Policy debates and controversies

# Does forestland possession enhance households' access to credit?—Examining China's forestland mortgage policy ☆

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## ARTICLE INFO

## ABSTRACT

Many countries have seen a rising demand for forest policy reform. This paper explores the effects of China's forestland mortgage policy, a supporting measure for collective forest tenure reform, on household credit access. In theory, the forestland mortgage policy could have three impacts on households: (1) forestland possession could change households' willingness to access credit (2) forestland possession could enhance household access to credit, and (3) the contract structure follows the theoretical predictions of the credit contract design mechanism. Our results show that households' willingness to enroll in the mortgage policy as well as their potential to obtain credit increased when households possessed larger areas of forestland. However, the proportion of households that successfully obtained credit were fairly modest. Meanwhile, we found a positive relationship between collateralized forestland and the amount of the forestland mortgage loan, and a negative relationship between collateralized forestland and the interest rate. These findings are consistent with the theoretical predictions of the contract mechanism design. The existing forestland mortgage policy has increased households' credit access to some extent; however, there is much room for improvement from a policy perspective. This requires divising policy arrangements that would facilitate a fully developed credit market available to households. Forest tenure mortgage loans alone may not be able to fully meet households' financial needs.

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## 1. Introduction

China's Collective Forest Tenure Reform (CFTR) has redefined the forestry sector by clearly defining property rights and allocating forestland to rural households (Managi et al., 2019). By implementing the CFTR, the government expected to stimulate rural households' forest production. However, many rural households lack access to formal credit needed to

improve forestry production. To tackle with the problem, central government has issued the Forestland Mortgage Policy (FMP) as a supporting policy of CFTR.

The emergence of FMP is critical to rural households in managing collectively-owned forests after the adoptin of CFTR. The forest tenure arrangement in China, particularly in southern provinces has been dominantly collectively-owned since the 1960s (Liu et al., 2018). Collectively-owned forest tenure means that community members belonging to the same rural community jointly own all of the community's forestland (Zhang et al., 2020). However, households' rights regarding forest use has changed over time. Additionally, while forest resources are abundant particularly in the southern provinces of China, population density is extremely high. The population of these provinces is 678 million people, accounting for 49.85% of total population in China, while the area in these provinces amounts to 1,153,498 km$^2$, accounting for 55.54% of total forested area in China. At the same time, the area forested of these provinces amounts to 2,560,000 km$^2$, accounting for only 26.67% of China's land (China's Forest Resources Inventory in 2013, 2013; State Statistical Bureau, 2013). Considering that collective forest management has low production efficiency and makes low contribution to household income, in 2008, the central government implemented CFTR nationwide. This policy grants long-term property rights over collectively-owned forests to rural households (Yin et al., 2013). In doing so, the government aims to improve forestry production and to increase household income.

As a supporting policy of CFTR, FMP has been implemented since 2008, with clear policy objectives. First, FMP aims to increase forest production yields and incomes for rural households (Central Committee of the Communist Party of China, State Council, 2008). The FMP enables rural households to use their forestland as collateral to apply for credit from formal financial institutions. Such economic value comes from household property rights over forest resources associated with forestland (China Banking Regulatory Commission, State Forestry Administration, 2013). Second, through the implementation of FMP, the central government mandates that formal financial institutions issue mortgage loans, particularly the qualified rural credit cooperatives. Meanwhile, the central government encourages leading financial institutions to involve in FMP, including the Agricultural Bank of China, the Postal Savings Bank of China and other state-owned banks (The People'S Bank of China, 2009).

In this study, we analyze the impact of FMP on rural household's access to credit. From a theoretical perspective, we further explore the development of rural financial market and the various factors affecting its development. Politically, our study provides insights regarding the achievements of China's collective forest tenure reform and presents implications for future policies for forestry financing. The rest of this paper is arranged as follows. The second section explains our analytical framework. The third section presents the methods. The fourth section describes the data. The fifth section presents the results. The final section discusses the main results of this paper and provides a conclusion.

## 2. Analytical framework

Our analytical framework is based on the literature related to the impact of land reform on household's formal credit access. We begin by explaining the impact of household forestland on formal credit access. Next, we introduce some variables of household characteristics. The analytical framework is summarized in Fig. 1.

