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Does access to credit matter in land transfer decision-making? Evidence from China

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Land transfer is a favorable tool to solve the low land utilization rate caused by population aging and migration. Most previous studies on land transfer behavior focused on the participation and area of transfer, while little attention was paid to farmers' future land transfer intentions. Hence, by building an analysis framework of land transfer-in "participation-area-future willingness," this study uses the recent farm-level data from China to systematically examine the relationship between access to credit and land transfer-in decisions. To address the potential endogeneity and selection bias from the observable and unobservable factors, we employ the endogenous switching regression (ESR) model and endogenous switching probit (ESP) model for the analysis. The empirical results show that access to credit increases the expected probability of land transfer-in participation and futural intention, as well as helps to expand the land transfer-in area. Specifically, access to credit contributes to increasing the participation, area, and futural willingness of farmers' land transfer-in by 62.6%, 126%, and 74.9%, respectively. The positive role of access to credit is confirmed by the estimates of the propensity score matching (PSM) approach. Our findings highlight that financial support through access to credit can encourage farmers' land transfer-in decisions and further protect the limited arable land source.

KEYWORDS

access to credit, land transfer-in, selection bias, endogenous switching models, China

1 Introduction

Land is the most essential material condition for human survival and also one of the basic inputs of agricultural production (Yubo and Yuyu, 2022). Given the importance of land resources, how to make full and effective use of land resources to ensure food security has always been a hot topic of research. However, from a global perspective, due to aging populations and migration, the shortage of agricultural labor and the abandonment of arable land make both developed and developing countries face the challenge of improving land use efficiency (Zhang, Mishra et al., 2020). For example, the study by Plotkin and Hassanein (2017)found that by 2040, the issue of an aging population will lead to 70% of the farmland in the United States being transferred. This problem is more severe in China as a developing country. On the one hand, China's population is aging, and on the other hand, China's urbanization and industrialization have attracted a vast number of young rural laborers who choose to work in non-farm industries (Jaquet, Schwilch et al., 2015). These factors have led to a severe phenomenon of rural agricultural labor, "off-agricultural or non-agricultural", resulting in a structural shortage of laborers required for agricultural production (Xu, Deng

et al., 2019). This has led to a series of agricultural development challenges, such as abandoned cropland, low agricultural production efficiency, and food security problems (Deininger, Jin et al., 2014).

Currently, China has introduced a number of policies to motivate rural households to transfer land, in order to reduce the abandonment of cropland and make rational use of land resources (Zhou, Liang et al., 2021). According to China's agricultural and rural statistics for 2020, the transfer area of land management rights nationwide has reached 532 million mu (one mu is equal to 0.067 ha), accounting for 32% of all household farmland areas. However, in 2019, the growth rate of land transfers decreased to 4.71%, which is 17.95% lower than that in 2013. Although land transfer has achieved specific results under the promotion of government policies, challenges such as a large number of small-scale farmers and the decline in the growth rate of land transfer are still not conducive to the development of agricultural modernization.

In the context of China's shortage of agricultural labor, how to reduce land abandonment and ensure food security is an important issue worthy of study. Land transfer is considered an important strategic measure to protect land resources, guarantee food security, and promote farmers' income (Chamberlin and Ricker-Gilbert, 2016). In other words, transferring the idle land in the hands of some farmers to other farmers is an effective solution (Deininger, 2003). The issue of land transfer has been discussed and studied extensively in the existing literature. From a macro-perspective, it has been argued that the macro-external environment has a remarkable impact on farmers' land transfer behavior decisions (Deininger and Jin, 2005; Long, Li et al., 2012; Cheng, Hu et al., 2022), such as thebuilding of infrastructure, policy systems, and natural conditions. From a micro-level, some scholars argue that the household head's individual characteristics, family characteristics, resource endowments, and non-agricultural employment are the main factors influencing farmers' land transfer decisions (Zhou, Yan et al., 2020a; Gao, Song et al., 2020; Huang, Deng et al., 2020). Meanwhile, a few studies have found that access to credit has a noticeable effect on farmers' land transfer decisions. For instance, based on the different national-level farm survey data, Hou, Huo et al. (2017) and Jiang, Paudel et al. (2018) found that agricultural credit enables farmers to transfer-in land by easing the financial constraints of agricultural production. Arunrat, Wang et al. (2017) conducted an analysis on Thailand and found that social capital can help farmers adopt climate change adaptation measures, regardless of how they perceive climate change. In addition, Du, Zeng et al. (2019) found that access to credit helps reduce farmers' abandonment of their farmland. In addition, Li, Ma et al. (2020) found that access to credit can help some farmers invest in agriculture, which encourages farmers to transfer-in land. At the same time, it can also make some other farmers invest in non-agricultural sectors (e.g., convenience stores), which may cause land transfer-out by some other farmers. In summary, the few studies on the relationship between access to credit and land transfer have primarily focused on the effect of credit on whether farmers abandoned their land (Du, Zeng et al., 2019) or participated in land transfer (Li, Ma et al., 2020).

