

The impact of land certification on cropland abandonment: evidence from rural China

Protection of
land quantity

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Abstract

Purpose – This study explores how the land tenure system helps in protecting land quantity during agricultural production by estimating the influence of land certification on cropland abandonment, its mechanisms and its heterogeneous effects among groups at the provincial, community and household levels.

Design/methodology/approach – To deal with potential homogeneity concerns, the authors investigate the impact of land certification on the area of abandoned croplands using nationally representative panel data from the 2017 and 2019 China Rural Household Panel Survey on 15,000 households across 29 provinces and time-varying difference-in-differences and propensity score matching-difference-in-differences models.

Findings – Land certification significantly contributes to the protection of land quantity during agricultural production, and it reduces the area of abandoned croplands by at least 4%. This effect is mainly achieved by improving soil fertility, promoting land transfer, increasing the availability of agricultural subsidies and raising agricultural income. However, while land certification benefits farmers in nonmajor grain-producing areas and western regions, in plain, remote and nonpolitically central villages, and farmers who have not undergone land transfer or land adjustment, it is not beneficial for others.

Research limitations/implications – In the postepidemic era, food security based on the protection of the amount of cultivated land becomes increasingly important. It is realistic and inevitable to rationally use every inch of cultivated land and curb the cropland abandonment by strengthening land tenure system reform, especially in the case of the insecurity of land tenure.

Practical implications – There are various factors affecting farmers' cropland abandonment, such as poor soil fertility, unavailable land transfer, too little agricultural subsidies and too low agricultural income, but the root cause is the insecurity of land tenure. Empirical evidence from rural China has shown that a clear definition and effective protection of property rights can help curb the cropland abandonment. Enhancing the land protection behavior of farmers through the reform of land certification and promoting the sustainable use of land are what the reform of land tenure system should be.

Social implications – Cultivated land, as the material carrier and endowment basis of grain production, is of great importance to safeguarding national food security, especially in the postepidemic era. At the present stage, it is still necessary for most developing countries to strengthen the construction of land tenure system, to carry out land certification reform and to issue farmers with clearly defined and legally effective land certificates. Equally important, efforts also should be made to promote the diversified utilization of the achievements of the certification after the completion of land certification reform in China and other developing countries.

Originality/value – Expropriation and occupation of croplands are essential in protecting land quantity during rapid urbanization, and so is reducing cropland abandonment during agricultural production; therefore, it deserves close attention. In this regard, this study estimates the impact of land certification on the area of abandoned croplands, examines its possible mechanisms and identifies its heterogeneous effects to test the applicability of the property rights theory in the Chinese context and enrich the relevant literature and provide Chinese evidence for other developing countries to strengthen the protection of land quantity, by deepening the reform of the land tenure system under different circumstances.

Keywords Land certification, Time-varying DID model, Cropland abandonment, Protection of land quantity

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1. Introduction

In the 21st century, the greatest challenge facing humankind is how to deal with two opposing trends: population increase and limited food supply (Ward and Pulido-Velazquez, 2008). According to the latest estimates from the Food and Agriculture Organization (FAO) of the United Nations, from 2014 to 2019, the number of people suffering from starvation increased by nearly 10m each year, and the number of chronically underfed people has risen by about 60m during this period. Worse still, due to the rapid spread of the coronavirus disease 2019 (COVID-19), the number of chronically hungry people worldwide may exceed 130m by the end of 2020 (FAO, 2020). With irreversible population growth, the global food crisis is likely to become more serious (Lambin and Meyfroidt, 2010).

Since human beings began practicing an agricultural civilization, it has been widely believed that cropland is a major carrier of food production (Zavalloni *et al.*, 2021). To guarantee food security, a certain amount of available cropland must be maintained (Alonso-Sarría *et al.*, 2016). However, with the development of the economy and the subsequent rural–urban labor migration, the abandonment of cropland has gradually become a global social and economic phenomenon in recent decades (Gellrich *et al.*, 2007). According to incomplete statistics, since the beginning of the 20th century, the total area of abandoned cropland worldwide has reached approximately 3,850,000–4,720,000 km² (Campbell *et al.*, 2008), which has had significant negative impacts on food security among countries. As such, cropland abandonment has attracted widespread attention from scholars (Queiroz *et al.*, 2014), and abundant literature has been produced in this regard.

Several driving factors, including biophysical features and socioeconomic characteristics, affect the abandonment of cropland. Specifically, existing studies have shown that unsuitable environmental conditions (e.g. steep landforms, poor soil fertility, land fragmentation and remote areas), low agricultural income, insufficient agricultural labor (e.g. labor migration, off-farm work and high dependency ratio), imperfect land rental market and lack of agricultural policy incentives may lead to cropland abandonment by farmers (Prishchepov *et al.*, 2013; Lieskovsky *et al.*, 2015). In addition, the land tenure system is also an important factor influencing the abandonment of cropland, which cannot be ignored. Based on remote sensing data from 1989 to 2000, Alix-Garcia *et al.* (2012) found that cropland abandonment in Poland and Slovakia can be partly explained by the reform of the land tenure system, while cropland abandonment in the border areas of Ukraine was mainly caused by the incomplete reform of the land tenure system. Macro data from the Soviet Union also indicated that incomplete or inadequate land reforms have resulted in the abandonment of extensive croplands (Prishchepov *et al.*, 2013). However, there are relatively few quantitative studies based on micro-farmer household data that explore the relationship between land tenure system reform and cropland abandonment (Saint-Macary *et al.*, 2010), especially the reform of land certification (Zheng and Luo, 2019). Relevant research on land tenure systems mainly discusses the economic effects, focusing on land transfer, investment and credit (Feder and Nishio, 1998), while the ecological effects are rarely studied (Zheng *et al.*, 2021).

