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How has the new round of farmland certification in China affected farmers' economic welfare?

RESEARCH ARTICLE

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Abstract

It is vital to evaluate the effects of China's farmland certification programme on farmers' economic welfare and clarify the impact mechanism. This paper uses the China Labour Dynamics Survey (2014, 2016),[1] building endogenous switching regression and endogenous switching probit models to test the impact of the farmland certification programme on farmers' net agricultural income and poverty status after correcting for endogeneity. A robustness analysis is conducted applying instrumental variable and propensity score matching methods. The results indicate that the farmland certification programme can significantly increase farmer households' economic welfare, including an 83.10% improvement in agricultural net income and a 3.17% reduction in poverty. Farmland certification also prompts farmers to allocate more resources to agriculture and reduces poverty by increasing farmers' agricultural income. This study presents a constructive evaluation of the performance of China's farmland certification policy, providing a strong theoretical and empirical foundation and a useful policy reference for consolidating the achievements of poverty alleviation and effectively linking rural revitalisation.

Keywords: farmland certification programme, farmers' economic welfare, endogenous switching regression model, endogenous switching probit model
JEL code: Q15

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[1] Data used in this paper is from the China Labor-force Dynamics Survey (CLDS) by the Center for Social Science Survey at Sun Yat-sen University in Guangzhou, China. The opinions are the author's alone. Please refer to http://css.sysu.edu.cn for more information about the CLDS data.

1. Introduction

Income increase and poverty alleviation are the most direct and significant embodiments of farmers' improved economic welfare (Pigou and Aslanbeigui, 2017), and it remains an important goal for China to build a prosperous society and a modern socialist country in an inclusive manner. From 2013 to 2020, China reduced the number of people living in poverty by 82.49 million, completely eliminating absolute poverty in the nation, demonstrating a miracle of poverty reduction to the world. This does not mean that our study of poverty reduction is outdated, as the reduction of poverty is an enduring global topic and our research can provide greater understanding of the poverty reduction experience of China for the world. At present, global poverty remains high. In 2021, 698 million people were still living in extreme poverty, 1.803 billion people were living below the poverty line and more than 3.293 billion people lived on only $5.50 a day.[2] Although China eradicated absolute poverty in 2020, the future work of poverty alleviation has not stopped, including the prevention of falling back into poverty and the governance of relative poverty. The low-income population that no longer suffers from absolute poverty continues to have a low income and represents a large population, and it remains very likely for them to fall back into poverty. In 2020, the per capita disposable income of the bottom 20% (about 282 million people) in China was only 7,868.8 RMB Yuan, meaning 655.7 RMB Yuan per month.[3] 'Promoting sustained income growth for those who have eliminated poverty' and 'resolutely holding the bottom line of not falling back into poverty on a large scale' are key requirements of the No. 1 Central Document of China issued in 2022. As an important basic element of agricultural production and operation, farmland is an essential aspect of promoting rural economic development and improving farmers' welfare. The 14th Five-Year Plan proposes to 'improve the policy and system of distribution according to factors, improve the mechanism that all factors of production are paid by the market and explore ways to increase the factor income of low- and middle-income groups through the right to use and profit from land, capital and other factors',[4] which further highlights the significance of farmland factors to farmers' economic welfare.

Property rights economists argue that stable and well-defined farmland property rights are important catalysts in driving economic growth. Unclear and unstable farmland property rights are a significant problem faced by developing countries at present which hinders economic growth (Acemoglu *et al.*, 2001; Mauro, 1995). Therefore, many developing countries, including China, have conducted vital institutional farmland reforms to clarify and stabilise farmland property rights. To solve the emerging land disputes in the farmland transfer process, due to a lack of clarity, fuzzy boundaries of contracted farmland management rights and other reasons, as early as 1998, China enacted the Land Management Law of the People's Republic of China, legally requiring farmers to be issued farmland management rights certifications for the first time. In 2008, the central government enacted 'the Central Committee of the Communist Party of China's Decision on Promoting Rural Reform and Development of Certain Major Issue', opening up a new round of farmland certification, which further emphasised the separation of farmers' rights regarding farmland ownership and the rights to contracts and land management. The new round of farmland certification solved some issues encountered in the process of previous farmland certification efforts, such as the lack of clarity regarding farmland boundaries and ownership as well as inaccurate farmland areas. This paper primarily focuses on the certification of contracted farmland management rights. The certification of contracted farmland management rights is an important reform in China's farmland system, which is conducive to the efficient allocation of farmland resources and guaranteeing the supply of primary agricultural products, especially grain. At the same time, ensuring farmland rights can strengthen the foundational support of modern agriculture and appropriately acknowledge the role of farmland's basic elements. On-going farmland system reforms, such as the confirmation of homestead use and natural resource rights, must also draw lessons from the farmland certification process. Therefore, our research will not only provide reliable experience for global poverty

[2] Data from the website of 'Development initiatives, Poverty trends: global, regional and national'. Available at: https://www.devinit.org/resources/poverty-trends-global-regional-and-national/

[3] Data from National Bureau of Statistics, China Statistical Yearbook 2021. Available at: https://data.stats.gov.cn/publish.htm?sort=1. (in Chinese)

[4] The content of 'The 14th Five-Year Plan for National Economic and Social Development and the Vision for 2035 of the People's Republic of China' is available at: http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm. (in Chinese)

reduction work and future consolidation of poverty alleviation achievements and relative poverty governance in China but will also offer practical insights to inform such on-going farmland system reforms.

Current literature investigating farmland rights confirmation predominantly focuses on its influence on farmers' resource allocation behaviour, including three aspects. First, farmland certification promotes farmers' agricultural investment (Jacoby *et al.*, 2002). The stability of farmland rights brought by contracted certification of farmland management rights improves the expected behaviour of property owners and raises farmers' investment demand (Feder and Nishio, 1998), which is conducive to farmers' medium- and long-term investment in farmland (Alston *et al.*, 1996; Brandt *et al.*, 2004; Saint-Macary *et al.*, 2010) and to improving farmland quality (Besley, 1995). Second, farmland certification promotes the transfer of farmland (Besley and Burgess, 2000; Deininger and Jin, 2005; Meeks, 2018; Luo, 2018) and labour (Chernina *et al.*, 2014; De Janvry *et al.*, 2015). Farmland certification increases farmers' land-leasing market participation rate (Deininger *et al.*, 2011; Holden and Yohannes, 2002) by reducing negotiation costs (Besley, 1995; Besley and Ghatak, 2010) and transaction costs (Wang *et al.*, 2018) in the process of farmland transfer, which promotes farmland transfer (Holden *et al.*, 2007). Third, farmland certification increases the availability of credit for farmers. Some of the literature focuses on the relationship between farmland property rights and credit, asserting that compared with those without formal legal farmland documents, farmers holding such legal documents are more likely to obtain loans by using farmland as collateral (Routray and Sahoo, 1995), thus increasing the availability of farmers' credit and reducing credit rationing problems (Besley *et al.*, 2012; Ghebru and Holden, 2015; Newman *et al.*, 2015).