While agriculture is an industry that is greatly affected by objective factors, such as the natural environment and climatic conditions, the high risk of engaging in agriculture makes it very uncertain whether farmers are willing to transfer-in land in the future. Therefore, the existing research paid little attention to the impact on farmers' future land transfer willingness and further lacks a systematic analysis of land transfer decision behaviors. Hence, by constructing an analytical framework of "participation→area→willingness" of farmers' land transfer-in, this study aims to systematically analyze the impact of access to credit on farmers' land transfer decision behaviors. Under the situation that agricultural labor shortage and land abandonment persist, further analysis of farmers' willingness to transfer-in land is significant for addressing the issue of "who will farm the land" in China. Thus, in the context of the development of the land transfer market in China, this study attempts to provide further insights into the following questions: how does access to credit affect farmers' decision-making regarding land transfer participation? Will access to credit motivate farmers to transfer-in more land? How does access to credit affect farmers' willingness to transfer-in land?

2 Analysis framework and research hypothesis

Based on the existing literature on land transfer (Zhou, Ma et al., 2020b; Xu, Yong et al., 2020; He, Deng et al., 2021) and the actual situation of the land transfer market in China, we constructed a three-stage analytical framework to systematically analyze farmers' land transfer decision behavior. As shown in Figure 1, the three stages of land transfer decision behaviors are "participation→area→willingness." The literature has extensively analyzed and studied the first two stages of land transfer (Grubbström and Eriksson, 2018; Jiang, Paudel et al., 2018; Valliant, Ruhf et al., 2019; Yu, Yin et al., 2021), while relatively less research has been conducted on the third stage—farmers' willingness to transfer-in land. The agriculture sector is susceptible to the natural environment and has a long investment return period. There is an obvious uncertainty about whether farmers are willing to transfer land in the future. This is related to not only continuously protecting the limited arable land resources but also ensuring food security and sustainable agricultural development (Ye, 2015). Land and capital are the core fundamentals of agricultural production (Du, Zeng et al., 2019).

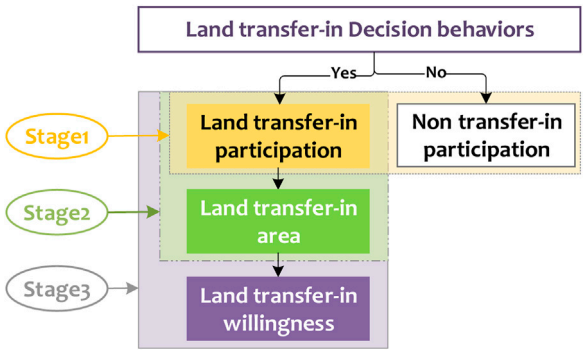

FIGURE 1
Analysis framework of household's land transfer-in behaviors.

Farmers in developing countries generally face serious credit constraints due to inefficient rural financial markets (Chandio, Jiang et al., 2017). Therefore, because of financial constraints, it is quite difficult for farmers to achieve the best investment funds needed to maximize the benefits of agricultural production and operation (Du, Zeng et al., 2019). For a long time, smallholder farmers have been under tremendous pressure in agricultural production and operation due to their limited household capital and lack of high-value materials that can be used as collateral for loans (Dong, Lu et al., 2012; Li, Ma et al., 2020). As a result, financial constraints can affect farmers' adoption of agricultural machinery and improved agricultural inputs.