Fortunately, the reform of the land tenure system in China provides a good observation window for the impact of land certification on cropland abandonment. Marked by the No. 1 Document of the Communist Party of China Central Committee in 2013, the Chinese government launched a new round of land certification reform programs nationwide, aiming to strengthen the protection of farmers' land property rights and grant farmers' increased property rights. Compared with the reforms in other countries, the new round of land certification reform in China has two main characteristics. First, it is massive. According to statistics from the Third National Agricultural Census, there were as many as 207.43m farmers in China in 2016. The reform required full implementation of land certification to ensure that every farmer received a land certificate that was accurate in size, clear in ownership and fully functional. Second,

China's reform is state-led. The reform of land certification was led by the Ministry of Agriculture and Rural Affairs of China and implemented by local governments at all levels. It had a strict timetable and required the country to complete the registration and issuance of the land certificate in five years.

In fact, discussing the relationship between land certification and cropland abandonment is of great practical significance and theoretical value in the context of China. On the one hand, similar to the economic structural transformation of developed countries, China now is currently experiencing rapid industrialization, urbanization and economic globalization. In this process, the issue of cropland abandonment has become increasingly serious (Zhang *et al.*, 2018). On the other hand, China is a developing country with the largest population in the world. In the context of economic globalization and the COVID-19 pandemic, China's food demand has a significant impact on the global food market (Deng *et al.*, 2019). If China cannot guarantee its food security and take effective measures to deal with cropland abandonment, this may inevitably have a huge impact on the world's food market and even cause food panic in countries worldwide (Yan *et al.*, 2009). Therefore, it is of informational value for other countries to find out how to leverage land quantity protection through land reform (Lichtenberg and Ding, 2008), prevent farmers' cropland from being abandoned and thereby build a strong food security barrier. Moreover, whether it is from a practical or theoretical perspective, the abandonment of cultivated land is not a new phenomenon in China, while land certification is. However, the only two relevant Chinese studies that use cross-sectional data (Luo *et al.*, 2017; Zheng and Luo, 2019) not only fail to fully explore the causal relationship between land certification and cropland abandonment, but also greatly restrict the dissemination of knowledge on this subject. Given this, our study uses nationally representative panel data from the China Rural Household Panel Survey (CRHPS) and a time-varying difference-in-differences (DID) model to empirically test the impact of land certification on the area of cropland abandonment and eventually provides empirical evidence of the land tenure system reform promoting the protection of land quantity.

Compared with the two directly related Chinese studies, the possible marginal contributions of this paper are mainly reflected in the following aspects: First, existing studies have not distinguished the specific time of land certification when measuring the new round of land certification, but China has conducted multiple rounds of land certification since the reform and opening up (Zheng *et al.*, 2021). There will be measurement errors in doing so, and this paper can use the time of land certification to scientifically identify the new round of land certification. Second, when the existing research discusses the impact of land certification on cropland abandonment, it mainly focuses on whether farmers have abandonment behavior but lacks attention to the area of abandoned croplands. Restraining the expansion of abandonment areas is an important part of the protection of land quantity. This paper focuses on the impact of land certification on the area of croplands abandoned by farmers and uses whether or not farmers have abandoned and the ratio of cropland abandonment as a robustness test, to deepen related research and dialogue with existing research. Third, existing studies mainly investigate the impact of land certification on cropland abandonment in general and lack the heterogeneity analysis of the role of land certification in different situations. In contrast, this paper will further examine the heterogeneity of land certification from the dimensions of the province, community and household. Fourth, existing studies mainly use cross-sectional data from a small number of provinces of China in 2014, and it is difficult to control unobservable factors at the farmer level. However, this paper uses panel data from 29 provinces across the country in 2017 and 2019 and adopts a time-varying DID model. Not only the samples are relatively new, but also the endogenous problems that may be caused by missing variables can be dealt with, making the conclusions more credible.

2. Literature review and theoretical analysis

The land tenure system is an institutional arrangement with cropland as the core. There are numerous factors that affect the abandonment of cropland. Whether it is natural, economic or social, most of them are related to the land tenure system to some degree. In the context of the massive rural–urban labor migration (Chen *et al.*, 2014), four factors – soil fertility, land transfer, agricultural subsidies and agricultural income – become the main obstacles to the protection of land quantity, which is especially obvious in a situation of insecure property rights (Zheng and Luo, 2019). Therefore, enhancing the security of land property rights through land certification can improve the constraint conditions of land utilization to a certain extent to reduce cropland abandonment.

