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Smallholder participation in the land rental market in a mountainous region of Southern China: Impact of population aging, land tenure security and ethnicity

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ABSTRACT

Rural land rental markets in China play an increasingly important role in the transformation of the agricultural sector. This study focuses on the rural land rental market in the Xishuangbanna Dai Autonomous Prefecture in Southern China, a mountainous region, where rapid changes in land use have taken place with the transition from traditional agriculture and a tropical rainforest to rubber monoculture. Notably, we assess the impacts of population aging, land tenure security, and ethnicity on the participation of smallholders in the land rental market. The analysis suggests that a higher proportion of older people in a household increases the likelihood of renting out land and reduces the probability of renting in land, implying that population aging fosters land rental market development by transferring land from older to younger farmers. We also confirm that the availability of a land tenure certificate has a significant and positive impact on the renting out of land. Furthermore, ethnic minority groups are less likely to rent out land, indicating that land rental markets are ethnic sensitive. Additionally, specialization in rubber farming, household wealth and the altitude of household location also influence participation in the land rental market.

1. Introduction

Rural land rental markets in China play an increasingly important role in the transformation of the agricultural sector in the context of urbanization and societal aging. Better off-farm income possibilities in urban areas are strong incentives, especially for the rural youth to take up non-farm employment (Wang et al., 2011a), and hence the rural land rental market is gaining momentum (Huang et al., 2012). Furthermore, population aging in rural China makes it necessary to facilitate land transactions from the households lacking a labor force to those with surplus labor. To facilitate land transactions in rural China, the development of a land rental market is important. The study of Deininger and Jin (2005) conducted in China showed that the rural land rental market has a positive impact on land access by redistributing land to those with higher agricultural potential. Since the promulgation of the legislation known as the "Rural Land Contract Law" in 2002, rural land reallocation in China has become more complicated. Given this context, land rental markets in rural China are now a more important means of land redistribution compared to the administrative reallocation processes (Deininger and Jin, 2005).

Previous studies found that the development of rural land rental markets in China could have positive growth and productivity effects without necessarily jeopardizing equity (Tan et al., 2006; Jin and Deininger, 2009; Feng et al., 2010). As demonstrated by Deininger and Jin (2005), the emergence of the land rental market can be beneficial to poor producers provided they have abundant labor endowments. It can also help to reduce land fragmentation to some extent, one of the major constraints to technological advancement in Chinese agriculture (Tan et al., 2006). By allowing a more efficient use of unused land, the participation of farmers in land rental markets can also increase agricultural output (Jin and Deininger, 2009). Empirical evidence from southeastern China suggests that land rental markets significantly contribute to higher rice production (Feng et al., 2010). Considering the growing food demand and limited land resources in China, a well-functioning rural land rental market is important for enhancing the efficiency of land allocations and thereby, contributing to the growth of agricultural output (Kimura et al., 2011).

The advantages of a well-functioning rural land rental market have also gained recognition at the policy level in China. Recently, the Chinese central government encouraged the establishment of land markets where farmers can "subcontract, lease, exchange, or swap" land-use rights (Wang et al., 2011b). Policy documents also clearly state

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that farmers should strive to rent land to increase farm size and improve efficiency and labor productivity (Huang et al., 2012).

To establish a well-functioning rural land market, an important precondition is to guarantee land tenure security (Deininger and Feder, 2001; Deininger et al., 2003; Lunduka et al., 2009; Holden et al., 2011). In many areas where individual land rights are not yet well specified, the risk of losing the rights of rented-out land can be a major constraint on land rental transactions (Otsuka and Place, 2001). In China, land tenure security improved after the government introduced a long-term certificate for land tenure under the "Rural Land Contract Law" promulgated in 2002. For instance, the Chinese central government established a fixed 30-year certificate for farmland tenure (Wang et al., 2011b). A new round of forest tenure and institutional reforms has also been undertaken in China; the duration of forestland held by individual households can last up to 70 years, and the forestland tenure certificate can be renewed upon maturity (Yin et al., 2013).

However, to date, there is still a lack of quantitative studies in China that could provide empirical evidence of the impact of land tenure security on the development of the rural land rental market, although there are numerous studies that discuss various perspectives of land tenure (Li et al., 1998; Kung, 2000; Liu, 2001; Brandt et al., 2002; Deininger and Jin, 2003; Ma et al., 2013; Qin and Xu, 2013; Robinson et al., 2014), as well as several studies on the development of rural land rental markets (Yao, 2000; Deininger and Jin, 2005; Huang et al., 2012). An exception is the study of Jin and Deininger (2009), which found that the possession of land certificates had no significant impact on participation in land rental markets. Hence, it remains unclear whether improving land tenure security can facilitate farmers' access to the land rental market in rural China.