Many economists have emphasised the important contribution of the clarification of property rights to economic development (Feder and Feeny, 1991; North, 1990), arguing that regularised farmland rights are the basis of poverty reduction, economic growth, political stability, social inclusion, gender equality and sustainable development (Rusenga, 2019; Townsend, 2018). However, there is limited direct evidence demonstrating the impact of farmland certification on farmers' economic welfare. The measurement methods for assessing farmers' economic welfare in the limited literature vary considerably. Feder and Nishio (1998) note that farmland certification may increase income, but there is a lack of empirical verification. Besley and Burgess (2000) empirically demonstrate the contribution of India's land reforms to poverty alleviation, asserting that the abolition of intermediaries and lease reforms can help reduce poverty. De Janvry *et al.* (2015) analyse welfare effect by evaluating the impact of certification on farmer household-level consumption in rural Mexico. Notably, rural farmland certification in China refers to contracted farmland management rights through the certification of farmland use rights, as opposed to farmland ownership rights. As such, there is a clear difference between these countries' land reforms and China's farmland certification programme. Differences in various countries' protection of property rights lead to significant differences in the subsequent economic development (Acemoglu *et al.*, 2001). Therefore, it is necessary to conduct detailed and in-depth research on the consequences of the farmland use rights certification in China for economic welfare to obtain reliable conclusions. The research content and conclusions of this paper offer an effective supplement to the current research on property rights and economic welfare.

The questions that this paper hopes to answer are as follows: does China's farmland certification improve farmers' economic welfare? How strong is this improvement, and what are the influencing mechanisms? Notably, the variables of economic welfare examined in this paper primarily include farmers' net agricultural incomes and poverty status. The rationale for this choice is that changes in farmers' agricultural income are the most direct measure of the effect of farmland confirmation. The resources allocation to farmers generated by farmland confirmation can affect many aspects of farmers' economic welfare. Farmers' poverty status is also a meaningful indicator and provides an overall measure of farmers' multi-channel income. As previously noted, summaries of China's poverty alleviation experience are also a practical need. This paper uses the survey data from the China Labour Dynamics Survey (CLDS) in 2014 and 2016, constructing an endogenous switching regression (ESR) model to analyse the impact of farmland certification on farmers' net agricultural income and an endogenous switching probit (ESP) model to analyse the impact of farmland certification on

farmers' poverty. Both methods effectively address the endogenous problem of farmland certification. This paper then analyses the influence mechanism of farmland certification on Chinese farmers' economic welfare.

The research contribution of this paper is as follows. This study uses data prior to 2020, when absolute poverty was not yet eliminated in China, and farmland rights were gradually being confirmed. Reliable evidence regarding the welfare effect of farmland certification was obtained by constructing quasi-natural experiments. This study also adds evidence from China to the research framework on the effects of farmland reform policies and provides guidance regarding farmland reform and poverty reduction for other countries.

The remainder of this paper is arranged as follows. The next section constructs the theoretical framework; Section 3 introduces the data sources, variables and empirical model setting; Section 4 presents the descriptive statistics, empirical results, robustness analysis and mechanism investigation; the final section details the conclusions and implications.

2. Theoretical framework

Farmland certification is a crucial formal institutional arrangement to stabilise farmland property rights, and the stabilisation of farmland rights is an important function of China's new round of farmland certification. Generally, the legality of farmland rights will affect farmers' perception of farmland rights security, and farmers will adjust their decision-making and behaviours according to these perceptions (Van Gelder, 2007). Specifically, unstable property rights diminish farmers' long-term expectations for their own farmland, resulting in a lack of confidence to invest numerous highly specialised fixed assets in the farmland, causing a reduction in farmland investment. The farmland certification programme provides farmers with a formal qualification certificate as a guarantee of farmland property rights. This certificate confirms farmers' legal rights and reduces the uncertainty caused by fuzzy property rights, which can strengthen farmers' perception and confidence of farmland rights stability. According to the incentive effect of property right, the security of farmland rights can reduce the possibility of land adjustment and guarantee that farmers exclusively enjoy land-related income. Subsequently, farmers' enthusiasm for agricultural production is stimulated, and farmers could increase production investment in farmland, including seeds, pesticides, fertiliser and other material capital input, as well as agricultural labour input. Farmers may also bring previously abandoned farmland back into production.

In addition, farmland certification clarifies farmland property rights, reducing farmers' credit costs and risks, increasing their ability to obtain financial capital through formal channels and providing additional funding sources for farmland investment. In reality, the primary obstacles to farmers' credit access are asymmetric information with credit institutions and insufficient collateral (Aikaeli and Markussen, 2017; Deininger and Binswanger, 1999). By issuing certificates to farmers and enabling them to become effective collateral recognised by the formal rural financial institutions, farmland certification endows rural farmland management rights with the right to obtain mortgages and guarantees, thus solving the problem of insufficient standard collateral for farmers (Heltberg, 2002). In addition, certification provides an institutional guarantee for farmland transfer and reduces the default risks faced by financial institutions (Huang and Du, 2018); thus, the availability of farmers' financial capital increases, meeting agricultural investment demand.

Farmland certification mainly provides a legal institutional guarantee of farmland rights. Based on this guarantee, farmers can reallocate material capital, natural capital (farmland), human capital (labour force) and financial capital (credit) according to comparative advantages to maximise their own profits. Once farmland rights are guaranteed, farmers can safely devote their resources (material capital, farmland, credit and labour) to agriculture. It is logical that the increasing resources allocated to agricultural production will increase agricultural income. Based on the above analysis, this paper proposes the first research hypothesis:

H1: Farmland certification can increase farmers' agricultural income by allocating resources to agricultural production; that is, farmland certification can improve farmers' economic welfare.

Another important function of farmland certification is to standardise the transaction of farmland management rights. Farmland certification provides a set of formal rules for farmland use, farmland benefits and farmland exchange in the form of legal system. Based on this, farmers' contracted land management rights have been more widely recognised by the society. This is conducive to improving the predictability of economic relations based on property rights by constraining the activities on both sides of farmland transfer, greatly reducing transaction uncertainty and cost in the process of farmland transfer. Consequently, farmers can obtain property income by transferring their farmland. Furthermore, the implementation of farmland certification solidifies contracted farmland management rights, reducing the possibility of farmland being illegally occupied by a lessee (Yami *et al.*, 2016), which addresses the concerns of farmers who are willing to work outside the farm and increases the probability of the rural labour engaging in off-farm income generating activities. Farmers obtain wage income by doing off-farm work, while receiving income from farmland transfer.

Nevertheless, it cannot be ignored that farmland is a kind of personified property, and farmers have a strong demand for in-office control of their farmland. Compared with alternative property, the pain caused by the loss of a personified property cannot be alleviated by obtaining other additional property (Radin, 1982). Farmland owned by farmers is endowed by their membership in rural collective economic organisations, which has strong identity characteristics and is manifested as typical personified property. In China, farmland is not only the basic factor for farmers to conduct agricultural production, but also represents the social security function of living, making the endowment effect is particularly strong,[5] Farmland certification in China is the confirmation of farmland management rights, which is the long-term solidification of farmland management rights which further increases the endowment effect. When farmers rent out their farmland, they lose control over the actual use of the farmland, and it becomes impossible to inspect the quality of the farmland. To avoid excessive use of farmland by lessees, farmers tend to sign short-term lease contracts, leading to a decrease in specific investment and intensification of short-term behaviour. If this continues, farmers will not lease their farmland.

