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EDITED BY

Tibebu Kassawmar,
Addis Ababa University, Ethiopia

REVIEWED BY

Noshaba Aziz,
Shandong University of Technology, China
Satis Devkota,
University of Minnesota Morris, United States
K. V. Suryabhagavan,
Addis Ababa University, Ethiopia

*CORRESPONDENCE

Zhao Ding
✉ zding@sicau.edu.cn

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Nexus between farmland transfer, agricultural loans, and grain production: empirical evidence from China

Zhao Ding*, Qianyu Zhang and Yu Tang

College of Economics, Sichuan Agricultural University, Chengdu, Sichuan, China

Introduction: Food production stands as a critical global concern necessitating comprehensive investigation. This study utilizes provincial-level data from China to explore the intricate relationships between farmland transfer, agricultural loans, and grain production, with the aim of shedding light on the complexities of these dynamics.

Methods: A two-way fixed effects model and instrumental variable approach are applied to assess the interplay between farmland transfer, agricultural loans, and grain production. These methods provide a robust framework for understanding the complex relationships among these variables.

Results and discussion: The study reveals a notable positive correlation between farmland transfer and grain production. Conversely, agricultural loans demonstrate a significantly negative impact on grain production. However, the positive interaction term between farmland transfer and agricultural loans suggests a nuanced relationship. While profit-driven financial activities may not inherently favor grain production, they contribute to more efficient utilization of farmland resources, ultimately promoting grain production. The findings underscore the significance of continued government support for rural land system reform and active guidance of farmland transfer. It is emphasized that a moderate-scale operation of farmland is crucial for finance to play a lubricating and catalytic role. Furthermore, there is a need to guide agricultural finance towards investing in medium and long-term projects of agricultural production. Attention is also directed to preventing potential food crises arising from the phenomenon of “non-farming” associated with agricultural loans.

KEYWORDS

farmland transfer, agricultural loans, grain production, non-farming, China

1 Introduction

The market-oriented economic reforms implemented in China have resulted in a significant increase in agricultural production and the income levels of rural residents. Indeed, over the period 1980 to 2020, China's total grain output and *per capita* income of farmers have risen from 320.56 million tons and 216 yuan to 669.49 million tons and 17,132 yuan, respectively.¹ The income and agricultural output of farmers are largely determined by the impact of their livelihood activities, in

1 Data was compiled from China Statistical Yearbook.

which farmland transfer and agricultural production are two critical activities.

Farmland is the primary input required for agriculture, playing a vital role in food security, ecosystems, and the living standards of farmers (Fei et al., 2021). To optimize farmland and other resources such as capital and labor, bounded rational farmers will allocate farmland and resources from production sectors with lower marginal productivity to sectors with higher marginal productivity through appropriate land transfers, thereby addressing inefficiencies arising from farmland fragmentation and enhancing farm productivity and income (Berry, 1972; Barrett, 1996). Factors such as industrialization and urbanization (Liu et al., 2018), land finance system (Sippel et al., 2017) and labor migration (Gao et al., 2020), may lead to land transfer out of agriculture. On the other hand, the development of “appropriate-scale” farming (Rogers et al., 2021), farmland protection system (Li et al., 2021), and agricultural incentive policies (Lin and Huang, 2021) tend to promote the transfer of land into agriculture or within the agricultural sector. A well-functioning land market is critical, not only for non-agricultural growth but also for efficiently reallocating idle land resources (Jin and Deininger, 2009; Leimer et al., 2022). In addition, clear farmland property rights secure farmers’ ability to use the land for specific purposes, stabilize labor supply, increase investment, and promote economic growth (Luo and Fu, 2009; Hornbeck, 2010).

Farmland transfer, accompanied by improvements in property rights reform, has proven to be an effective approach in achieving agricultural modernization and large-scale operation, and has also become a prerequisite for harmonizing urban and rural land demands to realize industrialization and urbanization (Kan, 2021). An example of such progress is the Chinese government’s “Separation of Three Rights” principle, proposed in 2011 and formally established in 2018. This principle separates ownership rights, contract rights, and management rights for contracted rural land, aligning with the development trend of modern society. It satisfies the requirements of agricultural industrialization, allowing farmers to retain contract rights while transferring management rights. However, some studies have found that allocating land for large-scale investment projects may reduce food security (Shete and Rutten, 2015). Additionally, promoting farmland transfer has not always been effective in improving agricultural economies of scale (Luo, 2018) and, in some instances, may even result in reduced crop yields (Zhang et al., 2021).

Exploring the linkages between farmland transfer and agricultural production is therefore crucial in shaping future agricultural policies, particularly in light of the growing significance of food-related concerns. Clearly, the impact of farmland transfer on agricultural production is closely tied to the role of agricultural loans, which have been demonstrated in studies highlighting their potential to enhance financial inclusion and stimulate increased investment in the agricultural sector (Yang et al., 2018). Several studies have found that increased uptake of agricultural loans can lead to higher average agricultural productivity and raise agricultural income (Emerick et al., 2016; Khandker and Koolwal, 2016; Fink et al., 2020). Equally important is the inherent uncertainty involved in the development of agricultural loan programs related to farmland markets. Despite the availability of farmland mortgage loans through these markets, farmers often do not seek to align their access to formal credit with land rental market (Kochar, 1997). In addition, access to credit can facilitate potential tenants in securing more efficient land rental contracts (Das et al., 2019), and specific forms of loans may play a

particularly pivotal role in stimulating investment in off-farm production and operations (Peng et al., 2020).

In China, substantial structural transformations are currently unfolding within the agricultural and rural domains. These transformations encompass the orderly and efficient flow of resources, such as farmland, labor force, and capital, between urban and rural areas and between agricultural and non-agricultural sectors. This dynamic has given rise to the emergence of novel agricultural entities such as agricultural cooperatives, family farms and agricultural enterprises, thereby amplifying the specialization of agricultural production. As a result, the farmland transfer market has gained momentum, leading to an upsurge in agricultural loans and the advancement of agricultural production. This phenomenon has spurred out interest in delving into various facets of farmland, including the mechanisms through which it influences agricultural loans, and how to promote farmland transfers while maximizing the use of agricultural loans to increase agricultural production and ensure food security.