Access to credit mainly influences farmers' land transfer behavior by alleviating the pressure of land transaction costs, increasing production factor inputs, and extending the agricultural production chain. Specifically, access to credit contributes to alleviating the pressure of land transfer transaction costs faced by farmers, thereby promoting land transfer. At present, the increasing cost of land transfer has become one of the main expenses of agricultural production. For example, based on a survey from Tanzania, Ricker-Gilbert and Chamberlin (2018) found that land transaction costs are one of the main factors restricting farmers from transferring land. Second, on the one hand, access to credit helps farmers use sufficient agricultural production inputs (e.g., fertilizer and seeds) to maximize agricultural output. On the other hand, it also helps farmers apply advanced agricultural technologies (e.g., agricultural machinery) to improve agricultural productivity. For example, the results reported by Abate, Rashid et al. (2016) showed that access to credit can facilitate the adoption of new agricultural technologies by Ethiopian farmers. In addition, the study by Nukpezah and Blankson (2017) showed that access to credit enables farm entrepreneurs to expand their production scale, processing chain, and participation in marketing. Finally, access to credit can support farmers in vertically extending the agricultural industry chain (e.g., agro-processing industry and agro-tourism), thereby increasing the value added to agriculture. Li, Ma et al. (2020) argued that access to credit could ease farmers' financial constraints, thus enabling them to transfer-in more land for agricultural production-related business activities.

Therefore, the following research hypotheses are proposed for this study:

Hypothesis 1. (H1). Access to credit positively affects farmers' participation in land transfer-in.

Hypothesis 2. (H2). Access to credit can help increase farmers' land transfer-in area.

Hypothesis 3. (H3). Access to credit helps increase the likelihood of farmers' futural willingness on land transfer-in.

3 Data and descriptive statistics

3.1 Data resource

The data used in this study were obtained from a survey conducted from July 2020 to October 2020 in China. A multi-stage stratified random sampling method was employed to collect data from rural households. During the first stage, 11 cities (namely, Chengdu, Deyang, Mianyang, Ziyang, Meishan, Suining, Neijiang, Nanchong, Dazhou, Guangan, and Luzhou), which are the primary agricultural production cities in Sichuan Province, were chosen. Next, we randomly sampled two counties from each city and then randomly selected two to three towns from the selected counties. Then, face-to-face interviews were conducted with 10–20 households in each selected town, resulting in a valid sample of 858 households. In the field survey, the questions in the structured questionnaire included farmer's individual features (e.g., gender, age, and educational background), the characteristics of the household and farm (e.g., farm size, off-farm, Wi-Fi, and car ownership), village characteristics (e.g., distance to the market center and the local topography), and land transfer information (e.g., current participation and area of land transfer-in and the futural willingness on land transfer-in).

3.2 Variables

3.2.1 Dependent variables

We consider land transfer-in decision behaviors as the dependent variables. Considering that land transfer behaviors can be classified as land transfer-in and transfer-out, this study focuses on farmers who transfer-in land. This is because the farmers who transfer-out land are more likely to leave farming and mainly work in the non-agricultural sector. As stated previously, land transfer-in behavior comprises three stages: land transfer-in participation (LTP), land transfer-in area (LTA), and land transfer-in willingness (LTW). LTP and LTW are binary variables, representing whether the farmer has participated in land transfer-in (1 means yes, otherwise 0) and whether the farmer is willing to transfer-in land in the future (1 means yes, otherwise 0), respectively. LTA refers to the area of transfer-in land, which is a continuous variable.

3.2.2 Key variable

This study uses access to credit as the focus variable. Here, credit access is set as a binary variable, indicating whether farmers have access to credit. The question "have you accessed credit for farm activities in 2019?" is designed in the questionnaires to capture farmers' access to credit. Among our total samples, 37.53% of the interviewed farmers have access to credit. Furthermore, for those farmers who had access to credit, we continually asked, "what do you do with credit?" The results illustrated in Figure 2 show that over half of the farmers who had already obtained credit used it for land transfer-in. This result indicates that there is a potential relationship between farmers' access to credit and land transfer-in.

3.2.3 Control variables

Referring to the existing literature related to credit access and land transfer behaviors (Porgo, Kuwornu et al., 2018; Du, Zeng et al., 2019; Li, Ma et al., 2020), we selected four groups of control variables. The control variables contained the characteristics of