Farmland certification has a restraining effect on the non-agricultural transfer of the labour force. The personified characteristic and demand for in-place control of farmland will restrain transfer of labour force to non-agricultural. The security of farmland property rights endowed by farmland certification stimulates farmers' investment in farmland and expands the possibility of agricultural production, raising the opportunity cost of non-agricultural employment transfer. In addition, farmers' characteristics could also reduce their inclination towards non-agricultural employment. In China, farmers are generally poorly educated, leading to the high cost of learning new things. At the same time, valuable experience and considerable costs are accumulated in long-term agricultural production. Consequently, farmers form path dependence on agricultural production, reducing the probability of non-agricultural labour transfer. For farmers, engaging in agricultural production not only creates direct economic incomes, but also generates spiritual satisfaction, resulting in non-material utility (Key and Roberts, 2009). Therefore, farmland certification is expected to induce farmers' intensified engagement in agricultural production.

Farmland certification reduces farmland system risk and increases agricultural input, raising agricultural income. Agricultural income is the main source of income for farmers, and the increase in agricultural income is of considerable significance to eliminating farmers' poverty. The set poverty line is pl, and farmer households' income is π. When the farmer households' incomes rise above the national poverty line, that is, $\pi > pl$, farmer households can eliminate their poverty status. Based on the above analysis, this paper proposes the second hypothesis:

H2: Farmland certification reduces poverty by increasing agricultural incomes, improving farmer households' economic welfare.

[5] Thaler (1980) proposed the endowment effect, referring to the phenomenon in which the amount of money an individual requires to sell the item is usually higher compared with the amount of money an individual is willing to pay for an item.

In summary, theoretically, farmers' uncertainty regarding property rights is diminished following farmland certification, and farmers will reallocate capital factors including material capital, natural capital (farmland), human capital (labour force) and financial capital (credit), according to their expectations of farmland, increasing agricultural income and reducing poverty, ultimately improving farmers' economic welfare. This mechanism is illustrated in Figure 1. Next, this paper will use the CLDS (2014, 2016) survey data from China and adopt a series of appropriate empirical methods to verify the above two research hypotheses.

3. Materials and methods

3.1 Data and variables

■ *Data*

The data used in this paper were obtained from the 2014 and 2016 CLDS, conducted by the Social Science Survey Centre of Sun Yat-sen University of China. The CLDS was designed to be a nationally representative survey covering 29 provinces (excluding Hong Kong, Macao, Taiwan, Tibet and Hainan). The population weights used in sampling correspond to the sixth National Population Census conducted in 2010. Moreover, to mitigate potential sample selection bias, the sampling design is based on respondents' birthplace, rather than their residence during the survey. The CLDS focuses on current circumstances and changes in China's labour, covering a wide range of topics, such as education, jobs, migration, health, social participation, economic activities and related considerations. This paper selects a sample of farmers who lived in rural areas and engaged in agricultural production. Because the CLDS sampling process uses a multistage cluster, stratified, probability proportionate to size sampling method, a large number of farmers are not tracked (Lin *et al.*, 2018); therefore, notably unbalanced panel data from CLDS2014 and CLDS2016 are used for empirical analysis in this paper. After deleting samples with missing information on farmland confirmation and other core variables, the final clean data include 5,356 observations in 2014 and 5,596 observations in 2016.

■ *Variables*

Definitions of variables used in the empirical analysis are shown in Table 1. This paper measures economic welfare according to per capita agricultural net income and farmer households' poverty status. Poverty is defined according to the farmer households' annual net income per capita of 2,736 RMB Yuan in 2013 and

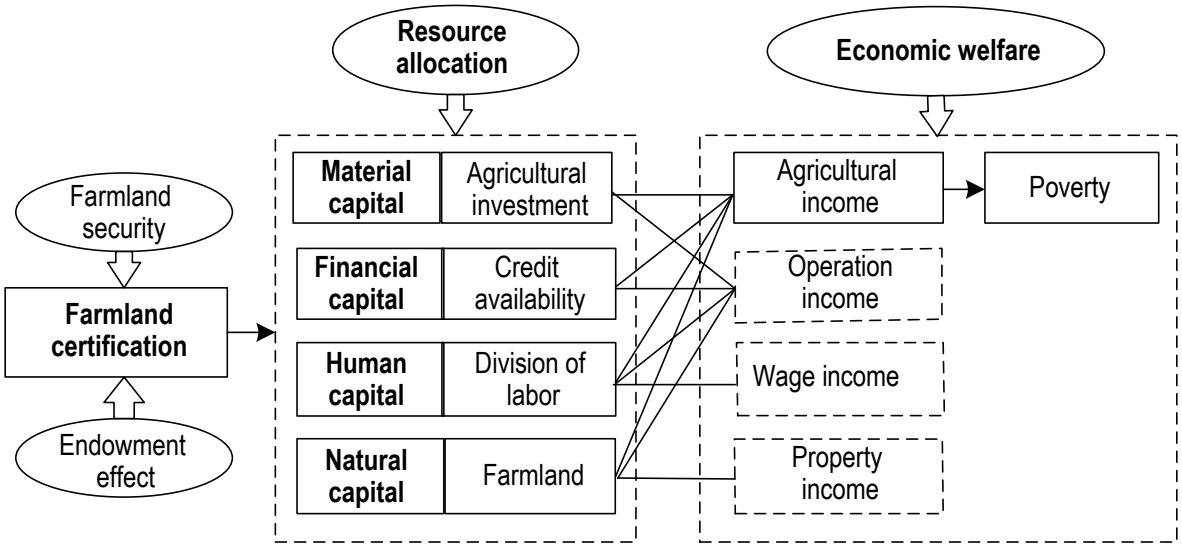

Figure 1. The mechanism of farmer households' economic welfare by farmland certification.

Table 1. Variable definitions.

Variables	Variable definitions
Dependent variables	
Agricultural income	Farmer households' per capita annual net income from agricultural production (unit: RMB10,000 Yuan);
Poverty	1 = if the farmer is in poverty, 0 = otherwise
Key explanatory variable	
Farmland certification	1 = if the farmer household received a contracted farmland management rights certificate, 0 = otherwise
Other income variables	
Wage income	Farmer households' per capita annual income earned through off-farm employment (unit: RMB10,000 Yuan)
Property income	Farmer households' per capita annual income from movable and immovable assets, including interest, rent, dividends and related considerations (unit: RMB10,000 Yuan)
Operational income	Farmer households' per capita annual income earned from operating off-farm activities, such as shops and outlets (unit: RMB10,000 Yuan)
Control variables	
Resource allocation behaviour	
Agricultural material capital	Farmer households' per capita investment value of agriculture and forestry production (unit: RMB 10,000 Yuan)
Farmland	Ratio of farmland area put into agricultural production to total farmland area owned by farmer households
Division of labour	Proportion of the number of farmer household members engaged in agricultural production for more than three months per year.
Credit	1 = if the farmer household obtained productive loans from a formal financial institution, 0 = otherwise
Household characteristics	
Tractor	1 = if the farmer household owns tractor, 0 = otherwise
Other agricultural machinery	1 = if the farmer household owns large agricultural machinery other than tractors (including harvesters, transplanters, planters, large combine harvesters and other equipment); 0 = otherwise
Agricultural subsidies	1 = if the farmer household received government subsidies for farming, 0 = otherwise
Householder's age	Age of the householder
Householder's education	Years of education received by the householder (unit: Year)
Village characteristics	
Irrigation and drainage services	1 = if the village has unified irrigation and drainage service, 0 = otherwise
Transportation infrastructure	1 = if the village has a highway, 0 = otherwise
Non-agricultural economy	1 = if the village has a non-agricultural economy, 0 = otherwise
Farmland adjustment	1 = if the village has farmland adjustment, 0 = otherwise
Instrumental variable	
Proportion of farmland certification	Proportion of farmers who obtained farmland certification in the village

2,855 RMB Yuan in 2015 (according to poverty standard in 2011, which was determined by the Central Poverty Alleviation Work Conference of China at the end of 2011). Using this standard, when a farmer households' income exceeds the poverty line, it has eliminated poverty.