Understanding the nexus between farmland transfer, agricultural loans and agricultural production is important, given that investments in agriculture – which directly boost agricultural production – are driven by the financing of financial capital, which, among other factors, is profoundly influenced by the allocation of farmland resources. The primary contributions of this study to the literature are threefold. First, this paper presents a novel attempt to examine the effects of farmland transfer and agricultural loans on grain production in China. Although there are multiple factors that affect grain production, farmland is the most fundamental element in the entire agricultural industry chain, and finance serves as a lubricant and catalyst for the flow of other elements. Secondly, food security is of paramount importance, and it is essential to answer the important question of whether the free flow of farmland factors and the capitalization of agriculture will lead to the non-food issue of farmland, which will in turn affect food security. Third, we show that the inverse agricultural loan-grain production relationship persists across various types of farmland transfers, possibly due to loans being used for trade and other commercial purposes rather than investment in grain production, but it is also found that agricultural loans will enhance the positive effect of farmland transfer on grain production.

The rest of the paper is structured as follows. Section 2 presents a comprehensive literature review. Section 3 presents the data and the methodology used in the study. The empirical results are then reported in section 4. The final section presents concluding remarks and implications.

2 Literature review

2.1 The economic impact of farmland transfer

Farmland transfer can be categorized into two types: transfer outside and within the agricultural sector. The former entails converting land from agricultural to non-agricultural use, while the latter involves the transfer of farmland among agricultural operators without changing its agricultural use, which is the focus in this study. Studies have identified several economic benefits of farmland transfer, including enhanced land use efficiency, increased farmers’ household income, and shifts in agricultural structure. In an investigation of rural

land rental markets in Malawi and Zambia, Chamberlin and Ricker-Gilbert (2016) revealed efficiency gains from transferring land to more productive users. Recent studies in developing countries like Vietnam, Ethiopia, and China (Adamie, 2021; Fei et al., 2021; Nguyen et al., 2021) also found positive effects of farmland transfer on production efficiency. These findings underscore the role of farmland rental markets in improving resource allocation and driving economic transformation in rapidly growing rural economies.

Farmland transfer can be categorized into rented-in and rented-out land (Wang et al., 2019). Farmers with rented-in land tend to centralize and engage in large-scale farming, reaping economies of scale, optimizing input utilization, and improving efficiency and productivity (Huang and Ding, 2016; Cao et al., 2020). In contrast, land rental markets provide stable income to farmers with limited non-land resources, enabling them to rent out land management rights and freeing redundant rural workers for off-farm employment (Grimm and Klasen, 2015; Peng et al., 2020). The farmland rental market contributes to a more balanced farm size distribution by facilitating efficient transfers from less productive to more efficient operators (Deininger et al., 2012). Research also shows that farmers can mitigate disaster-related losses by optimizing their farm size through land transfers, enhancing both efficiency, and resilience in the agricultural sector (Eskander and Barbier, 2022).

However, alongside these positive effects, Jin and Jayne (2013) and Baumgartner et al. (2015) have highlighted potential downsides, including income inequality and power imbalances resulting from large-scale farmland operations. Moreover, farmers who lease rather than own land face greater risks, as land ownership offers better tenure security (Sommerville and Magnan, 2015). While scaled farms can drive agricultural transformation, it remains crucial to strengthen land tenure security for local rural communities to protect land rights and support productivity investments by smallholder farmers (Jayne et al., 2019). Consequently, the outcomes of farmland transfer are nuanced, and non-food and non-agricultural issues deserve attention.

2.2 The impact of agricultural loans on agricultural production

Finance is one of the main constraints that hinder agricultural modernization in developing countries. Access to finance has been confirmed effective in promoting technology adoption and inputs use, leading to heightened agricultural productivity, increased rural incomes, and improved food security (Abate et al., 2016; Balana et al., 2022). Without access to such loans, cash-constrained households are often unable to adopt new seed, fertilizer, or chemical technologies that would enable them to intensify production (Poulton et al., 2010; Fink et al., 2020). Developed countries like the United States, Canada, and Australia have extended great support to agriculture, including credit support, such as farm mortgages aimed at providing capital for purchasing inputs and equipment (Martin and Clapp, 2015). Recent global food economy trends, such as growing demand, rising commodity prices, and ongoing agricultural industrialization, have made agriculture increasingly attractive to financial stakeholders. These stakeholders have introduced new models and logics into farmland ownership and agricultural production (Magnan, 2015). Thus, in order to realize returns from agricultural production, finance pushes for the increased capitalization of agricultural production (Clapp et al., 2017).

However, some studies have argued against the efficacy of microfinance in enhancing agricultural productivity and income derived from agriculture (Phan et al., 2014; Khandker and Koolwal, 2016; Thanh et al., 2019; Nakano and Magezi, 2020). For example, in a recent study on Vietnam, Thanh et al. (2019) found that while microfinance significantly increased total income and output value from all earned sources, these gains were largely driven by self-employment rather than agricultural activities like crop cultivation, livestock rearing, or aquaculture. Similarly, using a randomized control trial of microfinance in Tanzania, Nakano and Magezi (2020) found that microfinance did not lead to greater technology adoption or rice productivity. This is partly attributed to loans being used for trading and other business purposes instead of on-farm investments (Ksoll et al., 2016), as the agricultural productivity benefits of agricultural loans hinge on their appropriate use for on-farm purposes (Elahi et al., 2018). Another reason to consider is that loans from microfinance institutions may not yield significant effects in the short term, for instance, one year (Hossain et al., 2019).

2.3 Research on the farmland finance

In recent years, research in the realm of farmland and agri-food has increasingly focused on the concept of financialization. Land, traditionally perceived for its “use value” in meeting human needs, is now being treated as a pure financial asset alongside its “exchange value” in the market (Harvey, 1982; Haila, 1988). However, Coakley (1994) and Ouma (2015) have highlighted the unique nature of agricultural land, which is intrinsically tied to factors such as weather dependence, geographical variability, socioecological embedment, and political significance, making it less amenable to transformation into a standard asset class. In an era of increasing resource scarcity, the financialization of farmland as a quasi-financial asset is becoming increasingly prominent (Fairbairn, 2014; Ashwood et al., 2022). The argument for considering farmland as an investment opportunity is rooted in the principles of contemporary portfolio management theory, which assert that diversification increases expected portfolio returns while minimizing volatility (Chen et al., 2015; Fairbairn et al., 2021). In particular, clear farmland property rights play a central role, not only as a crucial aspect of investor’s economization strategy but also as a key driver of the “value creation” process (Ouma, 2016).