### 2.1. The impact of household forestland on credit access

In the rural credit market of developing countries, rural households often experience difficulties in credit access. As such, rural households cannot obtain loans at a reasonable interest rate. Formal financial institutions generally require a certain amount of collateral when providing loans for rural households because of information asymmetry. Compared to formal financial institutions, rural households are much more aware of the risk of their production activities in rural areas. In addition, financial institutions do not have effective ways to enforce contracts. They cannot easily apply penalties in instances where rural households borrow loans and then break loan contract (Banerjee et al., 1994; Steijvers and Voordeckers, 2009).

The possession of land can increase the loan amounts granted to households. Previous studies in developing countries showed that the amount of land owned by households significantly improved their access to credit (Besley et al., 2012; Kemper et al., 2015). In theory, there are two ways through which the possession of land can affect access. First, the possession of land can stimulate household's willingness to formal credit access because a larger amount of land demands more investment to improve production (Barslund and Tarp, 2008). Second, land owned by households serves as qualified collateral (Jia et al., 2010; Swain, 2007). Given that formal credit access goes beyond the bilateral activity of the household, household with more land can access formal credit more easily because they have more land as collateral to meet the credit requirements of financial institutions (Bardhan and Rudra, 1978; Hussain and Thapa, 2012; Menkhoff et al., 2012; Stiglitz, 2016). As such, formal financial institutions tend to design credit contracts where a greater amount of land as collateral leads to a higher loan amount granted at a lower interest rate.

In theory, the use of land as collateral helps financial institutions design mechanisms for distinguishing high-risk and low-risk borrowers. Financial institutions can design two types of credit contracts. One type of contract would offer a low interest rate and a high loan amount but requires a high amount of collateral. The other type would require a high interest rate and low loan amount, but a low amount of collateral. Under the precondition of sufficient collateral, the low-risk borrowers would choose the former while the high-risk borrowers would choose the latter, resulting in the

separating equilibrium (Besanko and Thakor, 1987; Bester, 1985; Coco, 2000). In addition, research on the moral hazard phenomenon shows that, if borrowers break the contract, the collateral can offset the lenders' loss. If borrowers need more loans, they will need to provide more collateral. Therefore, the provision of more land as collateral can increase the amount of loan obtained and reduce the interest rate in a credit contract.

Although current studies have not analyzed the impact of household forestland on credit access, the insights above help to understand how forestland can impact households' credit access in the context of FMP. First, forestland owned by households can stimulate households' willingness to access credit. Second, with more forestland, can access credit more easily because they would be eligible for a higher loan amount at a lower interest rate in a credit contract. This analysis is summarized in Fig. 1.

### 2.2. The impact of other household characteristics on credit access

Apart from household forestland, other household characteristics could also have a impact on households' credit access. The first variable is household cropland. In the Chinese context, cropland is legitimately different from forestland. Cropland is used for agricultural production while forestland is used for forestry production. The theory in Section 2.1 still fits into the impact of household cropland on credit access. The possession of cropland can stimulate households' willingness to apply for formal credit.

The second variable is the education of the household head. Household heads with higher education levels can have a better understanding of finance, which can increase their willingness to apply for formal credit access. Moreover, a household head with more education is more likely to repay the loan (Barslund and Tarp, 2008; Goetz and Gupta, 1996; Mpuga, 2010; Okten and Osili, 2004).

The third variable is the age of the household head. The age of the household head is expected to be negatively associated with willingness to apply for formal credit because household head tends to become risk averse with age (Mpuga, 2010; Okten and Osili, 2004).

The fourth variable is the gender of the household head. The impact of gender on formal credit access has been a controversial debate in literature. With regard to willingness to apply for formal credit, the role of the household head's gender seems to be contingent on cultural cultivation (Radhakrishnan, 2015). Some studies argues that women may experience discrimination in credit market. However, several empirical analyses rejected the existence of such discrimination (Goetz and Gupta, 1996; Muravyev et al., 2009; Radhakrishnan, 2015).

The fifth variable is household size. It may be easier for larger households to locate credit information, and thus have more access credit (Okten and Osili, 2004). On the other hand, a larger household size may reduce household resources, making each household member less qualified for credit application (Mpuga, 2010). Therefore, the overall impact of household size on formal credit access is uncertain.

The sixth variable is the household head's official status, as a current or former officer. In the Chinese context, official status is a critical source of social capital, which can potentially affect the households' acess to credit access.

Finally, the household's financial situation can potentially have an impact on access to credit. Critical households' financial features include household income, household savings and household loans. These variables potentially have impact on households' willingness to apply for credit as well as financial institutions' decisions to grant loans (Barslund and Tarp, 2008; Swain, 2007).