The key independent variable in this paper is farmland certification. The new round of farmland certification currently implemented in China primarily includes three aspects of rights certification, including rural homesteads, rural collective farmland and contracted farmland management. Notably, the farmland certification examined in this paper only refers to the certification of contracted farmland management rights, referring to the right to use farmland, which is measured by whether the farmer household received a contracted farmland management certificate.

Farmland certification policy is often broadly considered an exogenous policy shock. The implementation of China's farmland certification policy is a process of gradual implementation. The determination of which area would be the first to implement farmland certification is not a random process. This paper holds that farmland certification is endogenous. Specifically, the main causes of farmland certification endogeneity are threefold. First, the time and location of farmland certification are based on government choice, and family and village characteristics will significantly affect the possibility of farmers obtaining a certificate (Di Falco *et al.*, 2020; Holden *et al.*, 2009). The government is likely to choose villages with superior outcomes in the second round of farmland contracts, referring to more fertile farmland and less contradiction between people and farmland, to easily and effectively organise and implement the pilot work of farmland certification. The government may also be more inclined to choose villages with higher populations, less farmland and more contradictions between people and farmland to accumulate experience. Second, reverse causality problems between farmers' income, poverty and farmland certification may exist. Farmers often take a series of actions to improve the stability of farmland rights to protect their rights and interests (Besley, 1995). Villages with less distortion of factor allocation and higher agricultural production efficiency may be more likely to be for farmland certification. The incomes of farmers in these villages may be higher, while the incidence of poverty of farmers may be lower. At the same time, farmers with higher incomes or those above the poverty threshold are more motivated to actively obtain farmland rights certificates to reduce the uncertainty of farmland property rights and protect their incomes. Finally, some factors affecting farmers' incomes, such as the quality of farmland, are difficult to obtain, and these factors may also influence the government's decision on whether the farmland certification policy should be implemented in a region. Subsequently, there may be some problems in model setting and variable selection, such as missing variables and measurement errors (Besley, 1995; Holden *et al.*, 2009), which often lead to endogeneity. To obtain more reliable estimation results, this paper uses the instrumental variable (IV) method to address the endogeneity of farmland certification. Referencing Qi (2011), the IV is the proportion of farmer households in a village that have received a certificate of contracted farmland management rights. This variable reflects the implementation intensity of farmland certification in a village and is related to whether farmer households have received a farmland certificate. The proportion of farmland certification can signify the economic effect of use certification on local development. This measure has no direct impact on farmer households' income level but is only related to the economic circumstances of the entire village. Therefore, it is feasible to use the proportion of farmland certification in a village as the IV to measure whether farmer households have received farmland certification.

This paper also analyses the mediating effect of farmland certification from the perspective of resource allocation. The potential mediating variables examined include human, material, natural and financial capital input. Human capital is measured by farmer households' agricultural work share, which is used to measure the distribution of the families' agricultural and non-agricultural work. Material capital is measured by the farmer households' operational agricultural input (such as chemical fertilisers and pesticides). Natural capital is measured by the ratio of farmland area put in production to total farmland area owned by farmer households. Financial capital is measured by the availability of credit. To make the influence values of different mediating variables comparable, the mediating variables are dimensionless. Furthermore, this paper examines the impact of farmland certification on other income sources to further verify that farmers will allocate more resources to agricultural production after farmland certification, achieving poverty reduction through increased agricultural income.

To better explain the impact of farmland certification on farmers' economic welfare and ensure the reliability of the regression results, this paper introduces a series of farmer household and village control variables. Referencing the control variables used in existing research, this study selects whether a farmer household owns a tractor or other large agricultural machinery, as well as age and education to overcome the impact of farmer households' heterogeneity (Zhang *et al.*, 2020). The influence of policies and regional economic development levels on farmers' economic welfare has been demonstrated by many studies (Du *et al.*, 2005; Yao *et al.*, 2004). The village characteristic variables included are whether a village has irrigation and drainage services, transportation infrastructure, a non-agricultural economy and farmland adjustments are controlled.

3.2 Model specification

To solve potential endogeneity problems, this paper applies a series of methods, including two endogenous treatment effect models, IV and propensity score matching (PSM) methods. The IV method can solve the endogeneity problem caused by reverse causality and missing variables, but it cannot address the selective deviation problems caused by individual heterogeneity well. Therefore, this paper first applies the ESR model to analyse the impact of farmland certification on farmers' agricultural net income, then applying the ESP model to analyse the impact of farmland certification on farmers' poverty. Both of these endogenous treatment effect models are more appropriate for correcting sample selection deviation and considering both observable and unobservable factors. This paper also applies IV and PSM methods to test robustness. Finally applying a mediating effect model for mechanism analysis.

■ *Endogenous switching regression model*

The ESR model adopts the full information maximum likelihood (FIML) estimation method, which can simultaneously estimate the selection equation and the result equation of the model and produce consistent standard errors (Lokshin and Sajaia, 2004). This method not only solves endogeneity problems, but also corrects sample selection deviations. It can also consider the influence of observable and unobserved factors simultaneously to solve problems of effective information omission more adequately. Therefore, the ESR model is employed to analyse the impact of farmland certification on farmers' agricultural net incomes. The model is set as follows:

Assume that each farmer household is faced with two possible circumstances, namely, that farmland is certified (I=1) or not certified (I=0). The selection equation is:

$$\begin{cases} I_i = 1 & if\ I_i^* > 0 \\ I_i = 0 & otherwise \end{cases}, \quad I_i^* = \gamma Z_i + u_i \tag{1}$$

where I^*_i is a potential variable that determines whether the farmland is certified. If I^*_i>0, farmland is certified; otherwise, it is not certified. Z_i is the factor that affects farmland certification, and u_i is the random disturbance term. The result equation is as follows:

$$\begin{cases} lnIncome_{1i} = \alpha_1 X_i + \varepsilon_{1i} & if\ I_i = 1 \\ lnIncome_{0i} = \alpha_0 X_i + \varepsilon_{0i} & if\ I_i = 0 \end{cases} \tag{2}$$

Where $lnIncome_{1i}$ and $lnIncome_{0i}$ represent the per capita agricultural net income of farmer households with and without certificates, respectively. X_i is a set of variables that affect income. ε_{1i} and ε_{0i} are both random disturbance terms.