2.1 Land certification, soil fertility and cropland abandonment

Poor soil fertility is a direct factor in cropland abandonment by farmers (Alix-Garcia *et al.*, 2012). Generally, crop yields are relatively low in plots with poor soil fertility (Sluiter and De Jong, 2007). To obtain an average yield, farmers need to invest more time and energy (Rudel and Fu, 1996). Therefore, for rational farmers, it may be more economical to abandon instead of cultivate poor croplands (MacDonald *et al.*, 2000). In particular, when farmers are insecure about their land property rights, the option of abandoning the cropland becomes more obvious (Saint-Macary *et al.*, 2010), primarily because land tenure security is often associated with positive long-term behavior. If farmers cannot expect to recover their full investment from future income (Roth and Haase, 1998), they are likely to give up the cropland that has poor soil fertility. Fortunately, land certification can address the farmers' insecure status of property rights (Kassa, 2014), and enhance their security about land property rights (Zheng *et al.*, 2020). Once the farmers' croplands are certified, their expectations will become more stable (Wang *et al.*, 2015). In this case, farmers are likely to take long-term measures, including the use of organic fertilizers to improve soil fertility, which can further help reduce abandonment of croplands.

2.2 Land certification, land transfer and cropland abandonment

The unavailability of land transfer is an indirect factor contributing to cropland abandonment by farmers (Deininger *et al.*, 2012). In actuality, there is no reason or need for farmers to abandon their croplands. Renting out cropland will not only bring them extra rental income but will also make it easier for them to cultivate the land themselves in the future. Regarding land transfer, there are three possible reasons for cropland abandonment. First, the land transfer market is imperfect (Zhang *et al.*, 2014). Second, the transaction cost of land transfers is greater than the transfer rent (Jin and Deininger, 2009). Finally, farmers worry about losing their cropland after renting it out (Benjamin and Brandt, 2002). Property rights are a prerequisite and the basis for land transfer. Land certification is a form of legal empowerment to issue a legally valid land certificate to farmers, which not only provides legal property rights protection for the land, but also provides tradable property rights certificates for land transfer (Zheng *et al.*, 2020). Land certification helps in reducing information asymmetry and transaction costs, eliminates farmers' concerns about losing their croplands (Wang *et al.*, 2015) and thus, promotes the development of land transfer markets (Yami and Snyder, 2016). Therefore, land certification can create conditions for land transfer and thereby help reduce cropland abandonment.

2.3 Land certification, agricultural subsidies and cropland abandonment

The low availability of agricultural subsidies is an external motivation for farmers to abandon their cropland (Díaz *et al.*, 2011). Agricultural subsidies are an incentive and a

restraining mechanism (Strijker, 2005). With subsidies, farmers' enthusiasm for farming increases; without them, the probability of farmers abandoning their croplands increases (Estel *et al.*, 2015). In rural Chinese society, agricultural subsidies, including grain and seed subsidies, are generally based on the area of croplands as stated on the land certificates. In this case, if farmers lack the corresponding land certificate, the possibility of obtaining agricultural subsidies is reduced (Ignacio Díaz *et al.*, 2011). An important goal of the reform of land certification is to issue farmers their legally valid land certificates that clearly state the croplands' area (Zheng *et al.*, 2020), to protect their land rights and interests (Luo *et al.*, 2017). In this sense, land certification can not only reduce information asymmetry and transaction costs in the implementation of agricultural subsidy policies to make the issuance of agricultural subsidies more accurate (Deininger and Feder, 2009), but also protect farmers' legal rights and interests in obtaining agricultural subsidies and thereby improve their enthusiasm for agricultural production (Nordin, 2014) and reduce the possibility of cropland abandonment.

2.4 Land certification, agricultural income and cropland abandonment

An internal motive for farmers to abandon their croplands is the relatively low agricultural income (Chen *et al.*, 2014). The rapid expansion of China's economy, large imports of international agricultural products (Aide and Grau, 2004) and continuously rising factor prices (Lieskovsky *et al.*, 2015) have greatly increased the pressure on agricultural income growth (MacDonald *et al.*, 2000). It is understandable that if agricultural income continues to be lower than nonagricultural income and cannot be effectively increased, farmers would likely abandon their cropland, especially because of the insecurity of land property rights (Deininger *et al.*, 2012). Through the clear definition and effective protection of property rights, land certification can guarantee farmers' exclusive land-use rights, exclusive rights to income and the liberalization of transactions (Cheung, 1973), which will help stimulate farmers' enthusiasm for agricultural production (Zheng and Luo, 2019). With the economic incentive of property rights, farmers will either increase their agricultural investment (Besley, 1995) or expand the scale of agriculture (Holden *et al.*, 2011) to improve agricultural productivity further (Holden *et al.*, 2009), thereby increasing the level of agricultural income and reducing the probability of cropland abandonment.

In short, once the cropland is certified, the security of land tenure will improve accordingly; farmers will be motivated to improve their soil, be able to lease their cropland, have a certificate to receive agricultural subsidies and have an incentive to increase agricultural income, thereby reducing the probability of cropland abandonment.

3. Data, variables and research design

3.1 Data sources

The data employed in this study are sourced from the 2017 and 2019 CRHPS of Zhejiang University. The dataset adopts a stratified, three-stage sampling method proportional to the population size and covers 29 provinces (excluding Hong Kong, Macao, Taiwan, Xinjiang and Tibet) across China. The dataset is representative at multiple levels, including rural, urban, provincial and national levels (Qian, 2020). The official website that presents the data is: <http://ssec.zju.edu.cn/sites/main/default.aspx>. The CRHPS dataset involves relatively rich information about households in China, including the basic structure of the family, economic condition, agricultural production, land use and other aspects. Although the land certification information in this paper has been collected since 2015, the information on the area of croplands abandoned by farmers will not be available until 2017. Furthermore, considering that there are numerous factors affecting the cropland abandonment, we also retained

relevant variables such as individual characteristics, family characteristics and community characteristics. However, considering that not every household provided all the information on the above variables. We deleted 597 samples with missing information from the 15,086 original samples of farmers, and the sample loss rate was 3.96%. In the end, we got a nonbalanced panel of 14,489 farmers distributed in 29 provinces across the country.