In China, as land cannot be privately owned, farmland finance relies on using land as collateral for financial services. This practice serves to enhance the economic value of farmland and attract funding for agriculture. Recent empirical studies have found that legal guarantees of land property rights and land transfer have a significant and positive impact on the demand for and likelihood of obtaining agricultural loans (Zhang et al., 2019; Gong and Elahi, 2022). This agricultural loans represent a crucial source of investment for farmers, and easier access to them can incentive farmers to invest more in their land (Peng et al., 2020; Wang et al., 2023). The combination of lengthening rental tenures, escalating land prices, and increased capitalization has emboldened farmland consolidation, augmenting both the financial and productive appeal of land (Rotz et al., 2019). While some farmers perceive this interest from financial actors as a means to increase the value of their assets, others view it as a threat to family farming and a contributor to further disparities in land resource distribution (Sippel et al., 2017).

Despite insights from previous literature on the economic impact of farmland transfers, the relationship between agricultural loans, farm

production, and the financialization of farmland, the connections among farmland transfer, agricultural loans, and grain production in China remain intricate. Ongoing rural revitalization is altering how farmland transfers among agricultural operators. Farmland transfer promotes the shift from small-scale farmers to larger farms, encourages farm size and specialization, and effectively boosts food crop yields, a significant driver behind the growth of farmland transfers. However, the land rent cost associated with farmland transfer, along with the challenge of “limited profits from grain cultivation,” may result in substantial farmland allocation to “non-grain” crops, reducing the area devoted to food crops and subsequently impacting grain production. In addition, previous studies have overlooked the influence of farmland transfers and agricultural loans on China’s grain production. This study addresses this research gap by investigating the relationships among farmland transfer, agricultural loans, and grain production using a panel dataset from China.

3 Data and methodology

3.1 Data

The primary objective of this paper is to investigate the nexus between farmland transfer, agricultural loans and grain production in China. This study utilizes a panel dataset that covers 30 provinces and spans the years from 2009 to 2020. We employ two-way fixed effects and instrumental variable techniques to explore the interrelationship among the factors. The variable used in the study were compiled from diverse resources, including the China Statistical Yearbooks, China’s Rural Operation and Management Statistics Annual Reports, Almanac of China’s Finance and Banking, China Rural Statistical Yearbooks and China Population & Employment Statistical Yearbook. Table 1 presents a summary of the variables. In addition to the core variables, the study incorporates other variables closely related to grain production, such as labor force, fertilizer and pesticide consumption, plastic film usage, machinery, irrigated areas and crop damaged areas.

In particular, grain production is measured as the total output of grain crops, including cereals, beans and tubers. The mean of grain production is approximately 2035 (10,000 tons), but the standard

deviation indicates that data of grain production is widely dispersed. As we can see from the Figure 1. The geographical distribution of grain production in 2009 and 2020 is evident. Farmland transfer refers to the transfer of farmland management rights from farmers who possess such rights to other farmers or economic organizations. This process encompasses sub-contracting, leasing, exchanging, and swapping land-use rights, as well as establishing joint share-holding entities with their farmland. Agricultural loans are loans issued by financial institutions to provide funds for agricultural production. These loans are extended to various entities involved in agricultural, forestry, animal husbandry, and fishery production. Figures 2, 3 reveal substantial variations in farmland transfer and agricultural loans across different provinces in 2009 and 2022, revealing apparent correlations with changes in grain production.

3.2 Methodology

The empirical approach applied in this study explores the relationship between farmland transfer, agricultural loans and grain production through an extension of the standard production function.

This framework is able to examine the impact of farmland transfer and agricultural loans in addition to the basic drivers of inputs.

The production function is assumed to be Cobb–Douglas form,

$$Y_{it} = A_{it} N_{it}^{\alpha_1} K_{it}^{\alpha_2} L_{it}^{\alpha_3} M_{it}^{\alpha_4}, \quad (1)$$