## 3. Methods

Based on the analytical framework, two approaches were used in this paper. The first approach was the double-hurdle estimation strategy to examine the impact of forestland owned by household on their willingness to participate in the forestland mortgage market. The second approach was to study the relationship between crucial variables in the existing credit contracts, namely the relationship between the amount of collateralized forestland, the loan amount and the interest rate.

### 3.1. Method analyzing the impact of household forestland on households' willingness to participate in the forestland mortgage market

A bias error could occur in the sample selection, as a large number of rural households had not previously participated in the credit market. This is not because they are unwilling to apply for the secured loans, but because they are excluded from the market. It is possible that the households who applied for a secured loan were rejected by the bank. Another plausible scenario is that households know about the difficulty in accessing secured loans and thus willingly decide to not apply for one. Therefore, this study used the double-hurdle model. The double-hurdle model combines the discrete choice model and the truncated model (Engel and Moffat, 2014; Garcia, 2013). By using this method, the double-hurdle estimation, households' participation in the credit market can be divided into two stages. In the first stage, households decide whether they want to participate in the market or not based on their own circumstances, and a part of them can remain in the market after being screened by financial institutions. In the second stage, the financial institutions discuss with rural households and define the loan amount. These two stages are in line with the analytical framework
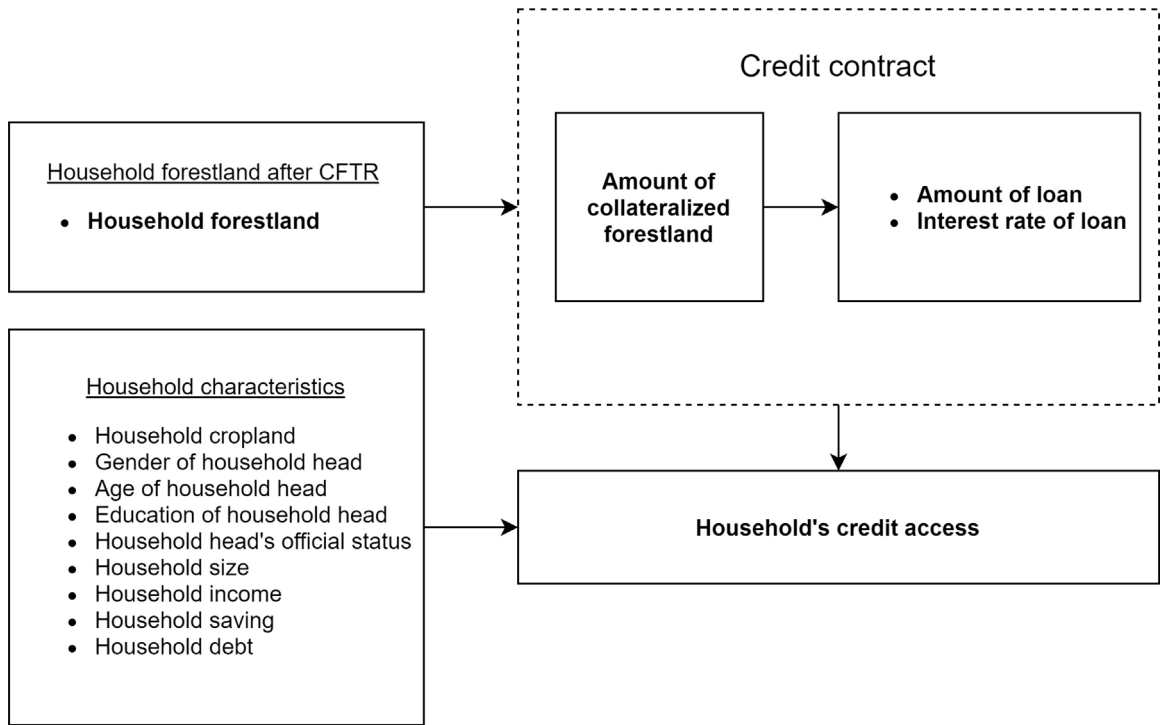
**Fig. 1.** Analytical framework.

outlined above describing household involvement in the forest tenure mortgage market. When analyzing the data, the double-hurdle model contains two estimation equations. One is the participation equation, which identifies households' willingness to involve in the mortgage market. The other is the quantity equation, which defines the loan amount that households can obtain after they enter the market.