3.2 Statistical description

Based on the research objectives of our study and the results of existing studies, the following variables are proposed.

3.2.1 Dependent variable. Unlike the quantity protection of cropland during urbanization, this study mainly investigates the quality protection of cropland during agricultural production, focusing on idle and wasted croplands. This is because nonagricultural conversion of cropland is mainly driven by urbanization, while cropland abandonment mainly depends on the farmers' subjective choice. As users and beneficiaries of croplands, it is important to guide farmers' behavior. Therefore, the area of croplands abandoned by farmers is used as a proxy indicator of the protection of land quantity, and cropland abandonment by farmers and the ratio of cropland abandonment are used for the robustness test.

3.2.2 Focus variable. Referring to [Zheng et al. \(2021\)](#), this study considers land certification as the core independent variable, which is mainly based on the two questions of the questionnaire used. One is, "Did your household have the land management rights certificate?" The other question is, "In which year was the certificate issued?" To identify the new round of land certification accurately instead of using the land certificate in general, this study chooses to consider land management rights certificates issued since 2013 as the standards to measure land certification. The main reason for this choice is that 2013 was the beginning of a new round of land certification in China. More importantly, this state-led reform, for the panel data of farmers, not only effectively avoids the reverse causality problem in econometric model inference, but also reduces the endogenous problem caused by selection bias.

3.2.3 Control variables. Consistent with existing studies, our study mainly controls for individual, household and community characteristics, which are deemed to influence both land certification and cropland abandonment. Specifically, the individual characteristics are the age and age squared of the householder ([Xu et al., 2019](#); [Zheng and Luo, 2019](#)) and the health and education of the householder ([Deng et al., 2019](#)). The main household characteristics include the dependency ratio ([Zavalloni et al., 2021](#)), off-farm employment ratio ([Xu et al., 2019](#)), per capita contracted land area ([Zhang et al., 2018](#)) and number of plots ([Yan et al., 2016](#); [Luo et al., 2017](#)). To exclude the influence of time-varying factors at the community level, this study also adopts the number of new farmers and the community's prior year per capita disposable annual income, which reflect the development of agriculture and economy at the community level, respectively. The definitions and descriptions of the main variables are presented in [Table 1](#).

3.3 Model setting

Considering that the new round of land certification reform initiated by the Chinese government since 2013 has gradual characteristics, it is essentially a quasi-natural experiment. To explore the relationship between the reform of land tenure system and the protection of land quantity, we designate families that have obtained land certificates as the treatment group and families that have not obtained land certificates as the control group. We adopt a time-varying DID model that is in line with the gradual characteristics of the new round of land certification reform to estimate the impact of land certification on the abandonment of croplands by farmers. The specific benchmark model is set as follows:

Variables	Definition	Mean	SD	Min	Max
Abandonment area	Area of abandoned cropland in rural households (mu)	0.26	1.51	0	50
Abandonment behavior	Whether to abandon cropland (0 = no; 1 = yes)	0.09	0.28	0	1
Abandonment ratio	The ratio of abandoned areas to total cropland	0.04	0.15	0	1
Land certification	Since 2013, whether farmers have obtained a land certificate (0 = no; 1 = yes)	0.56	0.50	0	1
Age	Age of the householder	53.58	10.65	16	69
Age2	Age square of the householder	2984.33	1069.20	256	4,761
Health	Health status of the householder (from good to bad)	2.85	1.05	1	5
Education	Whether the householder went to high school (0 = no; 1 = yes)	0.12	0.33	0	1
Dependency ratio	The dependency ratio of the elderly and children	0.35	0.48	0	5
Off-farm ratio	Household non-farm employment ratio	0.22	0.26	0	1
Land size	Per capita contracted land area of the household (mu)	3.06	6.32	0.01	360
Land number	The number of plots	5.50	5.97	0	120
Community agriculture	The number of new farmers	7.78	83.86	0	2,563
Community economy	The range of per capita disposable annual income (from low to high)	3.90	1.29	1	9

Table 1.
Variable definition and
summary statistics

Note(s): 1 mu = 1/15 hectare

$$Abandonment_area_{it} = \alpha_0 + \beta Certification_{it} + \delta_i + \varphi_t + \varepsilon_{it} \quad (1)$$

where subscript i represents the householder, and t represents the data collection time. *Abandonment_area* denotes the area of cropland abandoned by farmers. Note that considering the large difference in the abandoned area among farmers, the logarithm of the area of abandoned croplands is taken in the subsequent regression to eliminate potential heteroskedasticity problems and facilitate the interpretation of coefficient estimation. *Certification* represents the land certification variable. If the farmer i obtains the land certificate in year t , then for $t \geq \tau$, the value of *certification* is 1 and 0 otherwise, where $\tau \geq 2013$. α_0 is the intercept term; δ_i represents the fixed effect of farmers; φ_t represents the year-fixed effect; and ε_{it} is the random disturbance term.