In this study, we focus on the rural land rental market in the Xishuangbanna Dai Autonomous Prefecture (XSBN) in Southern China. This is an interesting case in several regards. First, XSBN is a mountainous region where rapid changes in land use have taken place with the transition from traditional agriculture and a tropical rainforest to rubber monoculture (Zhang et al., 2015); thus, land tenure questions are more complex than for ordinary farm lands. Second, until recently, extreme poverty was widespread in this region, but significant improvements have been achieved among smallholder farmers following the introduction of rubber (Fu et al., 2010) and therefore, equity issues involved in land use rights have become increasingly important. Third, XSBN is a minority autonomous region with a high degree of cultural diversity including several indigenous ethnic minorities such as Dai, Hani, Bulang, and others. It will be interesting to determine whether there are differences in land rental market participation between ethnic minorities and the Han majority.

In our analysis, we aim to investigate the behavior of smallholder rubber farmers with respect to participation in the local land rental market. In particular, we focus on two factors: (1) the effect of land tenure security on farmers' participation in the local land rental market and (2) the role of population aging, i.e., to what extent a farm household's age structure influences its decision to engage in land rental markets. The data used in this study were obtained from a cross-sectional survey of 612 smallholder rubber farmers in XSBN carried out in 2013. In this comprehensive survey, we collected detailed information, including land use history, natural land conditions, current land tenure status, land productivity, farm and off-farm activities as well as demographic characteristics of the individual member of the households.

To achieve our objectives, we developed two types of econometric models. First, a bivariate probit regression was developed to test the possible correlation between equations pertaining to the renting out and the renting in of the land. Second, an endogenous switching probit (ESP) model was employed to control for the possible endogeneity of the land tenure certificate to explain farmers' participation in the land rental market due to the consideration that land rental behavior without clear land tenure in previous years may cause conflicts and thereby affect the current issuance of land tenure certificates. The ESP model also can test and control for the potential selection bias of land tenure certificates caused by certain unobserved factors during the cross-sectional survey. Based on the estimation results of the ESP model, a counterfactual analysis was further conducted.

The results of our econometric models showed that households with a higher share of older people were more likely to participate in the land rental market, while the availability of a land certificate was a significant factor in facilitating participation in the land market. Hence, population aging and issuing of land tenure certificates can foster a rural land rental market in general. However, this is difficult to establish in an ethnic minority region because minorities tend to rent out less land. Although this study is limited to XSBN, the findings can contribute to a better understanding of land rental market development in rural China.

The rest of this paper is organized as follows. In Section 2, a conceptual framework related to farmers' participation in the land rental market is developed. Section 3 briefly introduces the study area and the data collection procedure. Descriptive statistics are presented in Section 4. Section 5 describes the empirical models developed to assess the likelihood that smallholders will rent out or rent in land. In Section 6, we report and discuss the results of our models. The last section consists of a summary and conclusions.

2. Conceptual framework

Following a household model of agricultural production and land rental market participation (Deininger and Jin, 2005; Jin and Deininger, 2009), we develop a conceptual model here to capture the determinants of a farmer's participation in the land rental market.

Suppose the i^{th} household's decision problem is to choose the land to be farmed (A_i), the amount of labor allocated to farming (l_{ia}) and the allocation of household labor for wage employment (l_{io}). This can be written in the following equation:

$$\begin{aligned}\text{Max}\{&pf(a_i, l_{ia}, A_i) + wl_{io} - I^{in}{}_i[(A_i - \overline{A_i})(r + TC^{in}{}_i)] \\ &+ I^{out}{}_i[(\overline{A_i} - A_i)(r - TC^{out}{}_i)]\}\end{aligned} \tag{2.1}$$

$$\text{s.t. } l_{ia} + l_{io} \le \overline{L_i} \tag{2.2}$$

where $\overline{A_i}$ and $\overline{L_i}$ are the fixed amounts of land and labor endowments, respectively, of the i^{th} household, while a_i is a given agricultural ability assumed to be affected by the endowment of household characteristics; $f(a_i, l_{ia}, A_i)$ is an agricultural production function; p denotes the price of agricultural goods; w is an exogenous wage rate for l_{io}; and r is a competitive rental rate for land. I_i^{in} and I_i^{out} are indicators for the renting in ($I_i^{in} = 1$ for rent in or 0 otherwise) and the renting out ($I_i^{out} = 1$ for rent out or 0 otherwise), respectively, of land. TC_i^{in} and TC_i^{out} are the respective transaction costs for the renting in and the renting out of land and can be assumed to be proportional to the amount of land transacted.