For farmers who receive farmland certification with characteristics X and Z, the expected value of the outcome is $E(Income_{1i}|I_i=1, X=x)$. $E(Income_{0i}|I_i=1, X=x)$ is the expected value of the outcome for the same farmer who does not receive a certificate. After estimating the parameters of the model, this paper calculates

the average treatment effect (ATT) value, representing the impact of the farmland certification on farmers' agricultural net income:

$$ATT = E(Income_{1i}|I_i=1, X=x) - E(Income_{0i}|I_i=1, X=x) \tag{3}$$

■ *Endogenous switching probit model*

The ESP model is suitable for cases in which the dependent variable is binary and there is a binary endogenous independent variable at the same time, which has obvious advantages for addressing endogeneity compared with other binary selection models (Lokshin and Sajaia, 2011). It also has higher estimation efficiency than other methods (Lokshin and Sajaia, 2004). Some similar methods can only estimate either the selection equation or the result equation and only under the condition of assuming that the coefficients of the result equations of the two treatment schemes are equal. In addition, these methods always require potentially tedious adjustments to obtain a consistent estimation standard error. The ESP model uses the FIML method, which can simultaneously estimate the selection and result equations of the model and generate a consistent estimation standard error. Therefore, the ESP model is used to analyse the effect of farmland certification on farmers' poverty level. The selection equation is the same as Equation 1. The result equation is as follows:

$$\begin{cases} pov_{1i}^{*} = \beta_1 X_{1i} + \varphi_{1i} & if \quad pov_{1i}=F(pov_{1i}^{*} > 0) \\ pov_{0i}^{*} = \beta_0 X_{0i} + \varphi_{0i} & if \quad pov_{0i}=F(pov_{0i}^{*} > 0) \end{cases}$$
$$pov_{\mathrm{i}} = \begin{cases} pov_{1i} & if \quad I_i = 1 \\ pov_{0i} & if \quad I_i = 0 \end{cases} \tag{4}$$

Where pov^{*}_{1i} and pov^{*}_{0i} are the latent variables that can determine the observable selection variables, pov_{1i} and pov_{0i}, to determine whether the farmer household is poor.

After estimating the parameters of the model, this paper calculates the expected effect of farmland certification on farmers' poverty:

$$\begin{aligned} TT(x) &= \Pr(pov_1 = 1 \mid I = 1, X = x) - \Pr(pov_0 = 1 \mid I = 1, X = x) \\ &= \frac{\Phi_2(\beta_1 X_1, \gamma Z, \rho_1) - \Phi_2(\beta_0 X_0, \gamma Z, \rho_0)}{G(\gamma Z)} \end{aligned} \tag{5}$$

where Pr(·) stands for probability. ρ represents the correlations between φ and μ. $G(\gamma Z)$ is the cumulative distribution function of univariate normal distribution. The average treatment effect of farmland certification on the poverty of farmers is obtained as follows:

$$ATT = \frac{1}{N_T} \sum_{\mathrm{i}=1}^{N_T} TT(x_i) \tag{6}$$

Where N_T is the number of observations for I=1 (treatment group).

■ *Mediating effect model*

To further explore how farmland certification improves farmers' economic welfare, this paper uses the mediating effect model (Baron and Kenny, 1986). The specific model settings are as follows:

$$Y_i = c_0 + c_1 I_i + c_2 X_i + \varepsilon_{1i} \tag{7}$$

$$M_i = a_0 + a_1 I_i + a_2 X_i + \varepsilon_{2i} \tag{8}$$

$$Y_i = c_0' + c_1' I_i + bM_i + c_2' X_i + \varepsilon_{3i} \quad (9)$$

where M_i is the mediating variable of the i farmer household. The intermediary effect ($a_1 b$) of farmland certification can be obtained by substituting Equation 8 into Equation 9, that is, the indirect impact of farmland certification on farmer households' agricultural net incomes through mediating variables.

4. Empirical results

4.1 Descriptive statistics

There are 2,520 farmers without farmland certificates and 2,836 farmers with certificates in the CLDS (2014) data and 2,423 farmers without certificates and 3,173 farmers with certificates in CLDS (2016) data, indicating that farmers who obtained farmland certificates in the sample accounted for 52.95% in 2013 and 56.70% in 2015. Table 2 presents the descriptive statistics of variables. Farmers with certification enjoy higher agricultural net incomes and less poverty. The average value of agricultural capital input, farmland, division of labour and credit availability are also higher for farmers with certifications. At the village level, the proportion of villages with non-agricultural economies and farmland adjustment for farmers with certification are lower than farmers without certification. These preliminary results indicate that farmers who received farmland certification had relatively more agricultural input.

Table 2. Descriptive statistics.

Variable	Farmers without certificate (A)		Farmers with certificate (B)		Diff. of mean (A-B)[2]
	Mean	SD[1]	Mean	SD[1]	
Proportion of farmland certification	0.275	0.231	0.651	0.234	-0.375***
Poverty	0.699	0.459	0.691	0.462	0.008
Agricultural income	0.110	0.210	0.159	0.273	-0.049***
Wage income	0.400	0.716	0.379	0.798	0.021
Property income	0.008	0.090	0.009	0.091	-0.001
Operational income	0.104	0.590	0.096	0.551	0.008
Agricultural material capital	0.094	0.124	0.127	0.147	-0.033***
Division of labour	0.502	0.312	0.538	0.310	-0.036***
Farmland	0.892	0.281	0.923	0.231	-0.031***
Credit	0.034	0.182	0.050	0.217	-0.015***
Tractor	0.124	0.329	0.189	0.392	-0.066***
Other agricultural machinery	0.024	0.152	0.026	0.160	-0.003
Agricultural subsidies	0.444	0.497	0.485	0.500	-0.041***
Householder's age	54.266	12.189	53.610	11.523	0.656***
Householder's education	6.821	3.364	7.069	3.266	-0.248***
Irrigation and drainage services	0.425	0.494	0.414	0.493	0.011
Transportation infrastructure	0.982	0.132	0.974	0.159	0.008***
Non-agricultural economy	0.283	0.451	0.228	0.420	0.055***
Farmland adjustment	0.298	0.586	0.230	0.471	0.068***
n	4,943		6,009		

[1] SD = standard deviation.

[2] *** indicate statistical significance levels at 1%.

4.2 Income increase effect of farmland certification

Table 3 presents the effect of farmland certification on farmers' agricultural income estimated using two methods. The second column of the table presents the ordinary least squares (OLS) estimation results. Columns 3-5 show the estimation results of the impact of farmland certification on farmers' agricultural income using the ESR model. Column 3 shows the estimation results of whether farmland is certified and columns 4 and 5 show estimation results of the result equation representing the effect of farmland certification on farmers' agricultural income. Column 3 indicates that the proportion of farmland certification in a village has a positive impact on farmland certification at a 1% significance level. Columns 4 and 5 reveal significant differences between farmer groups who received farmland certification and those who did not. Compared with farmers without certification, the income increase effect of agricultural input for farmers with certification is higher. Moreover, the Wald endogeneity test value is $chi^2(15)=42.96$, $Prob>chi^2=0.0000$, indicating that farmland certification is endogenous at a 1% significance level, confirming that the IV of the proportion of farmland certification in a village has certain explanatory power.