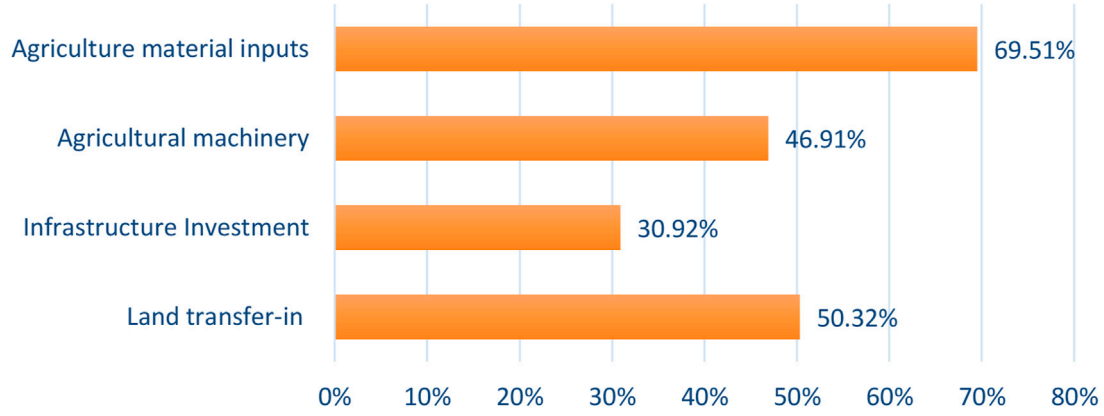

FIGURE 2
Distribution of farmers' credit usage.

the household head (e.g., age, gender, and education), the characteristics of the farm family (e.g., family size, off-farm workers, and car ownership), the environmental factors (e.g., distance to the market and terrain), and city dummy variables. Supplementary Appendix Table S1 presents the definition of selected variables and their descriptive statistics.

Age and education are two essential indicators of human capital (Ma, Abdulai et al., 2017). As mentioned by Schultz (1981), knowledge is an important human capital. Knowledge education improves people's ability to perceive, judge, and respond to new things. Concerning the personal characteristics of household heads, previous studies on developing countries have found that age and education positively influenced farmers' decisions to transfer land (Valliant, Ruhf et al., 2019; Yubo and Yuyu, 2022). Moreover, both age and age-squared terms are included in the specification to examine the potential non-linearities between these variables and access to credit, as well as land transfer decisions.

Consistent with previous studies, family size is expected to have a positive impact on land transfer decisions. Meanwhile, as indicated by Xu, Yong et al. (2020), non-farm employment has a negative effect on the probability of land transfer behavior, and we expect this variable to have a negative effect on land transfer behavior as well. With regard to physical assets, previous studies have shown that ownership of a vehicle, TV, and radio exerts a positive impact on the probability of accessing credit (Mottaleb, Rahut et al., 2017; Liu, Min et al., 2021a). In this study, we use ownership of a vehicle and Wi-Fi as proxy variables for ownership of physical assets, and we expect a positive impact of these variables on access to credit and land transfer decision-making.

In addition, distance to the nearest market and topography may increase farmers' transaction costs, leading to a lower probability of accessing credit and land transfer markets. We also expect that distance to markets and topography will have a negative impact on credit access and land transfer, as the higher the elevation, the less well-developed the credit market (Ma, Abdulai et al., 2018). Lastly, a set of location dummy variables is included to account for unobserved agroclimatic and socioeconomic heterogeneity among the sample areas (Ma, Abdulai et al., 2017; Li, Ma et al., 2020).

3.3 Mean difference

Supplementary Appendix Table S2 reports the mean differences of the selected variables between farmers who have access to credit (AC) and those who do not have access to credit (NAC). The results show that farmers in the AC group significantly differ from farmers in the NAC group. In particular, compared with the NAC group, the AC group is younger, better educated, has less farming experience, consists of fewer off-farm workers, has spent more time using Wi-Fi, and tends to own cars. More importantly, it shows the significant difference in the participation, area, and futural willingness on land transfer-in between the AC and NAC groups. The mean difference results imply that there are systematic differences between the two groups. To account for observable and unobservable factors that may influence these differences, we employed an endogenous switching regression model and an endogenous switching probit model to reduce the bias level.

4 Estimation strategies

4.1 Model selection

Access to credit is a choice made by farmers based on household resource endowments, not at random (He, Deng et al., 2021). Thus, some unobserved factors (e.g., motivations and management ability) may affect both credit access (AC_i) and the outcome variables ($LTP_i^*, LTA_i^*, LTW_i^*$), leading to potential self-selection bias. Failure to address this issue could lead to bias and inaccurate estimates (Ma and Abdulai, 2016). Several approaches have been used in the literature to deal with selection bias, namely, propensity score matching approach, inverse probability weighted regression adjustment (IPWRA), and augmented inverse propensity weighted (AIPW) estimator. In contrast to these previous methods, ESM (endogenous switching model) can deal with selection bias not only from observable factors but also from unobserved factors (Ma and Wang, 2020). Referring to recent research studies (Abdulai and

Huffman, 2013; Shahzad and Abdulai, 2020a; Liu, Min et al., 2021b), this study selects the ESM estimation technique to address the sample self-selection issues. More specifically, we use the endogenous switching probit model to estimate the impact of land transfer-in participation and future willingness. Also, endogenous switching regression (ESR) is adopted to evaluate the influence factors of the land transfer-in area.