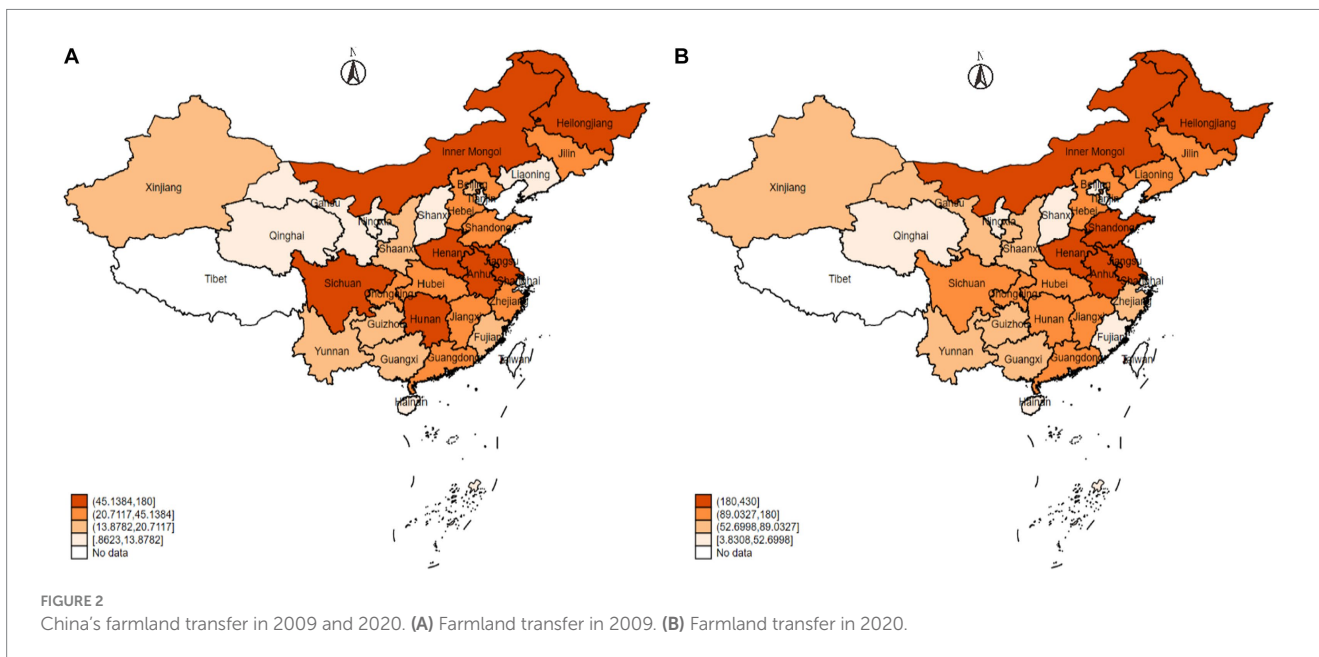
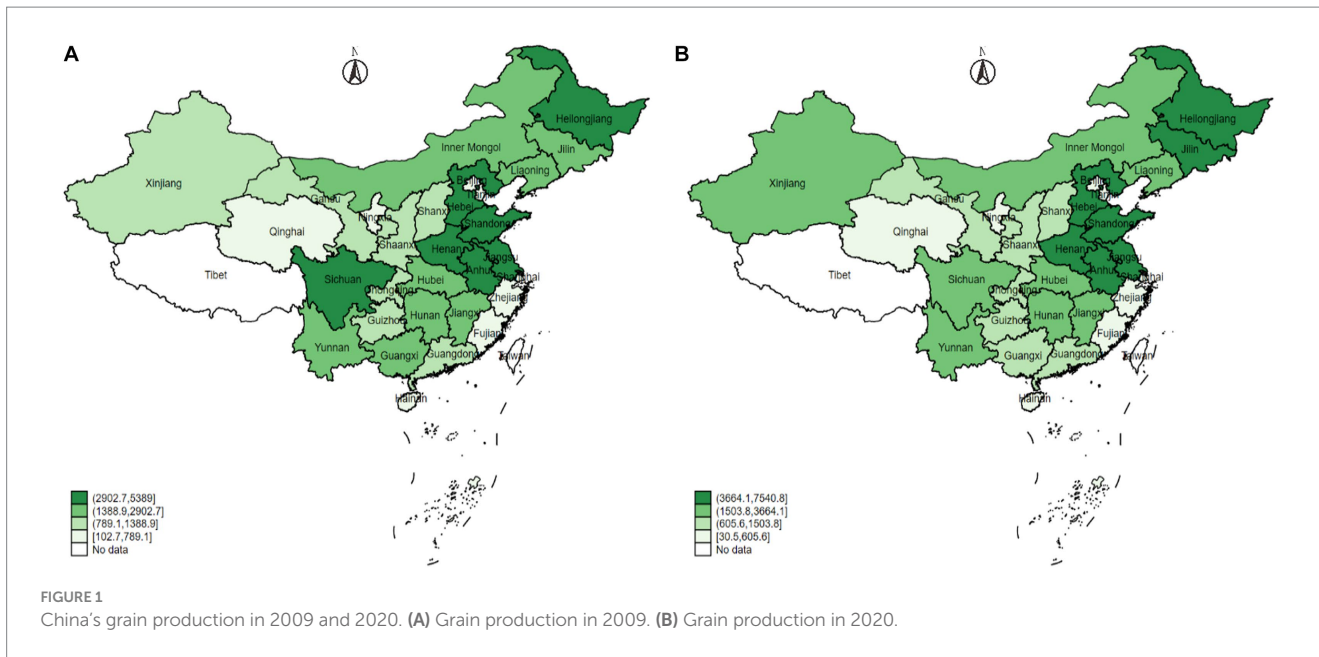
where i denotes the province, t denotes time, Y represents grain production, A is the index of technological progress, N, K, L, M are farmland, capital, labor and intermediate inputs. $\alpha_1, \alpha_2, \alpha_3,$ and α_4 are the output elasticity of each input.

In order to assess the nexus among the studied variables, we reinterpret the figures of the variables by taking their natural logarithm. When taking the logarithm of Equation (1), the following linear multivariate regression is produced,

$$\ln Y_{it} = \theta_0 + \theta_1 \ln_Farmland_{it} + u_i + D_t + \varepsilon_{it} \quad (2)$$

TABLE 1 Definition of variables.

Variable	Definition	Mean	Std. Dev.	Min	Max
Grain Production	Grain crops production (10,000 tons)	2034.93	1693.63	28.70	7540.80
Farmland Transfer	Transferred farmland, including sub-contract, lease, exchange and swap their land-use rights, or joined share-holding entities with their farmland (1,000 hectare (ha.))	862.14	870.18	8.62	4600.51
Agricultural Loans	Loans issued by financial institutions to operators engaged in agricultural production (100 million yuan)	1080.37	750.90	36	4,397
Labor	Number of labor force living in rural areas, excluding migrant workers (10 thousand)	1044.53	748.68	32.5	2920.2
Fertilizer	Consumption of chemical fertilizers (10 thousand tons)	190.36	144.97	5.5	716.10
Pesticide	Consumption of pesticide (10 thousand tons)	5.57	4.20	0.12	16.90
Agrifilm	Consumption of agricultural film (10 thousand tons)	8.05	6.61	0.24	32.30
Mechan	Power of agricultural machinery (10 thousand kilowatts)	3341.30	2909.59	94	13,353
Irrigate	Effective irrigated area (1,000 ha.)	2156.24	1625.46	109.2	6117.6
Disaster	Area of crops damaged by disaster (1,000 hectares), including drought, flood, hailstorm, freezing, typhoon	423.03	456.13	0	3,130



where Y_{it} denotes grain yield, $Farmland_{it}$ denotes the transferred farmland, u_i represents regional fixed effects and is used to capture specific features averaged across provinces, such as topography, precipitation, temperature and other unobservable factors, and D_t is time-specific effects and captures seasonal or cyclical effects, and other changes over time.