$$d_i^* = z_i'\alpha + \varepsilon_{1,i}$$
$$y_i^{**} = x_i'\beta + \varepsilon_{2,i}$$
$$\begin{pmatrix} \varepsilon_{1,i} \\ \varepsilon_{2,i} \end{pmatrix} \sim N \left[ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & \sigma^2 \end{pmatrix} \right]$$

In the equations outlined above, $d_i^*$ is the willingness of a household to be involved in the forest tenure mortgage market and $Z_i$ shows the features affecting the willingness of households. $y_i^{**}$ shows the result of the household's credit access, namely the loan amount. $x_i$ reflects the household features affecting their credit access. In addition, it is assumed that the disturbance terms in the two equations above follow a joint normal distribution and that they are uncorrelated. Furthermore, hurdle 1 can be presented as:

$$d_i = 1 \ if \ d^* > 0$$
$$d_i = 0 \ if \ d^* \le 0$$

Moreover, hurdle 2 can be presented as:

$$y_i^* = \max\left(y_i^{**}, 0\right)$$

Therefore, the observed result of accessible loans secured by forest tenure is as follows:

$$y_i = d_i y_i^*$$

Subsequently, the maximum likelihood method is adopted to obtain the estimated coefficient:

$$\{\hat{\alpha}, \hat{\beta}, \hat{\sigma}\} = \arg\max \left\{ \Sigma \ln\left(1 - \Phi(z_i'\alpha)\Phi(\frac{x_i'\beta}{\sigma})\right) + \Sigma \ln\left(\Phi(z_i'\alpha)\frac{1}{\sigma}\Phi(\frac{y_i - x_i'\beta}{\sigma})\right) \right\}$$

In the above equation, $\Phi(\bullet)$ means the cumulative distribution function (CDF) of the standard normal distribution.

The double-hurdle method can be used to estimate a household's willingness to be involved in the forestland mortgage market as well as their credit access and influence factors.

**Table 1**

Definition of variables.

| Variable | Variable explanation | Unit of variable |
|---|---|---|
| *Household's access to credit under FMP* | | |
| Amount of forestland mortgage loan | Amount of household's formal credit by collateralizing forestland under FMP | Yuan |
| Annual interest rate | Annual interest rate by collateralizing forestland under FMP | Percentage |
| Area of collateralized forestland | collateralized forestland under FMP | Mu |
| *Household willingness to access credit under FMP* | | |
| Household willingness to access forestland mortgage loan | Household's willingness to formal credit access: no willingness=0; certain willingness=1 | 0–1 decimal |
| *Household forestland after CFTR* | | |
| Household forestland | Total area of household forestland | Mu |
| *Other household characteristics* | | |
| Household cropland | Total area of household cropland | Mu |
| Gender of household head | Gender of household head: male=1; female=0 | 0–1 decimal |
| Age of household head | Age of household head | Years |
| Education of household head | Education of household head: primary school and below=0; middle school=1; high school=2; college and above=3 | Multinomial |
| Household head's official status | Official status of household head: government officer=1; otherwise=0 | 0–1 decimal |
| Household size | The number of household member | Persons |
| Household income | Total amount of household income | Yuan |
| Household saving | Total amount of household saving | Yuan |
| Household debt | Total amount of household debt | Yuan |

Note: 1. The exchange rate of RMB Yuan to US Dollar was averagely 6.2284 in 2015; 2. 1 Mu = 0.067 hectares.

### 3.2. Analysis of contract design

We conducted an OLS regression to explore the basic structure of forestland mortgage contracts. Based on the study on credit mechanism design, we analyzed the relationship between mortgaged forestland area, interest rate, and loan amount. This relationship is as follows:

$$r_i = L'_i\gamma + z_i\Gamma + \varepsilon_{3,i}$$
$$y_i = L'_i\delta + z_i\Gamma + \varepsilon_{4,i}$$

In the two equations above, $r_i$ refers to the interest rate stated in the signed contract, $y_i$ refers to the loan amount, $L_i$ refers to the mortgaged forestland area, and $Z_i$ refers to a group of control variables. $\varepsilon_{3,i}$ and $\varepsilon_{4,i}$ refer to the independent and the distributed disturbance terms, respectively.

This portion of the analysis aims to obtain the estimation results of $\gamma$ and $\delta$. It is estimated that $\gamma$ would take on a negative value and $\delta$ a positive value, according to the adverse selection mechanism.

