation of the previous agricultural land property right institution, which is the experience of farmers' land adjustment, has a certain negative moderation effect on the policy impact of land certification. This study shows that the experience of land adjustment will weaken the effect of the acceptance of the green production technologies (the GPTs) by farmers through weakening their institutional trust in land certification. Therefore, this study confirms that the previous system operation effect and the corresponding historical experience of farmers will lead to the differentiation of the follow-up system policy effect. Meantime, we should take this round of land certification as an opportunity to ensure the long-term stability of the land contract relationship, so that the new round of land certification can truly become an institution of trust for farmers and effectively protect farmers' land property rights.

(3) We should fully consider the impact of different farmer groups [27] and agricultural land characteristics. We should also focus on the objective reality of the current differentiation of agricultural land characteristics and the differentiation of farmers. In the process of encouraging farmers to accept the green production technologies (the GPTs) through land certification, we should adopt different strategies. In view of the heterogeneity caused by the scale of land management and the extent of land fragmentation, it is necessary to orderly accelerate the transfer of agricultural land, expand the scale of land management, form a scale effect, and reduce the negative impact of land fragmentation. For farmers who are highly dependent on agricultural income, we should improve their enthusiasm for farming and guide them to actively adopt the green production technologies (the GPTs). For the farmers with low dependence on agricultural income, it is necessary to stabilize their non-agricultural employment, ensure the stability of their non-agricultural income, and realize the optimal allocation of resources.

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