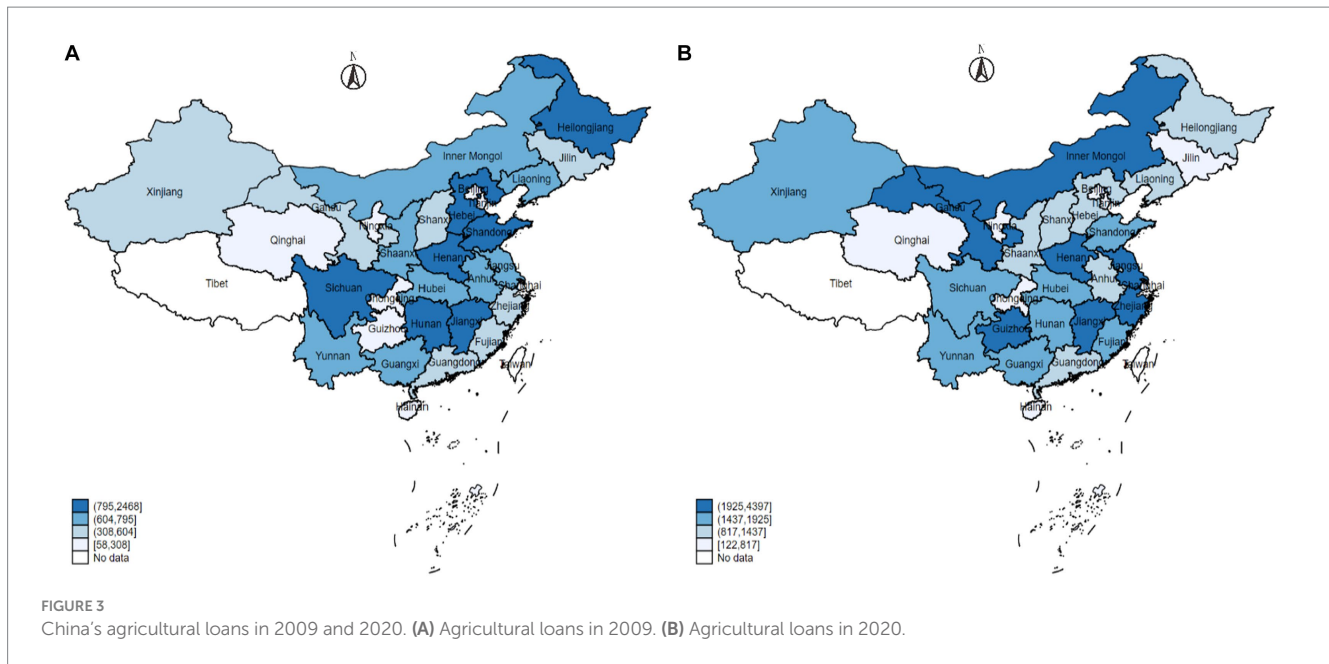
The Equation (2) can be employed to examine the relationship between farmland transfer and grain production, while controlling for farm fixed effects that remain constant over time. However, other inputs such as capital usage, which is subject to change over time, may also influence the farmland – grain production relationship.

Therefore, we include agricultural loans as a moderating variable and incorporate labor, fertilizer usage, pesticide usage, agricultural film

usage, total power of agricultural machinery, effective irrigation area, and crop disaster area to control for farm fixed effects. In theory, apart from the negative impact of disaster area on agricultural production, the input of other factors are supposed to increase grain yield. Based on this, the empirical model of this study is formulated as Equation (3):

$$LnY_{it} = \theta_0 + \theta_1 Ln_Farmland_{it} + \beta_1 Ln_Labor_{it} + \beta_2 Ln_Fertilizer_{it} + \beta_3 Ln_Pesticide_{it} + \beta_4 Ln_Agrifilm_{it} + \beta_5 Ln_Mechan_{it} + \beta_6 Ln_Irrigate_{it} + \beta_7 Ln_Disaster_{it} + u_i + D_t + \varepsilon_{it}. \tag{3}$$

The two-way fixed effects model with agricultural loans included as a moderating variable is then as Equation (4):



$$\begin{aligned}
 \ln Y_{it} = & \theta_0 + \theta_1 \ln_Farmland_{it} + \theta_2 \ln_Loans_{it} + \\
 & \theta_3 \ln_Farmland_{it} \ln_Loans_{it} + \beta_1 \ln_Labor_{it} + \\
 & \beta_2 \ln_Fertilizer_{it} + \beta_3 \ln_Pesticide_{it} + \\
 & \beta_4 \ln_Agrifilm_{it} + \beta_5 \ln_Mechan_{it} + \\
 & \beta_6 \ln_Irrigate_{it} + \beta_7 \ln_Disaster_{it} + u_i + D_t + \varepsilon_{it}.
 \end{aligned} \quad (4)$$

In addition, in order to address potential endogeneity issues in the model, this study further employs the instrumental variable method.

4 Results and discussion

4.1 Results

This study employs a two-way fixed effects model to conduct regression analysis, and the results are presented in Table 2. Since farmland transfer involves three main directions – transfer to farmers, professional cooperatives, and enterprises – we not only examine the overall effect of farmland transfer on grain production but also separately analyze its impacts on grain production when transferred to each of these entities.

As can be seen from the column I, after controlling for other variables, farmland transfer demonstrates a significant positive correlation with grain production at the 1% level. This indicates a strong positive relationship between farmland transfer and grain production. The results suggest that for every 1% increase in the quantity of farmland transfer, there is a corresponding 0.113% increase in grain yield. This finding is consistent with the results of Fei et al. (2021) and Rogers et al. (2021), that is, Land transfer can improve land use efficiency. In addition, the results further suggest that when farmland is transferred to farmers, cooperatives, and enterprises, a 1% increase in quantity results in grain yield increases of 0.085, 0.07, and 0.019%, respectively. This highlights the significant contributions of farmland transfer to both farmers and cooperatives in enhancing grain production. In addition, the coefficients of labor force, fertilizer usage, agricultural film, and irrigation exhibit significant effects at a

level of 5% or higher. This indicates that these inputs noticeably impact grain production. Although the area affected by natural disasters shows a significant negative correlation with grain yield, the coefficient is relatively small. This suggests that agriculture possesses a strong capacity for resilience against disasters.

The results in column II incorporate agricultural loans and the interaction terms between agricultural loans and different types of farmland transfer. It is interesting to note that agricultural loans show a significant negative correlation with grain production, indicating that a 1% increase in agricultural loans leads to a 0.06% decrease in grain yield. However, the coefficient of the interaction term between farmland transfer and agricultural loans is significantly positive, indicating that agricultural loans act as a moderating effect that enhances the main effect. In other words, although agricultural loans alone do not lead to increased grain production, their combination with farmland transfer contributes to the improvement of grain yield. One possible reason might be that agricultural loans can provide farmers with additional resources and capital, and when combined with farmland transfers, can improve land use efficiency and productivity. This infusion of resources may produce benign interactive effects. In addition, agricultural loans often face increased uncertainties and challenges due to the inherently risky nature of agriculture. The property attributes of farmland can help reduce agricultural credit risks, thereby enhancing the overall effect in a positive direction.