## 4. Data description

### 4.1. Data sources

The data was collected by China's seven local universities, including Fujian agriculture and Forestry, under the unified organization of Economic Development Research Center of State Forestry and Grassland Administration in 2015. Our selected samples covered seven provinces, including Fujian, Shanxi, Yunnan, Hunan, Jiangxi, Gansu, and Liaoning. The stratified random sampling method was adopted for the sample selection. First, China's collectively owned forest areas were delineated into five regions, namely the east, the west, the central, the northeast, and the northwest regions. The seven provinces mentioned above were selected from the five regions, and ten counties were then selected from each province. In each county, five villages were randomly selected, and then ten households were randomly selected from each village. Our final sample included seven provinces, 70 counties, 350 villages, and 3500 households. The data was covered in a total of 70 counties, 350 villages, and 3500 rural households.

### 4.2. Variable description

The variables were measure in accordance with the analytical framework. Detailed definitions of the variables are listed in Table 1. First, to measure households' access to credit under FMP, three variables were selected: amount of forestland

**Table 2**
Descriptive statistics of variables.

| Variable | Mean | Standard deviation |
|---|---|---|
| *household's access to credit under FMP* | | |
| Amount of forestland mortgage loan | 282,359.90 | 1,031,266 |
| Annual interest rate | 5.06 | 4.69 |
| Area of collateralized forestland | 121.10 | 230.35 |
| *Household willingness to access credit under FMP* | | |
| Household willingness to access forestland mortgage loan | 0.22 | 0.42 |
| *Household forestland after CFTR* | | |
| Household forestland | 83.42 | 196.35 |
| *Other household characteristics* | | |
| Household cropland | 7.35 | 11.67 |
| Gender of household head | 0.99 | 0.11 |
| Age of household head | 53.44 | 11.08 |
| Education of household head | 0.79 | 0.77 |
| Household head's official status | 0.25 | 0.43 |
| Household size | 4.71 | 1.90 |
| Household income | 70,612.21 | 159,061.40 |
| Household saving | 34,146.90 | 208,362.60 |
| Household debt | 8,133.18 | 34,859.92 |

Note: 1. The exchange rate of RMB Yuan to US Dollar was averagely 6.2284 in 2015; 2. 1 Mu = 0.067 hectare; 3. The figure is accurate to two decimal places.

**Table 3**
Households having willingness to access forestland mortgage loan and having successful access to forestland mortgage loan in Seven Provinces.

| Provinces | Fujian | Gansu | Hunan | Jiangxi | Liaoning | Shaanxi | Yunnan | Total |
|---|---|---|---|---|---|---|---|---|
| Percentage of household having willingness to access forestland mortgage loan (%) | 25.00 | 37.00 | 16.40 | 18.40 | 11.00 | 17.40 | 30.80 | 22.29 |
| Percentage of household having successful access to forestland mortgage loan (%) | 22.40 | 3.24 | 0 | 16.30 | 14.55 | 3.45 | 3.25 | 8.33 |

Note: The figure is accurate to two decimal places

mortgage loan, annual interest rate and area of collateralized forestland. Second, to measure household willingness to participate in the credit market under the FMP, households' willingness to access forestland mortgage loan was selected. To measure other household characteristics, the following variables were to selected: household cropland, gender of the household head, age of the household head, educational of the household head, official status of the household head, household size, household income, household savings and household debt.

Table 2 lists the statistical description of the variables in our sample. Regarding household's access to credit under FMP, the mean of the amount of forestland mortgage loan was 282,359.9 *Yuan*. Annual interest rate and area of collateralized forestland also had a low number of observations. Additionally, the mean of households' willingness to apply for a mortgage loan was 0.22. After the CFTR, the meaning and standard deviation of household forestland was 83.42 mu and 196.35. Finally, Table 2 reports descriptive statistics of other household characteristics. The mean of household cropland was 7.35 mu. The mean for gender of the household head was 0.99, meaning that most of household heads were male. The mean of the age of the household head was 53.44. The mean for the education of the household head was 0.79, meaning that most of household heads did not finish primary education. The mean for official status of the household head was 0.25, meaning that a quarter of household heads had been government officers. The mean of household size was 4.71 members. The mean of household income was 70612.21 *Yuan*. The mean for household savings was 34146.9 *Yuan*. The mean for household debt was 8133.18 *Yuan*.

Table 3 reports households having willingness to access forestland mortgage loan and having successful access to forestland mortgage loan in Seven Provinces. Among the 3500 households in the seven provinces, 780 households had applied for forestland mortgage loan, accounting for 22.29%. Gansu had the largest number of households having willingness to access forestland mortgage loan, and Yunnan and Fujian came in second and third place, respectively. Only 8.33% of the households who are willing to apply for forestland mortgage loan obtain loans successfully, nearly half of which are from Fujian.