Through solving the above maximization problem, we can derive the two equations for the renting in and the renting out of land as follows:

$$I^{in}{}_i = f(\overline{L_i}, l_{ia}, l_{io}, \overline{A_i}, a_i, TC^{in}{}_i, TC^{out}{}_i, w, r) \tag{2.3}$$

$$I^{out}{}_i = f(\overline{L_i}, l_{ia}, l_{io}, \overline{A_i}, a_i, TC^{in}{}_i, TC^{out}{}_i, w, r) \tag{2.4}$$

Assume w and r are consistent for all local farmers. TC_i^{in} and TC_i^{out} are different because only landlords have to face the risk of land loss; hence TC_i^{in} could be assumed to be consistent for all local farmers, while TC_i^{out} is also associated with land tenure security, which could be represented by the status of the land tenure certificate (C_i). The labor variables ($\overline{L_i}$, l_{ia}, l_{io}) could be represented by the household size (H_i), demographic structure (D_i) and wage employment (W_i). a_i is assumed to be determined by a vector of household characteristics (Z_i). Thus, by incorporating H_i, W_i, *and* $\overline{A_i}$ into the vector of Z_i *and separating ethnicity*

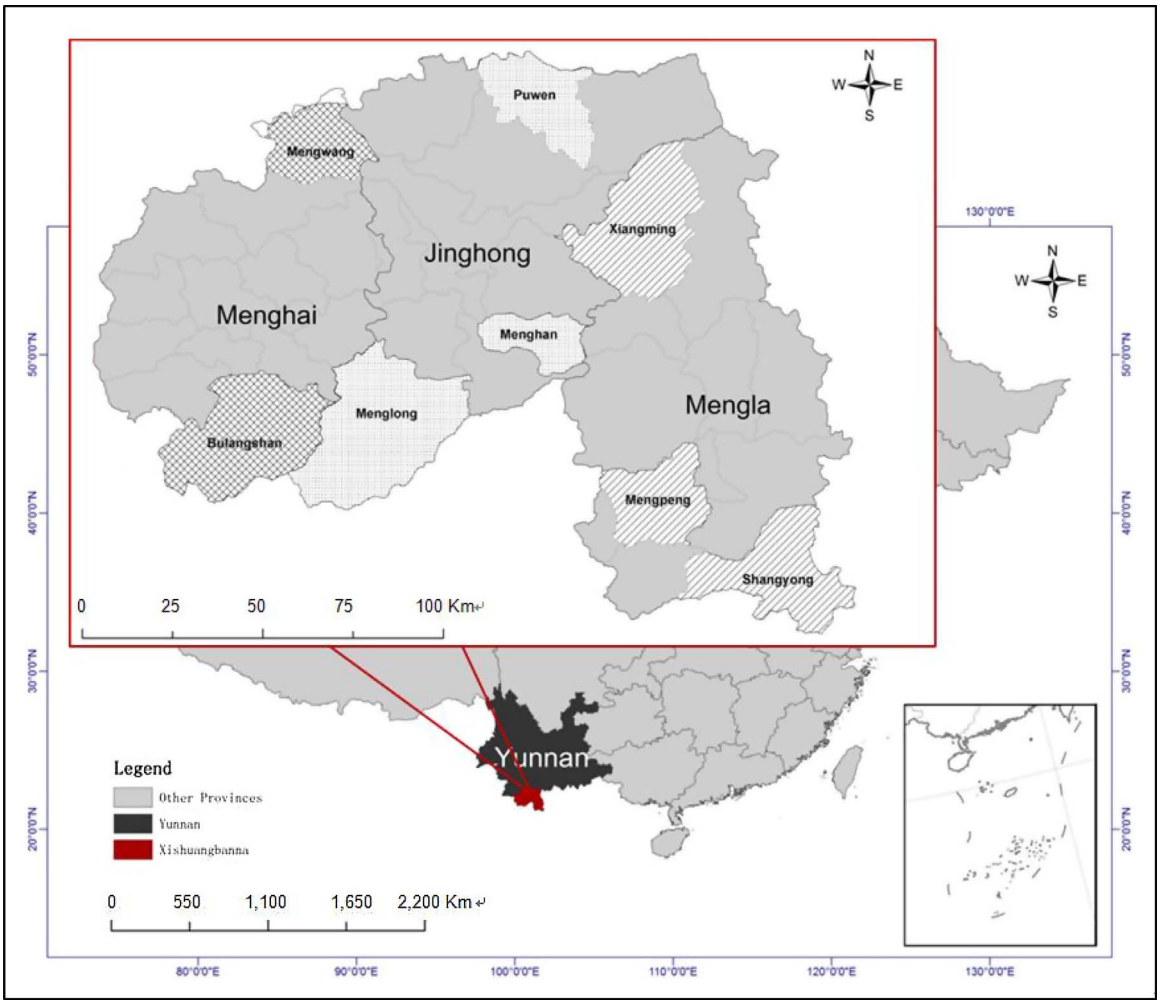

Fig. 1. A map of the study area and sample distribution.
Data sources: Min et al. (2017a); Authors' survey.