4.2 Endogenous switching models

The ESR model estimates the influence of credit access on the land transfer-in area (continuous outcome variable), while the ESP model is applied to estimate land transfer-in participation and futural willingness (binary outcome variables). According to the conceptual analysis framework of Lokshin and Sajaia (2004) and Lokshin and Sajaia (2011), both ESR and ESP contain two parts: the selection part and the outcome part.

4.2.1 For the first part

Based on the stochastic utility decision model proposed by Becerril and Abdulai (2010) and Abdulai and Huffman (2013), we assume that farmers are risk-neutral and whether farmers' access to credit depends on the difference between the utility from accessing credit (AC_{ia}) and the utility from not accessing credit (AC_{in}). Only if $AC_i^* = AC_{ia} - AC_{in} > 0$, farmers will choose to access credit. Since the utility difference cannot be directly observed, we define the decision-making equation for farmers' access to credit using a latent variable model as follows:

$$\boldsymbol{AC_i^* = \gamma Z_i + \mu_i, \text{with } AC_i = \begin{cases} 1, & if\ AC_i > 0, \\ 0, & otherwise, \end{cases}} \tag{1}$$

where $\boldsymbol{AC_i}$ refers to a binary variable (1 for accessing credit and 0 for not accessing), $\mathbf{Z_i}$ is a vector of explanatory variables (e.g., householder, household, and demographic characteristics) that are predicted to influence the decision to access credit, and $\boldsymbol{\gamma}$ is a vector of parameters to be estimated. In addition, $\boldsymbol{\mu}$ is the random error term.

4.2.2 For the second part

This study aims to examine the influencing factors of credit access and figure out the empirical relationship between access to credit and land transfer-in decision behaviors. The corresponding land transfer-in decision behaviors of farmers who did and did not have access to credit are as follows:

Stage 1 (ESP), for the land transfer-in participation.

Regime 1.1 (access to credit):

$$\boldsymbol{LTP_{1i}^* = \alpha_{11} X_{i1}^{'} + \sigma_{\mu 11}\lambda_{11} + \varepsilon_{i11}, LTP_{1i} = \begin{cases} 1, & LTP_{1i}^* > 0 \\ 0, & LTP_{1i}^* < 0 \end{cases}, for\ AC_i = 1} \tag{2a}$$

.

Regime 1.2 (non-access to credit):

$$\boldsymbol{LTP_{0i}^* = \alpha_{10} X_{i0}^{'} + \sigma_{\mu 10}\lambda_{10} + \varepsilon_{i10}, LTP_{0i} = \begin{cases} 1, & LTP_{0i}^* > 0 \\ 0, & LTP_{0i}^* < 0 \end{cases}, for\ AC_i = 0} \tag{2b}$$

.

Stage 2 (ESR), for the land transfer-in area.

Regime 2.1 (access to credit):

$$\boldsymbol{LTA_{1i} = \alpha_{21} X_{i1}^{'} + \sigma_{\mu 21}\lambda_{21} + \varepsilon_{i21}, if\ AC_i = 1.} \tag{3a}$$

Regime 2.2 (non-access to credit):

$$\boldsymbol{LTA_{0i} = \alpha_{20} X_{i0}^{'} + \sigma_{\mu 20}\lambda_{20} + \varepsilon_{i20}, if\ AC_i = 0.} \tag{3b}$$

Stage 3 (ESP), for the land transfer-in willingness.

Regime 3.1 (access to credit):

$$\boldsymbol{LTW_{1i}^* = \alpha_{31} X_{i1}^{'} + \sigma_{\mu 31}\lambda_{31} + \varepsilon_{i31}, LTW_{1i} = \begin{cases} 1, & LTW_{1i}^* > 0 \\ 0, & LTW_{1i}^* < 0 \end{cases}, for\ AC_i = 1.} \tag{4a}$$

Regime 3.2 (non-access to credit):

$$\boldsymbol{LTW_{0i}^* = \alpha_{30} X_{i0}^{'} + \sigma_{\mu 30}\lambda_{30} + \varepsilon_{i30}, LTW_{0i} = \begin{cases} 1, & LTW_{0i}^* > 0 \\ 0, & LTW_{0i}^* < 0 \end{cases}, for\ AC_i = 0.} \tag{4b}$$

In (Eqs 2a–b), $LTP_{1i}^*, LTA_{1i}^*, LTW_{1i}^*$ and $LTP_{0i}^*, LTA_{0i}^*, LTW_{0i}^*$ represent the land transfer-in decision behaviors of farmers who chose to obtain credit and those who did not choose to obtain credit, respectively. $X_{1i}^{'}$and $X_{0i}^{'}$represent the factors that impact the land transfer-in behaviors of the two groups of farmers. All ε_i parameters represent random error terms.