This paper next estimates the range of income increase from farmland certification, presenting the estimation results in Table 4. The ATT value in Table 4 is 0.0723, revealing that per capita agricultural net incomes for farmers with certification were 723 RMB Yuan higher than those without certification. The last column in Table 4 shows that per capita agricultural net income for farmers with certification significantly increased by 83.10%, compared with farmers without certification.

To make the analysis results more intuitive, this paper further draws the curve of density function of real and counterfactual farmer household agricultural incomes, as shown in Figure 2, illustrating that the agricultural net income of farmers with certification is significantly higher than those without certificate, confirming that farmland certification has a significant income-increasing effect.

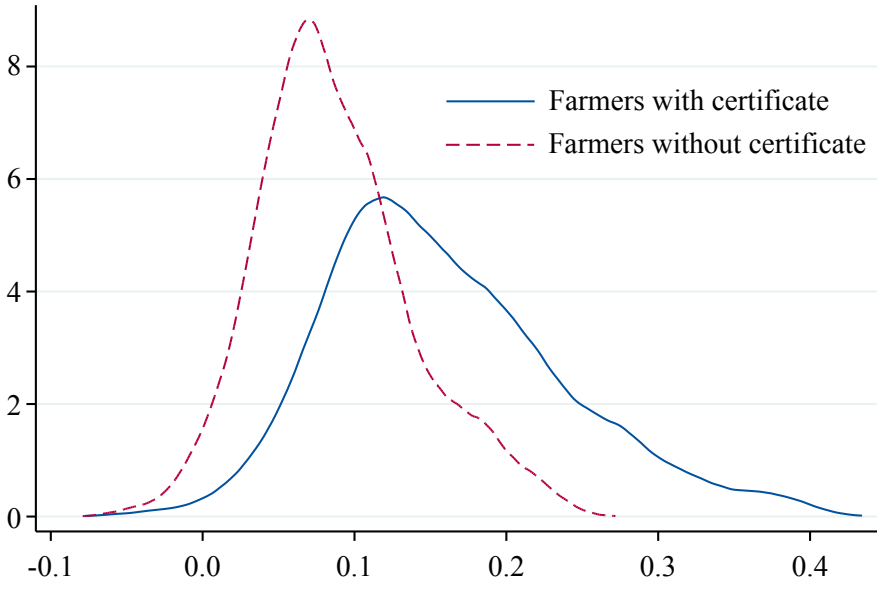

Figure 2. Density function curve of real and counterfactual farmer agricultural income[1].

[1] The abscissa is the natural log of farmers' agricultural net income, and the ordinate is the probability density.

Table 3. The impact of farmland certification on farmers' agricultural income.[1]

Variable	Ordinary least squares	Endogenous switching regression [2]		
		Selection equation	Result equation	
			Farmers with certificate	Farmers without certificate
Farmland certification	0.030***			
	(0.0044)			
Proportion of farmland certification		3.516***		
		(0.0587)		
Agricultural capital	0.186***	0.170	0.236***	0.062*
	(0.0238)	(0.1195)	(0.0323)	(0.0336)
Division of labour	0.095***	-0.011	0.104***	0.078***
	(0.0081)	(0.0505)	(0.0119)	(0.0103)
Farmland	0.062***	0.046	0.068***	0.048***
	(0.0059)	(0.0572)	(0.0098)	(0.0066)
Credit	0.037**	0.001	0.058***	-0.007
	(0.0165)	(0.0761)	(0.0223)	(0.0226)
Household characteristics	yes	yes	yes	yes
Village characteristics	yes	yes	yes	yes
_cons	-0.063	-3.049***	-0.019	-0.056
	(0.0424)	(0.2792)	(0.0681)	(0.0527)
$ln\sigma_1$			-1.338***	
			(0.0611)	
ρ_1			-0.148***	
			(0.0409)	
$ln\sigma_2$				-1.582***
				(0.1160)
ρ_2				-0.166*
				(0.0857)
n	10,952	10,952	6,009	4,943
R^2	0.075			

[1] ***, *, * indicate statistical significance levels at 1, 5 and 10% respectively. Values in the parentheses are robust standard errors.

[2] Wald endogenous test is $chi^2(15)=42.96$, $Prob>chi^2=0.0000$.

Table 4. The treatment effect of farmland certification on farmers' agricultural income.

	Mean	Std. err.[1]	ATT[1,2]	T-value	Difference
Farmers with certificate (fitting value)	0.1594	0.0010	0.0723***	153.5287	83.10%
Farmers without certificate (counterfactual value)	0.0870	0.0006			
n	6,009				

[1] ATT = average treatment effect; std. err. = standard error.

[2] *** indicate statistical significance levels at 1%.

4.3 Poverty reduction effect of farmland certification

Table 5 presents the results of the impact of farmland certification on farmers' poverty, estimated using three methods. The second column is the estimation results of probit model, showing that farmland certification has no significant impact on farmers' poverty. The estimates of the impact of farmland certification on farmers' agricultural net incomes using the ESP model are presented in columns 3 and 5. Column 3 shows the estimation results of the selection equation and columns 4 and 5 show the estimation results of the result equation. Column 3 indicates that farmer households' agricultural capital input and the proportion of farmland certification in villages have positive impacts on farmland certification. As evidenced in columns 4 and 5, there are significant differences between farmers with and without certification, indicating that agricultural capital input and access to credit for farmers with certification could alleviate poverty status.

Due to the endogeneity of farmland certification, this paper employs the ESP model to estimate the impact of farmland certification on farmer households' poverty to ensure more appropriate and reliable results. This paper then obtains the average treatment effect of farmland certification on poverty, as shown in Table 6. The ATT value is -0.0226 and is significant at a 1% significance level. This indicates that compared with farmers without certification, the incidence of poverty for farmers with certification can significantly reduce by 3.17%, confirming that the probability of eliminating poverty status for farmers with certification is 0.0226 percentage points higher than for farmers without certification.

Table 5. The impact of farmland certification on poverty.[1]

Variable	Probit	Endogenous switching probit		
		Selection equation	Result equation	
			Farmers with certificate	Farmers without certificate
Farmland certification	-0.012			
	(0.0259)			
Proportion of farmland certification		3.513***		
		(0.0562)		
Agricultural material capital	-0.601***	0.153	-0.743***	-0.324**
	(0.0986)	(0.1197)	(0.1260)	(0.1631)
Division of labour	0.017	0.002	0.007	0.040
	(0.0451)	(0.0505)	(0.0613)	(0.0668)
Farmland	0.018	0.047	0.023	0.018
	(0.0507)	(0.0573)	(0.0768)	(0.0681)
Credit	-0.111*	-0.011	-0.196**	0.034
	(0.0622)	(0.0765)	(0.0773)	(0.1056)
Household characteristics	yes	yes	yes	yes
Village characteristics	yes	yes	yes	yes
_cons	1.429***	-3.039***	1.825***	0.980***
	(0.2464)	(0.2791)	(0.3503)	(0.3559)
n	10,952	10,952	6,009	4,943

[1] ***, **, * indicate statistical significance levels at 1, 5 and 10% respectively. Values in the parentheses are robust standard errors.