4. Empirical results

4.1 Baseline regression

Table 2 reports the regression results of land certification to cropland abandonment. Using a time-varying DID model and a stepwise regression method, columns (1)–(4) represent the comparative benchmark analysis for adding no control variables to gradually adding individual, household and community characteristics, respectively.

We consider that the random disturbance term among different households in the same community may be correlated. On the one hand, the reform of land certification in China is often promoted by the whole village; the issuance of land certificates is essentially carried out at the same time, and the reform of land certification and land protection may both be affected by the collective's ability regarding land governance and control. As such, land certification at the household level may be interrelated. On the other hand, rural communities belong to an acquaintance society by nature, and there may be a peer effect in the behavior of abandoning

Table 2.
Land certification and
cropland
abandonment: basic
results

	The logarithm of the area of abandoned croplands			
	(1)	(2)	(3)	(4)
Land certification	−0.046** (0.020)	−0.045** (0.020)	−0.043** (0.019)	−0.042** (0.019)
Age		−0.018** (0.007)	−0.020** (0.007)	−0.020** (0.007)
Age2		0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Health		0.017** (0.008)	0.018** (0.008)	0.018** (0.008)
Education		−0.061* (0.031)	−0.064** (0.031)	−0.066** (0.031)
Dependency ratio			0.053** (0.021)	0.053** (0.021)
Off-farm ratio			0.069** (0.036)	0.068** (0.036)
Land size			0.007** (0.003)	0.007** (0.003)
Land number			0.007*** (0.002)	0.007*** (0.002)
Community agriculture				−0.000* (0.000)
Community economy				−0.012*** (0.005)
Farmer-fixed effect	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes
Obs	14,489	14,489	14,489	14,489
Adj-R ²	0.272	0.275	0.288	0.289
Note(s): ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; robust standard errors clustered at the community level are presented in parentheses				

cropland among community members. Considering the above, all the regressions' standard errors of clustering are at the community level, unless otherwise specified.

As Table 2 shows, the estimated results of the focus variable indicate that land certification has an inhibitory effect on cropland abandonment, and this is statistically significant at the 5% level. Compared with farmers who do not have land certificates, the area of abandoned cropland by farmers with land certificates is lower by about 4%, on average. Moreover, the results in columns (1)–(4) indicate that regardless of the inclusion of control variables, the estimated results remain robust. These results imply that land certification has a positive effect on the protection of land quantity in China, and that it can effectively inhibit the abandonment of croplands.

At the same time, the results in column (4) of Table 2 also show that the control variables have a significant impact on cropland abandonment. Specifically, for the individual characteristics, there is a *U*-shaped relationship between the age of the householder and the area of abandoned cropland, and the results indicate that improvement of the householder's health and education levels may reduce the abandoned area. These results are consistent with the previous research conducted by Deng *et al.* (2019). Considering family characteristics, the results indicate that the dependency ratio, off-farm ratio, land size and land number may increase the area of abandoned croplands. These findings are broadly consistent with those of previous studies (Yan *et al.*, 2016; Zhang *et al.*, 2018; Xu *et al.*, 2019). Regarding community characteristics, the results indicate that the greater the number of new farmers and the higher the income level of farmers in the community, the smaller the area of cropland abandoned by farmers. A possible explanation is that when a community has more market-oriented farmers

and higher per capita income, cropland resources become relatively scarce and thus, are more likely to be used.

4.2 Robustness test

To verify the positive effect of land certification on inhibiting cropland abandonment further, robustness tests are conducted.

4.2.1 *The dependent variables: abandonment behavior and abandonment ratio.* The farmers' cropland abandonment behavior and the ratio of the area of cropland abandoned by farmers are also important indicators of land quantity protection (Deng *et al.*, 2019; Zheng and Luo, 2019). As shown in Table 3, regardless of whether control variables are added, the regression coefficients of land certification remain significantly negative, this indicates that land certification has a significant inhibitory effect on cropland abandonment.

4.2.2 *Application of the PSM-DID model.* Because this study only has two periods of panel data, it is difficult to conduct an acceptable parallel trend test. Therefore, to exclude or alleviate the situation in which parallel trend may not be satisfied, the PSM-DID model is used here to make it easier for individuals in the treatment group and the control group to have the same time trend under the condition of the same given covariates. Specifically, we first select the commonly used "one-to-one" neighbor matching method and set the caliper range to 0.05. Second, we specify land certification as the treatment variable and the logarithm of the area of abandoned cropland as the outcome variable. Finally, after adding all the control variables in Table 1, the logit model is used to estimate the propensity scores.

The standardized deviation diagram (Figure 1) reveals that after propensity score matching, the standardized deviations of all control variables have a corresponding degree of reduction; their values are significantly less than 10%, and they are all near the 0 value. This means that there is no systematic difference between the treatment and control groups after matching, thus satisfying the balance test. Therefore, we further delete five samples not in the common support domain and then use the DID model to perform another estimation. Table 4 shows that the estimated results using the PSM-DID model are almost the same as those obtained using the DID model (Table 2). This proves once again that land certification helps strengthen the protection of land quantity and significantly reduces the area of cropland abandoned by farmers.