In the ESR and ESP model frameworks of Lokshin and Sajaia (2004) and Lokshin and Sajaia (2011), the ESP (Eqs 1b–b2b), (Eqs 1, 3a, 3b) and ESR models (Eqs 1, 4a, 4b) are estimated by the full information maximum likelihood (FIML) estimator, which overcomes the problem by allowing simultaneous estimation of two stages involving one choice and two outcome equations. In addition, for model identification, the ESR and ESP models require at least one instrumental variable (IV) that only influences the treatment variable (appearing in Eq. 1) but not the outcome variable.

Here, we take the average ratio of accessing credit in the same town except for the farmer under consideration as IV. Note that, as in previous studies (Kousar and Abdulai, 2016; Deng, Xu et al., 2019), according to the peer effect (Sampson and Perry, 2018), a peer's credit choice may affect a farmer's same decision to get credit. However, a peer's credit choice is not necessarily correlated with farmer's land transfer decision behaviors.

4.3 Treatment effect estimation

Based on the estimated results of the two parts of the ESMs, the coefficients from all models can be used to calculate the treatment effects of access to credit on land transfer-in decision behaviors. Again, following the analysis framework of Lokshin and Sajaia (2004) and Lokshin and Sajaia (2011), the average treatment effect on treated (ATT) can be estimated by the following equations:

For the ESR model of the land transfer-in area,

$$ATT_{LTA} = E[LTA_{1i} \mid AC = 1] - E[LTA_{0i} \mid AC = 1] = X_i(\gamma_{1i} - \gamma_{0i}) + \lambda_1(\sigma_{1\mu} - \sigma_{0\mu}) \quad (5)$$

For the ESP models of the land transfer-in participation and willingness,

$$ATT_{LTP} = \frac{1}{N_1}\sum_{i=1}^{N_1}[P_r(LTP_1 = 1 \mid AC = 1, X = x) - P_r(LTP_0 = 1 \mid AC = 1, X = x)] = \frac{\Phi_2(X_1\alpha_1, \gamma Z, \rho_1) - \Phi_2(X_0\alpha_0, \gamma Z, \rho_0)}{F(\gamma Z)} \quad (6)$$

$$ATT_{LTW} = \frac{1}{N_1}\sum_{i=1}^{N_1}[P_r(LTW_1 = 1 \mid AC = 1, X = x) - P_r(LTW_0 = 1 \mid AC = 1, X = x)] = \frac{\Phi_2(X_1\alpha_1, \gamma Z, \rho_1) - \Phi_2(X_0\alpha_0, \gamma Z, \rho_0)}{F(\gamma Z)} \quad (7)$$

In the ESR model, ATT is the difference between the actual and counterfactual outcomes for farmers who have access to credit (Eq. 5). For the ESP models, in equations (Eqs 6, 7), Φ_2 is the cumulative function of a bivariate normal distribution and F is a cumulative function of the univariate normal distribution. N_1 is the number of observations in the treated group (i.e., $AC = 1$). $P_r(LTP_1 = 1 \mid AC = 1, X = x)$ and $P_r(LTP_0 = 1 \mid AC = 1, X = x)$ refer to a probability that a credit user chooses to participate in land transfer-in in an actually observed context and a counterfactual context, respectively. Similarly, $P_r(LTW_1 = 1 \mid AC = 1, X = x)$ and $P_r(LTW_0 = 1 \mid AC = 1, X = x)$ refer to the probability that a credit user is willing to transfer-in land in the future in an actually observed context and a counterfactual context, respectively.

5 Empirical results

Supplementary Appendix Tables S3, S4, and S5 report the estimated results of the factors influencing credit access and the determinants of land transfer-in decisions in terms of participation, area, and futural willingness, respectively. In the bottom half of Supplementary Appendix Tables S3, S4, and S5, the statistically significant negative coefficients of ρ_1 and/or ρ_0 indicate a negative selection bias originating from the unobserved factors (Lokshin and Sajaia, 2011; Shahzad and Abdulai, 2020b; Li, Ma et al., 2020). Moreover, the Wald tests for $\rho_1 = \rho_0 = 0$ have a significant sign at the 5% or 1% level, revealing that the null hypothesis that accessing credit is exogenous is rejected. In summary, these findings suggest the appropriateness of employing ESM in this study.