Table 6. The treatment effect of farmland certification on poverty.

	Mean	Std. err.[1]	ATT[1,2]	T-value	Difference
Farmers with certificate (fitting value)	0.6911	0.0010	-0.0226***	-39.4313	-3.17%
Farmers without certificate (counterfactual value)	0.7137	0.0009			
n	6,009				

[1] ATT = average treatment effect; std. err. = standard error.

[2] *** indicate statistical significance levels at 1%.

4.4 Robustness analyses

■ *Instrumental variable method*

To ensure reliable estimates, this paper uses the IV method fixing time and region effects to test the robustness of the results and the validity of the IV. The test results are presented in Table 7. Columns 2-4 show the estimated results of farmland certification on agricultural net incomes, and columns 5-7 show the estimated results of farmland certification on farmers' poverty status. Both the regression results of OLS and IV models demonstrate a significantly positive impact of farmland certification on farmers' agricultural net incomes, while regression results of probit and IV probit models show that the impact of farmland certification on poverty is significantly negative. These results reveal that farmland certification significantly increases farmers' agricultural income and reduces poverty, suggesting that farmland certification can improve farmers' economic welfare. This result is consistent with the above empirical results, indicating that the results of this paper are robust. If the endogeneity of farmland certification is neglected, the impact of farmland certification on economic welfare will be underestimated. The first-stage results of IV and IV probit are presented in the final column of Table 7. The proportion of farmland certification in a village is highly correlated with whether farmers received farmland certification.

This paper also tested the validity of the selected IV, including endogeneity, under-identification and weak identification tests, presenting the results in Table 8. The F statistic of IV method is 779.99 (much higher than 10), and the Cragg-Donald Wald F statistic and Kleibergen-Paap rk Wald F statistic are much larger than the Stock-Yogo critical value, indicating no weak IV problem for the proportion of farmland certification in villages. In addition, the Anderson Canonical correlation Lagrange Multiplier Statistic and the Kleibergen-Paap rk Lagrange Multiplier statistic also reject the under-identification hypothesis at a 1% significance level. Thus, the proportion of farmland certification in a village has certain explanatory power as an IV.

■ *Propensity score matching method*

This paper also constructs 'counterfactual' scenarios based on the PSM method to reduce sample selection bias. Specifically, farmers with certificates are taken as the experimental sample and farmers without certificates as the control sample, matching the two groups of samples with a 1:1 in 0.05 callipers using the estimated propensity score values. Matching is found to be more successful with less sample loss than before matching[6] and the balance hypothesis test is passed.[7] Next, based on the matched samples, this paper estimates the impact of farmland certification on farmers' economic welfare applying ESR and ESP,[8] presenting the results in Table 9. The ATT value of farmland certification on agricultural income is 0.0723, indicating that per capita agricultural net income for farmers with certification is 0.0723 higher than for those without certification,

[6] There are two samples missing after matching, among which one sample is lost for the farmers with certification.

[7] The result of the balance hypothesis test shows the *P*-value of the *t*-test is larger than 0.1, indicating that there is no significant difference between these two groups and meets the balance hypothesis of PSM. See Supplementary Table S1 for the balance hypothesis test results.

[8] The estimated results of result and selection equations for ESR and ESP are shown in Supplementary Table S2.

Table 7. The welfare impact estimated with instrumental variable method.[1,2]

Variable	Agricultural income			Poverty			First-stage Result[3]
	OLS	OLS	IV	Probit	Probit	IVprobit	
Proportion of farmland certification							1.038***
							(0.0099)
Farmland certification	0.050***	0.030***	0.065***	-0.060**	-0.043*	-0.121***	
	(0.0047)	(0.0045)	(0.0077)	(0.0256)	(0.0263)	(0.0433)	
Agricultural material capital		0.193***	0.180***		-0.512***	-0.483***	0.039
		(0.0239)	(0.0240)		(0.1003)	(0.1011)	(0.0304)
Division of labour		0.107***	0.105***		-0.028	-0.023	0.012
		(0.0088)	(0.0088)		(0.0469)	(0.0469)	(0.0136)
Farmland		0.064***	0.061***		0.013	0.020	0.011
		(0.0058)	(0.0059)		(0.0508)	(0.0509)	(0.0153)
Credit		0.033**	0.031*		-0.116*	-0.111*	-0.019
		(0.0165)	(0.0164)		(0.0625)	(0.0624)	(0.0185)
Household characteristics	no	yes	yes	no	yes	yes	yes
Village characteristics	no	yes	yes	no	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes	yes
Region	yes	yes	yes	yes	yes	yes	yes
_cons	0.109***	-0.065	-0.066	0.356***	1.148***	1.153***	-0.367***
	(0.0048)	(0.0424)	(0.0424)	(0.0264)	(0.2477)	(0.2478)	(0.0727)
n	10,952	10,952	10,952	10,952	10,952	10,952	10,952
R^2	0.011	0.079	0.074				0.396

[1] ***, **, * indicate statistical significance levels at 1, 5 and 10% respectively. Values in the parentheses are robust standard errors.

[2] IV = instrumental variable; OLS = ordinary least squares.

[3] First-stage result shows the first-stage result of IV model and IV probit model.

Table 8. Test of instrumental variable.[1]

Under-identification test	
Anderson canonical correlation Lagrange Multiplier statistic	4,002.561***
Kleibergen-Paap rk Lagrange Multiplier statistic	3,636.120***
Weak identification test	
F statistic	779.990
Cragg-Donald Wald F statistic	6,296.910
Kleibergen-Paap rk Wald F statistic	11,000.000
Endogeneity test	
Chi-square	31.111***

[1] *** indicate statistical significance levels at 1%.

and the ATT value of farmland certification on poverty is -0.0227, indicating and the incidence of poverty for farmers with certification is 0.0227 percentage points lower than for farmers without certification. This indicates that the farmland certification can increase farmers' income by 83.10% and reduce poverty by 3.18%. Thus, the baseline regression results in this paper are robust and reliable.

Table 9. The welfare impact estimated with matched samples.[1]

	Mean	Std. err.[2]	ATT[2]	T-value	Difference
The ATT of farmland certification on agricultural income					
Farmers with certification (fitting value)	0.1593	0.0010			
Farmers without certification (counterfactual value)	0.0870	0.0007	0.0723***	153.7176	83.10%
The ATT of farmland certification on poverty					
Farmers with certification (fitting value)	0.6911	0.0010			
Farmers without certification (counterfactual value)	0.7138	0.0009	-0.0227***	-39.8523	-3.18%
n	6,008				

[1] *** indicate statistical significance levels at 1%.

[2] ATT = average treatment effect; std. err. = standard error.

4.5 Mechanism explanation

Previous literature primarily clarifies that farmland certification can improve family incomes through farmland transfer (Feder and Nishio, 1998) and reduce the poverty of future generations through a slow channel of increasing material and human capital input (Galiani and Schargrodsky, 2010). This paper conducts a more comprehensive mechanism analysis on the welfare effect of farmland certification. First, this paper analyses the effect mechanism of farmland certification on agricultural income from the perspective of resource allocation, including the input of human, material, financial and natural capital. The estimated results shown in Table 10 apply a mediating effect model with Equations 7, 8, 9 to test these paths. If the influence of farmland certification on economic welfare remains significant after adding the mediating variable, but the coefficient is smaller than that without the addition of the intermediary variable (i.e. $c_1' < c_1$), then the mediating variable has a partial mediating role. If it is no longer significant, this indicates a complete mediating effect.