4.3 Placebo test

We further verify whether the estimated results of this study are driven by nonobservable factors at the provincial, community and household levels and the year and so on. The test

	Abandonment behavior		Abandonment ratio	
	(1)	(2)	(3)	(4)
Land certification	-0.028** (0.013)	-0.026** (0.013)	-0.014** (0.007)	-0.013* (0.007)
Control variables		Yes		Yes
Farmer-fixed effect	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes
Obs	14,489	14,489	14,489	14,489
Adj-R ²	0.336	0.348	0.349	0.356

Note(s): ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; robust standard errors clustered at the community level are presented in parentheses; The control variables are the same as in column (4) of Table 2, the same below

Table 3.
Land certification and
cropland
abandonment:
robustness test I

Figure 1.
Standardization bias
before and after
matching

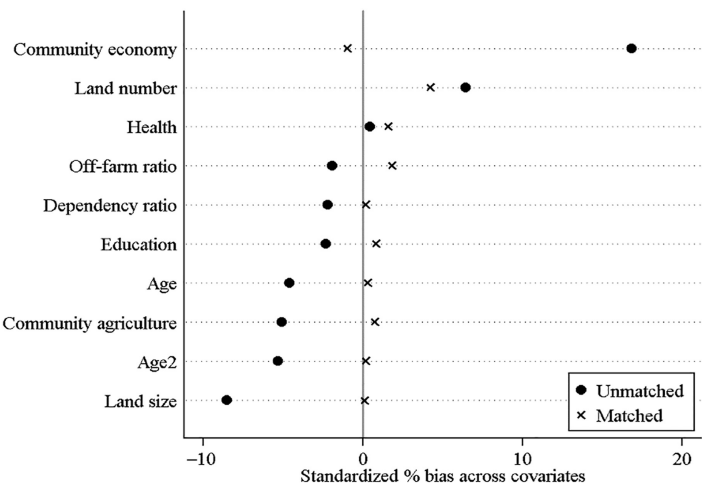


Table 4.
Land certification and
cropland
abandonment:
robustness test II

	The logarithm of the area of abandoned croplands			
	(1)	(2)	(3)	(4)
Land certification	−0.046** (0.020)	−0.045** (0.020)	−0.043** (0.019)	−0.042** (0.019)
Individual characteristics		Yes	Yes	Yes
Household characteristics			Yes	Yes
Community characteristics				Yes
Farmer-fixed effect	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes
Obs	14,484	14,484	14,484	14,484
Adj-R ²	0.272	0.275	0.288	0.288
Note(s): ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; robust standard errors clustered at the community level are presented in parentheses				

method of [Zheng *et al.* \(2021\)](#) is used as a reference, and the placebo test is conducted here for a virtual certification time randomly assigned by the province. Specifically, this study randomly selects any year from 2009 to 2019 for the 29 provinces in China as the year of land certification and then conducts a random sampling 500 times. After controlling for the age, age squared, health, education, dependency ratio, off-farm ratio, land size, land number, community agriculture, community income, farmer-fixed effect and year-fixed effect, the time-varying DID model is used for estimation, and we finally draw out the distribution of 500 estimated coefficients and their related *p* values.

[Figure 2](#) shows that the mean value of the estimated coefficients of land certification is concentrated around point 0, which is obviously different from the real estimated value of −0.042 in column (4) of [Table 2](#). The corresponding *p* values of most of the coefficient estimates are also greater than 0.1, thus rejecting the assumption that there is no difference with the real estimated result. This indicates that the results of our study are not biased and

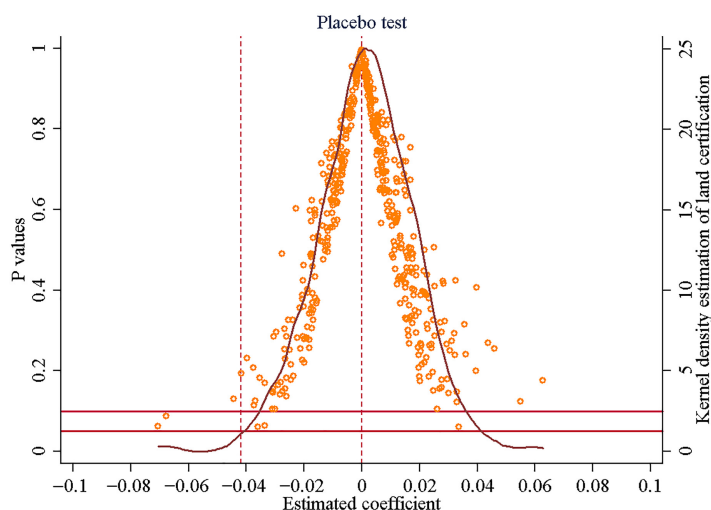


Figure 2.
Land certification and
cropland
abandonment:
placebo test

are unlikely to be affected by unobvious factors at the provincial, community and household levels and the year.

4.4 Endogeneity discussion

Endogenous problems are mainly caused by reverse causality, selection bias, missing variables and measurement errors. Regarding the first two factors, since China's land certification reform is state-led and compulsively promoted, the possibility of reverse causality and selection bias at the household level is relatively small. As for the last two factors, they have been addressed by adding control variables and by replacing the dependent variables in the time-varying DID model separately. In addition, the PSM-DID model estimation and placebo test also confirm the robustness of the estimation results. Therefore, endogeneity has been controlled for, to a certain extent.