**Table 4**
Results of household's willingness to participate in the forestland mortgage loan and their credit access.

| VARIABLES | Estimation result 1 | | Estimation result 2 | |
|---|---|---|---|---|
| | Quantity equation | Participation equation | Quantity equation | Participation equation |
| Household forestland area | 0.0020*** | 0.0006*** | 0.0020*** | 0.0008*** |
| | (0.0003) | (0.0001) | (0.0003) | (0.0002) |
| Household cropland area | 0.0041 | −0.0075** | 0.0022 | −0.0050 |
| | (0.0411) | (0.0038) | (0.0339) | (0.0037) |
| Gender of household head | −1.4050** | 0.4620 | −0.9800 | 0.4680 |
| | (0.6430) | (0.3570) | (0.8950) | (0.3710) |
| Age of household head | −0.0226 | −0.0122** | −0.0137 | −0.0118** |
| | (0.0156) | (0.0056) | (0.0143) | (0.0057) |
| Educational of household head | 0.0781 | 0.0009 | 0.0126 | −0.0245 |
| | (0.2410) | (0.0785) | (0.2450) | (0.0812) |
| Household size | 0.0714 | −0.0805** | −0.0474 | −0.0906*** |
| | (0.1050) | (0.0331) | (0.1070) | (0.0337) |
| Household head's official status | 0.1840 | 0.1460 | 0.3300 | 0.0844 |
| | (0.4960) | (0.1280) | (0.5730) | (0.1360) |
| Household income | 0.1310 | 0.1980*** | 0.2240 | 0.1320** |
| | (0.2300) | (0.0621) | (0.2820) | (0.0588) |
| Household saving | −0.0253 | −0.0147 | −0.0568 | −0.0321** |
| | (0.0485) | (0.0116) | (0.0567) | (0.0138) |
| Household debt | 0.0134 | 0.00187 | 0.0382 | −0.00499 |
| | (0.0371) | (0.0151) | (0.0497) | (0.0160) |
| Gansu | | | 0.02480 | 0.7950* |
| | | | (0.9270) | (0.3950) |
| Fujian | | | −0.6890 | 0.929** |
| | | | (0.4840) | (0.3620) |
| Jiangxi | | | −1.7920** | 0.8290** |
| | | | (0.7960) | (0.3730) |
| Liaoning | | | −1.5590*** | 0.4830 |
| | | | (0.5820) | (0.3610) |
| Shaanxi | | | −0.8710 | −0.2570 |
| | | | (1.630) | (0.4360) |
| Yunnan | | | −0.9240 | 0.1800 |
| | | | (0.6110) | (0.3770) |
| Constant | 11.1800*** | −3.6620*** | 10.7000*** | −3.3930*** |
| | (2.9190) | (0.8450) | (3.9420) | (0.8640) |
| Observations | 3,038 | 3,038 | 3,038 | 3,038 |

Note: 1. Standard errors in parentheses. 2. The figure is accurate to four decimal places.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

## 5. Results

Based on the analysis above, the results are reported in Tables 4 and 5. This section further explains the results.

Table 4 shows the estimation results generated from the double-hurdle model based on the sampled households from the seven provinces. In comparison with Estimation Result 1, Estimation Result 2 adds dummy variables for provinces to capture the variation in the operation of credit markets due to geographical differences. The two estimations show consistent results. Looking at the participation equation, which reflects households' willingness to participate in the credit market, we can find that the area of forestland owned by households has a significantly positive impact on their willingness to apply for a loan. The impact of household cropland varies in the two estimation results. That is, household cropland shows a significant negative effect before adding the dummy variables for provinces, but has a insignificant negative impact after adding the dummy variables.

Household income has a significant positive impact on households' willingness to apply for forestland mortgage loans. This suggests that households with more income have a greater intention to invest. Age shows a significant negative impact, implying that households' willingness to take on risk declines as the age of the household head increases. The estimation coefficient for the number of family members has a significant negative effect on a household's willingness to apply for a loan. This suggests that the number of family members can affect decisions regarding inputs of production factors when the labor market and credit market are imperfect. The level of equation reflects the result of credit access. As we can see, only the estimation coefficient of family-owned forestland area is significantly positive. This suggests that an increase in forestland resources owned by households increase the propensity of a household to apply for forestland mortgage loans. The gender of the household head was significant in Estimation Result 1, but was insignificant after