5.1 Determinants of credit access

The second columns of Supplementary Appendix Tables S3, S4, and S5 show the estimated results of determinants of access to credit based on the ESR and ESP models. The effect of age on credit access is not linear but shows an inverted U-shaped effect. This coefficient of age suggests that middle-aged farmers are more likely to obtain credit than younger and older farmers. This finding is generally consistent with the results reported by Dong, Lu et al. (2012) who found that there is a non-linear relationship between age and access to credit in rural areas. Possible reasons for this are that middle-aged farmers are more experienced and have better energy and stamina. The significant coefficients of education variables suggest that well-educated farmers are more likely to have access to credit, which is consistent with the finding of Li, Ma et al. (2020). Farm experience has a negative and significant sign, suggesting that the longer a farmer has been in agriculture, the less likely they are to obtain credit. In addition, the coefficients of off-farm variables are significantly negative, indicating that off-farm working of family members decreases the probability of accessing credit (Li, Ma et al., 2020). This may be because the income from off-farm working increases total household income and reduces the demand for credit. This study also finds that the coefficients of peer's effect (IV in the analysis) are significantly positive, indicating that credit acquisition could interact among peers. This is in line with the findings reported by Deng, Xu et al. (2019).

5.2 Determinants of land transfer decision behaviors

Supplementary Appendix Tables S3, S4, and S5 (columns 3 and 4) present the results of factors impacting the decisions of the AC and the NAC on land transfer-in participation, area, and futural willingness, respectively. A comprehensive analysis of the estimated results of the three tables enables us to find that age has a significant positive sign and age-squared terms has a significant negative sign in stage 3 of the NAC group. This implies an inverted U-shaped effect between age and futural land transfer intention, indicating that middle-aged farmers have stronger intentions to transfer-in land. This finding is consistent with the study by Xu, Yong et al. (2020) who argued that there is a significant inverse U-shaped correlation between head age and land transfer-in. Education has a significant negative effect on land transfer participation in the AC group, indicating that farmers with higher education levels are less likely to transfer-in land. One potential reason is that better educated farmers prefer to think about how to improve the value added to agriculture by extending the chain, not paying attention only to farm scale. The off-farm variable has a significant negative sign on the land transfer area in the AC group. This finding is similar to that pointed out by Li, Ma et al. (2020) and Xu, Deng et al. (2019) who believe that off-farm workers result in less agricultural labor and promote land abandonment. Moreover, family size has a significant positive sign in stages 2 and 3 of the AC group, indicating that more family members increase farmers' possibilities to transfer more land. This finding is in line with the results reported by Li, Ma et al. (2020) who argue that large farm household size provided more labor endowment resources. Farm experience has a significant negative sign in stage 3 of the AC group, indicating that the longer a farmer has been in agriculture, the lower the willingness to transfer land. The possible reason for this is that the longer the years of farming make farmers more strongly influenced by the traditional smallholder farming ideology and less willing to expand the scale of land management. It appears that hilly and mountainous areas have a significantly negative sign in the

NAC group for the three land transfer stages, indicating that farmer households located in hilly or mountainous areas are less likely to participate in land transfer. This result may be attributed to the fact that the natural environment in these areas is usually poor and not conducive to agricultural production, and this finding is in line with Li, Li et al. (2018 and Deng, Xu et al. (2019). The vehicle variable has a significant and positive sign in the NAC group for the three land transfer-in stages, suggesting that the ownership of vehicles facilitates the act of land transfer. A possible reason here is that vehicles make transportation more convenient, thus benefiting farmers' access to information on land transfers. Furthermore, the distance to the nearest market has a significant negative sign on land transfer-in participation and scale in the AC group (stages 1 and 2), revealing that the farther the farmer is from the marketplace, the less favorable the land transfer-in. One possible explanation is that settling far away from the marketplace makes it difficult for farmers to get land transfer information and agricultural input materials.

5.3 Treatment effects of credit access on land transfer decision behaviors

Supplementary Appendix Tables S3, S4, and S5 do not report the specific impact of credit access on land transfer-in decisions. Thus, ATT estimates, representing the quantitative impact of access to credit on land transfer-in decisions, were calculated. The estimates for the impact of access to credit on the expected probability of land transfer-in participation, area, and futural willingness are displayed in Supplementary Appendix Table S6. Overall, from the fourth column of Supplementary Appendix Table S6, the average treatment effect of credit access on all the three stages of land transfer decisions is statistically significant and positive. This finding shows that regardless of the current transfer choice (participation and scale) or the future transfer willingness (intention), the impact of credit access can help simulate farmers' land transfer decisions.