Given the potential influence of endogeneity in the benchmark regression results due to omitted variables and reverse causality between farmland transfer and agricultural production, this paper employs an instrumental variable (IV) approach to address the endogeneity issue. The primary focus of this paper is to assess the impact of farmland transfer on grain production. Therefore, our main objective is to find instrumental variables for farmland transfer. In this study, wage income, financial expenditure, and *per capita* road area are selected as instrumental variables for farmland transfer.

The findings of Su et al. (2018) and Fan et al. (2021) have indicated that non-agricultural employment has a significantly positive impact

TABLE 2 The estimation results on farmland transfer, agricultural loans, and grain production relationship.

Variable	Farmland transfer		Transfer to farmers		Transfer to cooperatives		Transfer to enterprises	
	I	II	I	II	I	II	I	II
Ln_Farmland Transfer	0.113*** (0.025)	0.104*** (0.025)	0.085*** (0.023)	0.077*** (0.022)	0.070*** (0.014)	0.075*** (0.014)	0.019 (0.018)	0.023 (0.017)
Ln_Agricultural Loans		−0.061*** (0.019)		−0.043** (0.020)		−0.062*** (0.019)		−0.060*** (0.020)
Ln_Transfer × Loans		0.026*** (0.008)		0.002** (0.001)		0.002** (0.001)		0.003*** (0.001)
Ln_Labor	0.801*** (0.098)	0.810*** (0.096)	0.796*** (0.099)	0.796*** (0.098)	0.748*** (0.099)	0.749*** (0.096)	0.847*** (0.102)	0.862*** (0.099)
Ln_Fertilizer	0.227** (0.103)	0.147 (0.102)	0.209** (0.104)	0.143 (0.104)	0.198** (0.102)	0.108 (0.102)	0.238** (0.108)	0.136 (0.108)
Ln_Pesticide	0.031 (0.061)	−0.017 (0.062)	0.077 (0.062)	0.043 (0.063)	0.010 (0.061)	−0.014 (0.061)	0.048 (0.063)	0.016 (0.062)
Ln_Agrifilm	0.124** (0.049)	0.013 (0.054)	0.102** (0.050)	0.038 (0.052)	0.129*** (0.049)	0.046 (0.052)	0.131*** (0.051)	0.043 (0.054)
Ln_Mechan	0.014 (0.040)	0.015 (0.039)	0.027 (0.041)	0.021 (0.040)	0.016 (0.040)	0.016 (0.039)	0.010 (0.042)	0.007 (0.041)
Ln_Irrigate	0.533*** (0.079)	0.488*** (0.078)	0.513*** (0.080)	0.484*** (0.079)	0.523*** (0.078)	0.480*** (0.078)	0.551*** (0.081)	0.512*** (0.080)
Ln_Disaster	−0.016** (0.007)	−0.013* (0.007)	−0.015** (0.008)	−0.014* (0.007)	−0.016** (0.007)	−0.015** (0.007)	−0.016** (0.008)	0.015** (0.007)
Region fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−3.598*** (0.588)	−2.646*** (0.614)	−3.133*** (0.604)	−2.421 (0.627)	−2.570*** (0.615)	−1.581** (0.644)	−3.564*** (0.606)	−2.685*** (0.628)
N	360	360	360	360	360	360	360	360
R-sq: within	0.615	0.638	0.607	0.625	0.6207	0.642	0.591	0.616
F	26.09***	25.95***	25.33***	24.50***	26.78***	26.37***	23.68***	23.63***

The values in parentheses are standard errors.

on farmland transfer, primarily due to the higher attractiveness of non-agricultural wages. Therefore, in this paper, we consider wage income as an instrumental variable for farmland transfer since it does not directly affect grain production but influences the decision to transfer farmland. Financial expenditure refers to government spending on agricultural and water affairs, encompassing investments and expenditures made by the government in the agricultural sector. These expenditures contribute to the improvement of rural infrastructure and agricultural production conditions, potentially exerting a significant impact on farmland transfer. While *per capita* road area may not directly influence agricultural production, accessible road transportation plays a vital role in facilitating the transportation of agricultural products. This, in turn, enhances market opportunities and serves as a motivating factor for farmland transfer.

The regression results using the instrumental variable (IV) approach are presented in Table 3. The validity test of instrumental

variables shows that the regression coefficients of wage income, financial expenditure, and *per capita* road area in the first-stage regression are all statistically significant at a 5% level or higher, indicating a positive correlation with farmland transfer. In particular, the coefficient of financial expenditure is significantly negative, suggesting that increased government investment in the agricultural sector and improvements in agricultural production conditions lead farmers to be more inclined to cultivate the farmland themselves rather than transferring it. In addition, compared to the promoting effect of road on farmland transfer, the coefficient of wage income is relatively small, implying a limited role of wage income improvement in facilitating farmland transfer. The results of the under-identification test, Hansen J statistic, and Cragg-Donald Wald F statistic also indicate that the instrumental variables are appropriate. Consistent with the baseline regression results, different types of farmland transfer exhibit a significant positive effect on grain production, while agricultural

TABLE 3 Regression results using IV approach.