**Table 5**
Results of the impact of collateralized forestland on interest rate and amount of forestland mortgage loan.

| Variable | Interest rate (1) | Amount of forestland mortgage loan (2) | Interest rate (3) | Amount of forestland mortgage loan (4) |
|---|---|---|---|---|
| Collateralized forestland | −0.0036* | 30,970** | −0.0039* | −0.0039* |
| | (0.0019) | (12,450) | (0.0019) | (0.0019) |
| Dummy Variable 2008 | −4.9140*** | 219,690 | −4.9480*** | −4.9480*** |
| | (0.3840) | (1,890,780) | (0.3890) | (0.3890) |
| Dummy Variable 2009 | −1.4140 | −1,677,320 | −2.1850 | −2.1850 |
| | (1.6850) | (2,676,360) | (1.4690) | (1.4690) |
| Dummy Variable 2011 | 2.3760 | −720,140 | 2.3510 | 2.3510 |
| | (1.5800) | (2,082,350) | (1.6200) | (1.6200) |
| Dummy Variable 2012 | −2.1030 | −3,009,550 | −1.7830 | −1.7830 |
| | (1.5460) | (3,714,040) | (1.7300) | (1.7300) |
| Dummy Variable 2013 | −0.2770 | 168,820 | −0.3780 | −0.3780 |
| | (2.2020) | (1,592,770) | (2.2390) | (2.2390) |
| Dummy Variable 2014 | 2.8380** | 401,290 | 2.7910** | 2.7910** |
| | (1.1250) | (1,711,130) | (1.1110) | (1.1110) |
| Dummy Variable 2015 | −2.0860 | −57,320 | −1.2600 | −1.2600 |
| | (1.9870) | (3,108,920) | (2.222) | (2.2220) |
| Liaoning | −1.2100 | 753,120 | 3.6290 | 3.6290 |
| | (2.6450) | (1,460,270) | (3.2720) | (3.2720) |
| Jiangxi | −1.7040 | −649,980 | −1.5610 | −1.5610 |
| | (1.6350) | (1,729,830) | (1.6720) | (1.6720) |
| Yunnan | 4.118*** | 1,331,000 | 4.176*** | 4.176*** |
| | (1.314) | (1,031,000) | (1.351) | (1.351) |
| Shaanxi | −4.1000 | −997,366 | −3.9710 | −3.9710 |
| | (2.5330) | (7,321,670) | (2.6370) | (2.6370) |
| Gansu | −2.9720* | 2,411,370 | −2.783 | −2.7830 |
| | (1.592) | (209,716) | (1.694) | (1.6940) |
| Constant | 5.6330*** | −1,340,930 | 5.6820*** | 5.6820*** |
| | (0.2824) | (2,087,392) | (0.2913) | (0.2912) |
| Observations | 55 | 61 | 50 | 50 |
| R-squared | 0.345 | 0.616 | 0.450 | 0.450 |

Note: 1. Standard errors in parentheses. 2. The figure is accurate to four decimal places.
***p < 0.01.
**p < 0.05.
*p < 0.1.

the dummy variables for provinces were controlled. Our results accord with previous research findings on households' land credit. As collateral, land can help mitigate the information asymmetry problem between households and lending institutions in the credit market.

Next, the existing contract sample was employed to analyze the contract structure. First, we performed data cleansing to deal with the contract samples. We obtained a sample of 65 valid households whose collateralized forestland was above zero. Among them, there were 13 households whose contracts stated an interest rate of zero. With such a limited sample size, the zero-interest-rate contracts account for 20% of all cases. This suggests that, to a certain extent, the forest tenure mortgage can be attributed to government political support consisting of preferential policies for households. In other words, the credit market in rural areas has not yet become an established business practice.

Table 5 shows the impact of collateralized forestland on the interest rate and the amount of forestland mortgage loan specified in the contract. In the OLS estimation method, relevant control variables were added as independent variables from Estimation Results 1–4. Dummy variables for years and provinces were added. Column (1) shows the estimation results for all households, using the interest rate as the dependent variable. As we can see, the estimation coefficient of collateralized forestland was significant and negative at 10%. Column (2) shows the estimation results applying all households but using the amount of forestland mortgage loan as the dependent variable. The estimation result of the collateralized forestland area was significant and positive at 5%. As the household sample contains some contracts stating a zero interest rate, this likely represents the difference between business loans and preferential loans under policies that benefit households. Columns (3) and (4) show the estimation results after excluding the contracts with a zero interest rate. Their estimation results are the same in columns (1) and (2). These results indicate that the contract mechanism design is supported by the theory, which is illustrated in the actual forestland mortgage practices. Namely, the negative relationship between collateralized forestland and interest rate reflects the financial institutions' contract design to address adverse risks. Likewise, the positive relationship between collateralized forestland and amount of the forestland mortgage loan reflects a contract design aimed at addressing the moral hazard risk. However, we should recognize the existence of zero-interest-rate loan contracts. Therefore, the results suggest that the current forestland mortgages are in line with the theoretical predictions of contract mechanism design, but only to a modest extent.