More specifically, access to credit can increase the expected probability of land transfer participation by 62.6% and increase the expected probability of futural land transfer willingness by 74.9%. For the farmers' land transfer-in area, the ATT result from the third line of Supplementary Appendix Table S6 shows that access to credit significantly increases the land transfer areas by approximately 126.7%. As mentioned previously, financial constraints limit the development of agricultural production by farmers. Thus, access to credit can ease the financial constraints of farmers and allows them to utilize yield-enhancing production inputs (e.g., improved seeds and chemical fertilizers). Garcias and Kassouf (2016) argued that access to rural credit motivates farmers to use advanced agricultural technologies (e.g., agricultural machinery), thereby increasing land productivity. Additionally, access to credit provides farmers with the opportunity to extend their agricultural chain, thus increasing farm income. Li, Ma et al. (2020) conducted a study on China and argued that access to credit enables rural farmers to invest in farm businesses, which increases their demand for farmland. The evidence presented here supports the three research hypotheses presented in Section 2, which confirms the positive role of access to credit in simulating farmers' decisions to transfer-in farmland.

5.4 Robust test

To verify the robustness of the impact of credit access on land transfer decisions, this study used the PSM approach to estimate the average treatment effects of access to credit on land transfer-in decisions. Supplementary Appendix Table S7 displays the estimated results of the PSM approach based on two different matching methods: nearest neighbor matching (NNM) and kernel-based matching (KBM). As shown in Supplementary Appendix Table S7, regardless of which matching method was used, the estimation results of the PSM approach obtained consistent results with the ESR model. This finding from the PSM approach further confirms a positive relationship between access to credit and land transfer-in decisions.

6 Conclusion and policy implications

This article examined the impact of access to credit on farmers' decisions on land transfer-in in rural China by building a three-stage analysis framework for land transfer-in decisions. To address the potential selectivity bias from both observed and unobserved issues, we used the ESR and ESP models to analyze the decisions of farmers to access credit and transfer-in land using the survey data from rural households in Sichuan Province, China. The empirical results revealed that access to credit has a statistically significant positive effect on land transfer decisions at all three stages. More specifically, the ATT estimates showed that access to credit could help increase the likelihood of land transfer-in participation and futural willingness by 62.6% and 74.9%, respectively. Also, it can increase the land transfer-in area by approximately 126%.

Additionally, the estimated results indicated that farmers' decisions in the first stage (land transfer-in participation) are influenced by the household head's education, car ownership, the distance to the central market, and mountain area. Their decision for the second stage (land transfer-in area) is affected by family size, off-farm work, car ownership, and hill/mountain area. The decision for the third stage (land transfer-in futural willingness) is impacted by the household head's age, farm experience, family size, car ownership, and hill/mountain area. For the influence factors of access to credit, the results revealed that household head's age, education, farm experience, and off-farm work are the main factors that significantly affect farmers' decisions to obtain credit.

The findings from this study raise several policy implications. Capital resource is one of the key factors for land transfer-in and agricultural development. Government departments should improve agricultural credit support services, expand agricultural financial credit access channels, and increase financial support for agricultural production and operation. First, the government can advocate the implementation of agricultural micro-credit policies to alleviate the financial constraints of farmers and improve their production and operation difficulties. It should be pointed out that even though this study is based on China, the findings of this study also have implications for other Asian countries, especially those where agricultural production plays

an important role. Second, the government should improve the agricultural rural financial market, strengthen financial support for farmers, and improve the availability of agricultural credit for farmers. For example, institutional organizations, such as rural credit cooperatives, can enhance the accessibility of financial credit services for farmers by creating multi-channel and diversified agricultural credit products. Thus, it can effectively improve the risk resistance of farmers to the financial constraints they face in agricultural production and operation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Conceptualization, XY and JL; data curation, XY, and QS; formal analysis, XY and JL; funding acquisition, JL; investigation XY, and QS; methodology, XY; project administration, JL; resources, XY and JL; software, XY and JL; supervision, XY and JL; validation, XY and JL; visualization, XY; writing—original draft, XY and QS; writing—review and editing, XY and JL. All authors have read and agreed to the published version of the manuscript.

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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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2023.1111089/full#supplementary-material

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