Variable	Farmland transfer	Transfer to farmers	Transfer to cooperatives	Transfer to enterprises
Ln_Farmland Transfer	0.259* (0.147)	0.365*** (0.135)	0.120** (0.056)	0.312*** (0.123)
Ln_Agricultural Loans	-0.377*** (0.122)	-0.401*** (0.100)	-0.196*** (0.058)	-0.285*** (0.076)
Ln_Transfer ×Loans	0.052*** (0.019)	0.067*** (0.018)	0.028** (0.012)	0.056*** (0.017)
Ln_Labor	0.813*** (0.134)	0.726*** (0.132)	0.780*** (0.127)	0.840*** (0.140)
Ln_Fertilizer	0.111 (0.103)	0.139 (0.111)	0.074 (0.100)	0.056 (0.115)
Ln_Pesticide	-0.089 (0.071)	-0.118 (0.075)	-0.057 (0.064)	-0.107 (0.072)
Ln_Agrifilm	0.056 (0.087)	0.064 (0.067)	0.008 (0.079)	0.103 (0.097)
Ln_Mechan	0.007 (0.030)	0.011 (0.033)	0.001 (0.029)	0.029 (0.031)
Ln_Irrigate	0.463*** (0.083)	0.452*** (0.080)	0.446*** (0.088)	0.499*** (0.084)
Ln_Disaster	-0.009 (0.010)	-0.006 (0.010)	-0.012 (0.009)	0.008 (0.011)
First-stage regression				
Wage income	0.00002*** (5.92e-06)	0.00002*** (5.92e-06)	0.00004*** (9.47e-06)	0.00003*** (6.84e-06)
Financial expenditure	-0.0004*** (0.0001)	-0.0004*** (0.0001)	-0.001*** (0.0001)	-0.001*** (0.0001)
Road	0.130** (0.055)	0.092** (0.040)	0.056** (0.019)	0.122** (0.057)
Underidentification test	35.441*** [0.000]	35.032*** [0.000]	39.757*** [0.000]	41.535*** [0.000]
Cragg-Donald Wald F statistic	25.435	28.420	40.329	34.513
Hansen J statistic	3.257 [0.196]	1.835 [0.399]	7.328 [0.256]	0.903 [0.545]

*, **, and *** represent significance level at 10, 5, and 1%, respectively. The value in brackets is the standard error, and the value in square brackets is *p*-value.

loans show a significant negative impact at the 1% level. However, the coefficient of the interaction term between farmland transfer and agricultural loans is significantly positive at the 1% level, suggesting that agricultural loans enhance the main effect, and the combination of agricultural loans and farmland transfer contributes to an increase in grain production.

According to various statistical criteria, apart from agricultural loans, there are different types of loans in the agricultural sector, including rural loans, rural household loans and agriculture-related loans. In particular, rural loans refer to loans provided to rural households, rural enterprises and various organizations, emphasizing loans within the administrative scope of counties and below. Rural household loans, on the other hand, are loans issued by commercial banks to eligible rural households for purposes such as production, operation, consumption, and other needs. Agriculture-related loans can be broadly classified into two main categories: loans for agriculture, forestry, animal husbandry, and fisheries (commonly known as “agricultural loans”), and other loans associated with agriculture. The latter category encompasses loans for agricultural materials and the circulation of agricultural products, loans for rural infrastructure construction, loans for agricultural product processing, loans for manufacturing agricultural production materials, loans for farmland construction, loans for agricultural technology, as well as loans for real estate, the construction industry, and rural individual businesses. Due to the different focuses of these various types of loans, their moderating effects on the relationship between farmland transfer and grain production may also differ.

Table 4 presents the role of loans in different agricultural sectors regarding the impact of farmland transfer on grain production. The results indicate that rural loans, rural household loans, and agriculture-related loans are significantly and negatively correlated with grain yield. However, their interaction terms with farmland transfer are all positive, indicating an enhancement of the main effects. Specifically, the findings in columns 1, 3, and 5 reveal that a 1% increase in rural loans, rural household loans, and agriculture-related loans results in a decrease in grain yield of 0.064, 0.058, and 0.048%, respectively. However, when effectively combined with farmland transfer, these loans contribute to an increase in grain yield by 0.119, 0.111, and 0.117%, respectively. Among the control variables, both the labor force and irrigated area remain significant at the 1% level, indicating their importance in grain production. In addition, the application of chemical fertilizers also has a significant positive impact on grain yield.

4.2 Discussion

As global policymakers increasingly focus on food security, food production has become a key area of academic attention. While existing research has explored the economic impacts of farmland transfer and the effects of farmland and finance on agricultural production, the connections among farmland transfer, agricultural loans, and grain production in China remain intricate. And in China, ongoing rural revitalization is altering the agricultural investment and financing model as well as changing how farmland transfers among agricultural operators. In contrast, this study utilizes provincial-level data from China spanning 2009–2020. Employing a two-way fixed effects model and an instrumental variable approach, we assess the impact of farmland transfer and agricultural loans on grain production.

Our findings reveal that farmland transfer contributes to an increase in grain production. The positive effects of farmland transfer to farmers, cooperatives, and enterprises differ, with the most significant effects observed when farmland is transferred to farmers and cooperatives. Therefore, this study argues that farmland transfer to farmers and cooperatives is most conducive to enhancing grain production. This finding aligns with recent studies focusing on farmland transfer and food production (Zang et al., 2021, 2023; Kuang et al., 2022), which highlight the optimization of arable land resource allocation, increased investment, and the promotion of agricultural economic growth through farmland transfer. Continuing to encourage farmland transfer is beneficial for promoting agricultural production and China’s “rural revitalization” initiative.

Interestingly, agricultural loans show a significant negative correlation with grain production. This result is similar to the findings of Khandker and Koolwal (2016), who discovered that microcredit raises agricultural income from activities such as livestock rearing but does not affect crop production. Additionally, this finding aligns with research conducted by Ksoll et al. (2016) and Nakano and Magezi (2020), suggesting that agricultural loans are being utilized for trading and other business purposes rather than investments in grain production, thus not contributing to an increase in grain yield. Although agricultural loans alone do not lead to increased grain production, we find that the interaction between agricultural loans and farmland transfer contributes to the improvement of grain yield. This finding is consistent with Jiang et al. (2023), who recently found that farmland transfer improved credit demand and increased agricultural investment. Luo (2018) also suggests that using land contracting rights as a financing tool integrates the profit-seeking nature, liquidity, exclusivity, and profitability of capital, achieving the financialization of farmland and forming productive entities that provide “specialization production.” Therefore, we argue that while finance serves as a lubricant and catalyst for the flow of other elements in the development of the agricultural industry, its profit-seeking nature may lead to non-agriculturalization. Hence, financial instruments in the agricultural sector should be more closely integrated with medium- to long-term agricultural industry projects. For example, governments should consider relaxing pilot programs for mortgage loans secured by farmland management rights.

Furthermore, we find that farmland transfer, especially when transferred to farmers with financial support, contributes more to grain production compared to transfers to cooperatives and enterprises. Thus, we argue that despite the growing importance of new agricultural operating entities, including cooperatives and family farms, in China’s agricultural industry development, the participation of farmers with a certain scale of cultivation remains a crucial force for grain production.