According to the results in Table 10, farmland certification can significantly increase farmers' agricultural income through four paths. First, farmland certification increases agricultural income by raising the farmer households' agricultural capital input. The regression results in Table 10 indicate that farmland certification has a significantly positive impact on farmer households' agricultural capital input, and this agricultural capital input has a significant positive impact on farmers' agricultural net income. The proportion of this mediating effect is 20.25%. In the same way, farmland certification could increase agricultural income by raising the input of natural capital, agricultural labour and credit availability, which could explain the 3.68,

Table 10. The mediating effect of farmland certification on farmers' agricultural income.[1]

Path/coefficient	c_1	a_1	b	c_1'	The proportion of the meditating effect (%)
The path of material capital input	0.0423***	0.0316***	0.2711***	0.0337***	20.25
	(0.0046)	(0.0025)	(0.0229)	(0.0045)	
The path of natural capital input	0.0423***	0.0247***	0.0631***	0.0407***	3.68
	(0.0046)	(0.0049)	(0.0058)	(0.0046)	
The path of human capital input	0.0423***	0.0377***	0.1331***	0.0372***	11.86
	(0.0046)	(0.0056)	(0.0083)	(0.0045)	
The path of financial capital input	0.0423***	0.0127***	0.0492***	0.0416***	1.48
	(0.0046)	(0.0039)	(0.0167)	(0.0046)	

[1] To simplify the table, only the estimation results of key variables are reported; *** indicate statistical significance at 1%; values in the parentheses are robust standard errors.

11.86 and 1.48% income increase respectively. In general, farmland certification could reduce farmland risk and strengthen farmers' perceptions and confidence in the stability of farmland rights. Farmers could increase agricultural input based on nostalgia, which would raise their net agricultural income.

Second, this paper analyses the impact of farmland certification on farmers' other types of income, to clarify the mechanism of farmland certification on poverty reduction. According to the regression results in Table 11, farmland certification can significantly improve farmers' agricultural income at a 1% significance level; however, farmland certification has no significant effect on farmers' wage, property or operational income. The results indicate that the poverty reduction effect of farmland certification is realised by increasing farmers' net agricultural income. After receiving certification, farmers' perceptions of farmland use security will strengthen, increasing willingness to engage in agricultural production.

5. Conclusions and implications

Farmland certification has enormous potential to improve farmers' economic welfare. Evaluating the effect of the current farmland certification policy and analysing its welfare effects is an important issue of common concern among theoretical and policy circles. Therefore, it is essential to evaluate the effect of farmland certification from perspectives of income growth and poverty reduction. Based on existing literature, this paper uses CLDS (2014, 2016) survey data and employs the ESR model to analyse the impact of farmland certification on farmers' agricultural net incomes and applies the ESP model to analyse the impact of farmland certification on farmer households' poverty level and conducts robustness tests using IV and PSM methods. This paper also analyses the mechanism of farmers' economic welfare enhancement through farmland certification. The research content and conclusions of this paper are an effective supplement to existing research on property rights and economic welfare. The main conclusions are as follows.

The farmland certification programme in China can significantly improve farmers' economic welfare. Although the farmland certification programme in China is relatively weak, only involving farmland contract rights

Table 11. The impact of farmland certification on incomes.[1]

Variable	Agricultural income	Wage income	Property income	Operational income
Farmland certification	0.065***	0.006	0.001	-0.015
	(0.0077)	(0.0226)	(0.0023)	(0.0167)
Agricultural material capital	0.180***	-0.196***	0.018***	-0.015
	(0.0240)	(0.0657)	(0.0070)	(0.0499)
Division of labour	0.105***	0.028	0.001	0.024
	(0.0088)	(0.0275)	(0.0037)	(0.0201)
Farmland	0.061***	-0.102***	0.005*	-0.037
	(0.0059)	(0.0304)	(0.0027)	(0.0275)
Credit	0.031*	-0.048	0.000	0.171***
	(0.0164)	(0.0384)	(0.0034)	(0.0450)
Household characteristics	no	yes	yes	yes
Village characteristics	no	yes	yes	yes
Year	yes	yes	yes	yes
Region	yes	yes	yes	yes
_cons	-0.066	0.187	0.010	0.590***
	(0.0424)	(0.1406)	(0.0193)	(0.1425)
n	10,952	10,952	10,952	10,952
R^2	0.074	0.062	0.004	0.033

[1] ***, * indicate statistical significance levels at 1 and 10%, respectively. Values in the parentheses are robust standard errors.

certification, it can also improve farmers' economic welfare. The empirical analysis indicates that the per capita agricultural net income of farmer households with certification significantly increases by 83.10% compared with those without certification. Additionally, the incidence of poverty for farmers with certification can be significantly reduced by 3.17%. Therefore, policymakers in China should continue to steadily promote the implementation of the farmland certification programme and the implementation of corresponding supporting measures, to fully protect farmers' land rights and interests and enhance farmers' expectations of farmland security. The government should also actively explore the transformation and application of the farmland certification experience in homestead use and natural resources rights certification, guiding residents to consciously and rationally use the rights granted by the policy and promoting the effective and reasonable allocation of social resources. Such measures will ensure that farmers secure rights, such as freedom of asset transfer and exclusive enjoyment of income and establish a solid institutional foundation for consolidating poverty alleviation achievements and realising rural revitalisation strategy.

The farmland certification programme in China can improve farmers' economic welfare by adjusting farmer households' resources allocation. The empirical analysis indicates that farmland certification is conducive to increasing farmer households' agricultural incomes by increasing the input of agricultural material capital, natural capital and agricultural labour force and improving credit availability. Among them, agricultural material capital input has the largest mediating effect. The poverty reduction effect of farmland certification is primarily realised through raised agricultural income. Consequently, the government should establish agricultural support service systems to provide agricultural production materials and improve rural labour, farmland markets and other factor markets. These efforts can create favourable external conditions for the effective realisation of the farmland certification welfare effect. The government should also implement policies of mortgaging farmland management rights, strengthen the reform of the rural financial system, broaden farmers' financing channels and ease the financial constraints of farmers' agricultural production and operation processes. Finally, relevant government departments should improve the social security system to ensure that farmers can choose to work on or off-farm according to comparative advantages, to expand farmers' channels for increasing income and promote common prosperity.

The research content of this paper can be further expanded. First, future studies can construct more multidimensional measurements of welfare, improving the economic welfare indicators to include consumption variables and other aspects of economic welfare to examine the welfare effect of farmland certification from a multidimensional perspective. Second, future studies can more deeply consider the impact of farmland certification on long-term resource allocation behaviours, such as the impact of farmland certification on long-term agricultural investment.

Supplementary material

Supplementary material can be found online at https://doi.org/10.22434/IFAMR2022.0009

Table S1. Balance hypothesis test of propensity score matching.
Table S2. Estimation results of endogenous switching regression (ESR) and endogenous switching probit (ESP) with matched samples.

Conflict of interest

The authors declare no conflict of interest.

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