4.5 Mechanism analysis

As pointed out in the literature, poor soil fertility, unavailability of land transfer, lack of agricultural subsidies and low agricultural income may lead to cropland abandonment. If so, can land certification improve the conditions concerning cropland abandonment by issuing land certificates with legal effects and multiple economic uses to farmers? This is the mechanism question that this study aims to answer.

The results in Table 5 show that land certification creates favorable conditions for improving soil fertility, promoting land transfer, improving the availability of agricultural subsidies and increasing agricultural income, and it has positive and significant promoting effects on these aspects. These results imply that land certification mainly helps restrain the expansion of abandoned croplands through the above mentioned channels and eventually plays a positive role in protecting land quantity.

5. Heterogeneity analysis

Considering the heterogeneity of provinces, communities and households, there may be differences in the influence of land certification on the area of abandoned croplands.

Table 5.
The mechanism of land
certification on
cropland abandonment

Mechanism	Dependent variable	Model	Land certification	Control variables	Obs	Wald χ^2	Pseudo- R^2 /Adj- R^2
Use of organic fertilizer	Whether to use organic fertilizer (0 = no; 1 = yes)	Logit	0.077*** (0.007)	Yes	14,489	373.65	0.133
Land transfer	Whether to transfer the land (0 = no; 1 = yes)	Logit	0.035*** (0.006)	Yes	14,489	486.33	0.252
Agricultural subsidies	Whether to get agricultural subsidies (0 = no; 1 = yes)	Logit	0.077*** (0.009)	Yes	14,489	269.25	0.120
Agricultural income	The logarithm of agricultural income	Fe	0.270* (0.143)	Yes	14,489	—	0.537

Note(s): ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; standard errors are presented in parentheses; the logit model reports average marginal effects

Therefore, it is necessary to explore the effects of land certification under different circumstances further.

5.1 At the province level

In this section, the effects of land certification on the abandoned croplands in different provinces are investigated from two dimensions: crop regions and geographical regions. As shown in Table 6, in terms of crop regions, land certification has a restraining effect on the area of abandoned croplands in nonmajor grain-producing areas, but has no effect on major grain-producing areas. The reason may be that major grain-producing areas shoulder the responsibility of ensuring national food security, and the government has both high economic incentives and strong administrative constraints on the farmers. Therefore, regardless of whether land certification has been completed, the possibility of farmers using their cropland is relatively high.

Table 6.
Land certification and
cropland
abandonment:
province heterogeneity

	The logarithm of the area of abandoned croplands				
	Crop regions		Geographical regions		
	Major grain- producing areas	None	East	Middle	West
Land certification	−0.020 (0.020)	−0.063** (0.032)	−0.008 (0.019)	−0.035 (0.047)	−0.096** (0.039)
Control variables	Yes	Yes	Yes	Yes	Yes
Farmer-fixed effect	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes
Obs	7,572	6,917	5,774	4,239	4,476
Adj- R^2	0.252	0.287	0.420	0.187	0.322

Note(s): ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; robust standard errors clustered at the community level are presented in parentheses; Crop regions are divided according to the standards of the former State Administration of Grain of China; geographically, the regions are divided according to the standards of the National Bureau of Statistics of China

Meanwhile, regarding geographical regions, land certification can reduce the area of abandoned croplands in the western region, but has no effect in the eastern and central regions. A possible explanation is that compared with the western region, the eastern and central regions have more developed economies and more off-farm employment opportunities; thus, land certification is not as attractive to these farmers.

5.2 At the community level

Table 7 reports the community heterogeneity of the impact of land certification on the area of abandoned croplands. Considering the natural geography, land certification mainly has a positive effect on curbing cropland abandonment in plain communities, but has no significant effect on mountainous communities. The main possible reason is that croplands in mountainous communities are not only of relatively low quality, but also are relatively inconvenient to cultivate (Prishchepov *et al.*, 2013). Regardless of whether the cropland is certified, the level of use of cropland in mountainous communities is difficult to change in a short period.

From the perspective of economic location, land certification can help reduce cropland abandonment in remote villages, but has no effect on suburban villages. A possible explanation is that it is more convenient to enter the city; therefore, farmers who live in suburban villages are more likely to engage in off-farm work, which implies that land certification has little effect on their land-use behavior.

Regarding the political centrality of a location, land certification mainly has a positive effect on the protection of land quantity in nonpolitically central communities, but has no significant effect on politically central communities. This may be due to the fact that politically centered villages are relatively close to the township government, regardless of whether the cropland is certified; thus, farmers are unlikely to abandon their cropland under the supervision of the township government.

5.3 At the household level

To investigate the difference in the impact of land certification on the area of abandoned croplands under different types of farmer households, this study uses land transfer-in, land transfer-out and land adjustment as grouping variables to conduct subsample regression.