5 Conclusions and policy implications

The current global food security faces multiple challenges, including dwindling land resources, water scarcity, and insufficient agricultural technology and infrastructure. This study, using provincial-level data from China spanning 2009–2020, employed a two-way fixed effects model and instrumental variable approach to assess the impact of farmland transfer and agricultural loans on grain production. Our findings indicate that farmland transfer has a

TABLE 4 Regression results of different types of agricultural loans.

Variable	Country loans	Country loans -IV	Farmer loans	Farmer loans -IV	Agricultural related loans	Agricultural related loans-IV
Ln_Farmland Transfer	0.119*** (0.025)	0.112* (0.078)	0.111*** (0.025)	0.168** (0.083)	0.117*** (0.025)	0.129** (0.047)
Ln_Loans	-0.064* (0.036)	-0.194** (0.077)	-0.058** (0.026)	-0.161** (0.072)	-0.048** (0.021)	-0.169** (0.084)
Ln_Transfer × Loans	0.023*** (0.007)	0.026** (0.012)	0.016*** (0.005)	0.019* (0.010)	0.024*** (0.007)	0.026** (0.013)
Ln_Labor	0.815*** (0.097)	0.819*** (0.135)	0.898*** (0.104)	0.871*** (0.125)	0.813*** (0.097)	0.840*** (0.137)
Ln_Fertilizer	0.214** (0.101)	0.172* (0.103)	0.167 (0.104)	0.144 (0.100)	0.226** (0.101)	0.190* (0.104)
Ln_Pesticide	0.003 (0.061)	-0.027 (0.069)	-0.048 (0.064)	-0.076 (0.073)	-0.009 (0.061)	-0.017 (0.066)
Ln_Agrifilm	0.036 (0.054)	0.030 (0.077)	0.037 (0.055)	0.024 (0.086)	0.056 (0.052)	0.054 (0.080)
Ln_Mechan	0.002 (0.040)	0.020 (0.029)	0.002 (0.040)	0.021 (0.031)	0.022 (0.040)	0.007 (0.028)
Ln_Irrigate	0.480*** (0.079)	0.480*** (0.089)	0.502*** (0.078)	0.506*** (0.084)	0.476*** (0.079)	0.469*** (0.088)
Ln_Disaster	-0.015** (0.007)	-0.013 (0.010)	-0.012 (0.007)	-0.010 (0.010)	-0.012* (0.007)	0.011 (0.010)
Region fixed	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-3.025*** (0.603)		-3.494*** (0.581)		-3.259*** (0.594)	
N	360		360		360	
R-sq: within	0.630		0.629		0.631	
F	25.06***		25.01***		25.12***	
First-stage regression						
Wage income		0.222*** (0.027)		0.413*** (0.035)		0.260*** (0.045)
Financial expenditure		-0.001*** (0.0001)		-0.001*** (0.0001)		-0.0005*** (0.0001)
Road		0.053** (0.020)		0.069*** (0.013)		0.016*** (0.004)
Underidentification test		49.670*** [0.000]		48.204*** [0.000]		38.791*** [0.000]
Cragg-Donald Wald F statistic		94.251		80.453		57.598
Hansen J statistic		0.713 [0.700]		1.218 [0.544]		2.268 [0.322]

*, **, and *** represent significance level at 10, 5, and 1%, respectively. The value in brackets is the standard error, and the value in square brackets is *p*-value.

significantly positive effect on grain production, particularly when farmland is transferred to farmers. In contrast, agricultural loans exhibit a notable negative influence on grain production. However, the interaction between farmland transfer and agricultural loans is positive, suggesting that while financial capital's profit-oriented nature may not favor low-profit grain crops, it contributes to increasing overall farmland productivity and, subsequently, grain yields. In addition, loans from different statistical categories within the

agricultural sector demonstrate a significant negative impact on grain production, but their interaction effects with farmland transfer remain positive, reinforcing the robustness of our results.

These findings carry important policy implications for ensuring food security through the lenses of farmland and finance. Firstly, the government should continue promoting rural land system reforms and actively facilitate farmland transfer. A moderate-scale farmland operation is essential for finance to play a supportive role, and

farmland transfer is crucial for promoting large-scale operations. Establishing standardized farmland transfer markets can incentivize agricultural entities to make long-term investments in farmland, thereby enhancing the efficient use of financial and other resources and ensuring the long-term sustainability of grain production. In addition, through the development of farmland finance that integrates farmland and finance, such as farmland mortgage loans, the property attributes of large-scale agricultural land can be leveraged, which will also help to further enhance agricultural productivity. Secondly, it is essential to remain cautious about non-grain challenges that may arise from financial development. While finance has been acknowledged for its positive impact on rural economies, including ours, inconsistent results regarding its influence on grain production suggest the need for careful guidance of agricultural finance. This guidance should direct investments toward medium and long-term agricultural production projects while preventing potential food crises resulting from “non-agricultural” agricultural loans. Thirdly, giving due importance to the rural labor force is significant. Our research reveals that the rural labor force consistently has a positive effect on grain production. Higher non-agricultural wages can drive farmland transfer, free up rural labor from farming, and attract rural labor to urban employment opportunities. Excessive rural-to-urban migration can be detrimental to grain production. Therefore, in addition to increasing grain subsidies for farmers, promoting market-oriented labor factor reforms and facilitating the two-way flow of urban and rural labor is essential.

Although this study has produced valuable findings, there are still areas requiring further exploration and enhancement. For instance, the reliance on macro-level data in this study poses challenges in integrating the individual characteristics, behaviors, and perspectives of farmers and agricultural operators into the analysis. Moreover, the relatively short timeframe of this study may limit its ability to capture long-term impacts and evolving dynamics. Future research endeavors could contemplate extending the observation period to encompass a more comprehensive view of trends. In addition, given the spatial mobility associated with farmland transfer and agricultural loans, future research may also benefit from exploring spatial measurements as a methodological approach.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ZD contributed to conception and design of the study, and wrote the first draft of the manuscript. QZ organized the database. YT made significant contributions during the paper revision. He played a crucial role in enhancing the introduction and literature review sections in response to reviewers' feedback, addressing grammatical issues and ensuring overall improvement in the paper. ZD and QZ performed the statistical analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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