## 6. Discussion and conclusions

Forestry management plays a key role in China (Managi et al., 2019; Sato et al., 2018). China's collective forest tenure reform brought significant change in the role played by households in managing collectively-owned forestland, where households became management entities. Thus, they require support to meet their financing needs in order to improve both the forest production and households' livelihoods. The FMP provides an opportunity to increase household access to credit. To date, there are few in-depth studies analyzing the impact of household forestland on household credit access in the context of the FMP.

The paper has examined households' ability to credit under China's FMP. We analyzed how households' collateralized forestland impacted their credit access. We also discussed the precautionary design principles of contracts based on the adverse selection and moral hazard theories. We developed a simple analytical framework to study the impact of forestland possession on households' credit access in the context of the FMP. The paper applied three dimensions in discussing access to credit: (1) whether forestland possession changed the household's willingness to apply for credit, (2) whether forestland possession increased their ability to credit, and (3) whether the contract structure followed the theoretical predictions regarding the credit contract design mechanisms.

3500 households were analyzed in seven Chinese provinces. We first applied the double-hurdle model to assess the impact of household forestland on household willingness to apply for forestland mortgage loan, as well as their likelihood to credit. Our results show that households with more forestland had stronger participation. At the same time, households with more forestland had more access to credit in the form of forestland mortgage loan. In addition, we studied the relationship between mortgaged forestland area, interest rate, and loan amount based on the existing contracts of forest tenure mortgage loans. Our results show that, the impact of collateralized forestland on interest rate was negative, which followed the predicted mechanism design in response to adverse selection. The impact of collateralized forestland on the amount of forestland mortgage loan obtained was positive, which followed the predicted mechanism design in addressing moral hazard issues. Nevertheless, it should be noted that only 8.33% of the households who are willing to apply for forestland mortgage loan can obtain loans successfully. Therefore, the empirical analysis in the paper suggests that, under the current forestland mortgage policy, the area of forestland owned by households has a positive effect on households' credit access. However, households still face difficulties in being approved for loans, and they still have limited access to credit. Considering the existence of partial zero-interest-rate contracts in the sample, it can be implied that the forest tenure mortgage, to some extent, results from the government's policy support for rural people.

The main results can be discussed in the context of previous studies on forest tenure reform in China. Previous articles showed that the impact of CFTR on household involvement in forestry was positive (Xie et al., 2013; Yi et al., 2014). Compared to these findings, our main results suggest that the status of households' formal credit access could be affected by collateralizing forestland through the FMP. Thus, CFTR might increase household forestry investment partly by increasing households' ability to apply for and receive formal credits. At the same time, our results show that household forestland only has moderate impact on household's credit access, meaning that forest tenure reform in China should be continued.

Additionally, our results can be discussed in forest tenure reform by enhancing household's property rights over forests. In current literature, devolved forest tenure reform can reduce constraints in forest management (Adam and Eltayeb, 2016; Dang et al., 2018; Xu and Hyde, 2018). Our findings indicate that devolved forest tenure reform has potential to improve forest management in the way of diversifying financial instruments, while this potential has been realized only moderately in China. Since this study only reflected China's case, our reflection may apply more reasonably to devolved forest tenure reform in countries where rights of forest management are transferred from state to households, e.g., Vietnam (Dang et al., 2018).

In conclusion, our analysis has several policy implications. While the current forestland mortgage loan helps increase rural household's access to credit, there is still much room for improvement. Households require policy arrangements that further improve the forest tenure mortgage market and allow its full development in the context of a strong government. Meanwhile, China's new forest management system needs to improve financial services offered to rural households. Currently, the forest tenure mortgage loans do not fully meet household's financing needs. In addition, China's experience may provide an example for other countries, whereas it is important to carefully consider how to address the financing issues for household's investments.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The viewpoint of this article only represents the author's personal understanding, and has nothing to do with any organizations.

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