The results in **Table 8** indicate that first, land certification has no effect on the area of abandoned croplands for transfer-in households, but has a significant inhibitory effect on the

	Terrain Mountains	The logarithm of the area of abandoned croplands				
		Plains	Economic location		Political location	
			Village	Suburb	<7 km	≥7 km
Land certification	−0.042 (0.044)	−0.043** (0.020)	−0.048** (0.020)	0.113 (0.127)	−0.018 (0.022)	−0.074** (0.031)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Farmer-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	3,989	10,500	14,134	355	7,203	7,286
Adj- R^2	0.264	0.362	0.287	0.445	0.336	0.206

Note(s): ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; robust standard error clustered at the community level are presented in parentheses; the division of locations in terms of political centrality is mainly based on whether the distance between the village committee and the township government seat is greater than the mean value

Table 7.
Land certification and
cropland
abandonment:
community
heterogeneity

Table 8.
Land certification and
cropland
abandonment:
household
heterogeneity

	The logarithm of the area of abandoned croplands					
	Land transfer-in		Land transfer-out		Land adjustment	
	Transfer in	None	Transfer out	None	Adjustment	None
Land certification	−0.004 (0.026)	−0.050** (0.023)	−0.019 (0.043)	−0.046** (0.022)	−0.029 (0.026)	−0.051* (0.029)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Farmer-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2,428	12,061	3,109	11,378	5,433	7,668
Adj- <i>R</i> ²	0.306	0.265	0.252	0.300	0.366	0.223
Note(s): ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; robust standard errors clustered at the community level are presented in parentheses; since part of the missing values were difficult to complete, the observed samples of the latter two groups were slightly lower than 14,489						

area of abandoned croplands for non-transfer-in households. This is mainly because the cost of abandoning croplands faced by transfer-in households is much higher than that of non-transfer-in households because they must pay rent for the transferred land. Regardless of whether the cropland is certified, they are more likely to choose farming the land instead of abandoning it.

Second, land certification significantly reduces the area of abandoned croplands by non-transfer-out households but does not have a significant impact on transfer-out households. The likely reason is that compared with non-transfer-out households, transfer-out households meet the conditions to transfer the remaining cropland that cannot be cultivated by themselves to others. Therefore, regardless of whether the cropland is certified, no land will be abandoned.

Third, land certification significantly reduces the area of croplands abandoned by farmers who have not undergone land adjustment, but it has no significant impact on farmers who have undergone land adjustment. The possible explanation is that for farmers who have undergone land adjustment, regardless of whether the land certification has been completed, they may have a distrustful attitude toward land tenure security. Since land adjustments have been previously implemented, they are likely to continue in the future; thus, the security of land tenure remains uncertain.

6. Conclusions and policy implications

6.1 Conclusions

In the postpandemic era, food security based on the protection of the amount of cropland has become increasingly important. The protection of property rights is the foundation of land protection. It is realistic and inevitable to rationally use every inch of cropland and curb cropland abandonment by strengthening the land tenure system reform, especially in the case of the insecurity of land tenure. Issuing land certificates with legal effect and multiple economic uses to farmers may improve land tenure security, curbing the expansion of cropland abandonment areas. This study uses nationally representative data from the 2017 and 2019 CRHPS and adopts a time-varying DID model to examine the impact of land certification on cropland abandonment.

The results of the study reveal that land certification significantly inhibits cropland abandonment and contributes to the protection of land quantity. Compared with farmers with

no land certificates, those with land certificates have less cropland to abandon. This estimation result remains stable even after a series of robustness tests. The mechanism test reveals that the inhibiting effect of land certification on cropland abandonment is mainly realized by improving soil fertility, promoting land transfer, increasing the availability of agricultural subsidies and raising the level of agricultural income. Further analysis indicates that the influence of land certification on cropland abandonment is heterogeneous at the provincial, community and household levels. From a regional perspective, land certification has a significant inhibitory effect on the area of cropland abandoned by farmers in nonmajor grain-producing areas and western regions. From a community perspective, land certification has a significant restraining effect on the croplands abandoned by farmers in plain, remote and nonpolitically central villages. From the perspective of households, land certification significantly reduces the area of croplands abandoned by farmers who have nontransferred and unadjusted land. These findings have important policy implications for countries facing both cropland abandonment and land tenure insecurity issues.

6.2 Policy implications

Cultivated land, as the material resource and endowment basis of grain production, is critical to safeguarding national food security, especially in the postpandemic era. Cropland is extremely valuable, and we cannot afford to waste it. Various factors affect farmers' cropland abandonment behavior, such as poor soil fertility, unavailability of land transfers, too little agricultural subsidies and too low agricultural income, all of which, to some extent, relate to insecurity of land tenure. Empirical evidence from rural China has shown that a clear definition and effective protection of property rights can help curb cropland abandonment. Similar to the situation in China's rural areas, most developing countries face both problems of cropland abandonment and insecure land tenure (Deininger *et al.*, 2012).

One who has property needs perseverance. The reform of the land tenure system should enhance the land protection behavior of farmers through the reform of land certification and promote the sustainable use of cropland. At present, most developing countries need to strengthen the construction of the land tenure system, carry out land certification reform and issue farmers with clearly defined and legally effective land certificates. Concurrently, efforts should also be made to promote the diversified use of land certificates after the completion of land certification reform in developing countries. For example, land certificates have a positive role in improving soil quality, promoting land transfer, increasing agricultural income and serving as the basis for subsidies. In addition, considering the heterogeneity of different provinces, communities and households, it is necessary to adopt measures according to local conditions. For example, in economically developed provinces, efforts should be made to train professional farmers, increase agricultural subsidies and improve agricultural income. In mountainous villages, the government should take measures to strengthen the construction of agricultural infrastructure and improve agricultural production conditions. For farmers who have experienced land adjustment, it is also necessary to further enhance the security of land tenure through legal empowerment.

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