(E_i) from Z_i, we can derive the reduced-form functions related to the renting in and renting out of land as:

$$I^{in}{}_i = f(D_i, C_i, E_i, Z_i) \tag{2.5}$$

$$I^{out}{}_i = f(D_i, C_i, E_i, Z_i) \tag{2.6}$$

The specifications in Eqs. (2.5) and (2.6) show that a farmer's decision to rent out or rent in land are expected to be determined by demographic structure, land tenure certification, ethnicity, as well as household and farm characteristics.

3. Data

3.1. Study site

The Xishuangbanna Dai Autonomous Prefecture (XSBN) is located in Southern Yunnan Province, China (Fig. 1), bordering Laos and Myanmar. XSBN covers approximately 19124.5 km^2, 95% of which are mountain regions with an altitude between 475 and 2430 m above sea level (MASL). As the most biodiversity rich region in the tropical zone of Southwestern China, although XSBN covers only approximately 0.2% of the land area of China, it contains approximately 25% of the country's plant species (Xu, 2006). As a minority autonomous region, over 70% of the population in XSBN is comprised of ethnic minorities, including Dai, Hani (called Akha in Thailand), Bulang and other traditional forest dwellers. In summary, XSBN is a typical region that characterizes the tropical area of China in a mountainous environment dominated by ethnic minorities.

Natural rubber planting was introduced to XSBN by the government for strategic purposes in the 1950s. Several state farms were successively established for producing rubber and for meeting the domestic demand from the late 1950s to the early 1980s (Hu et al., 2008). Since China's agricultural reform in the 1980s, an increasing number of rubber trees were planted by smallholder farmers (Xu, 2006). Previously forested lands were mostly cleared and replaced by rubber plantations (Xu et al., 2005); however, the unclear land ownership of these lands has resulted in current potential conflicts. Accordingly, the existence of land-use right conflicts between farmers, village authorities, and local state farms likely slows the progress of issuing land tenure certificates in XSBN.

The expansion of rubber plantations also increases the disparity of household income among smallholders in XSBN. In 2012, the per capita net income of rubber farmers exceeded 16000 Yuan[1] (Waibel et al., 2014), which was almost three times higher than the average household income of rural areas (6174 Yuan/person in 2012) in XSBN (Bureau of Statistics of Xishuangbanna Dai Autonomous Prefecture, 2013). The relatively large income gap between rubber farmers and other farmers deserves more attention. A possible measure to reduce inequality is to develop a rental market for agricultural land in XSBN, which can facilitate the transfer of land from rubber farmers to other farmers.

[1] 1 $ ≈ 6.3 Yuan (in 2012).

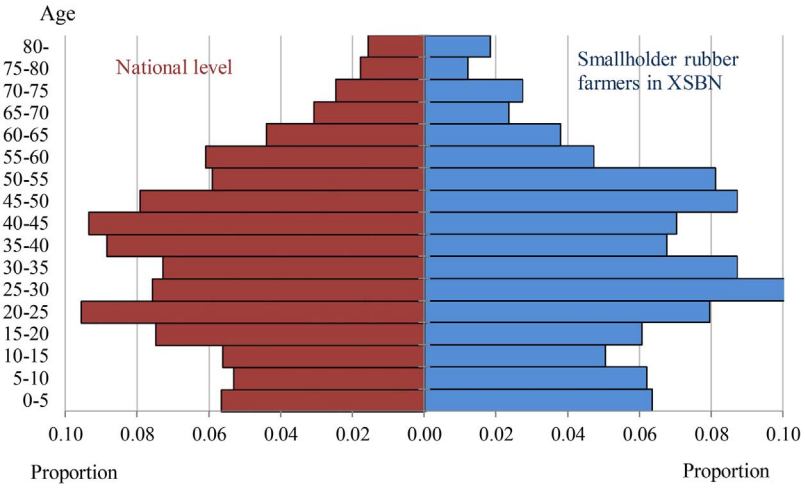

Fig. 2. Demographic structure at the national level and in XSBN. Data sources: National Bureau of Statistics of China (2011); Authors' survey.

3.2. Data collection

The data used in this study were obtained from a socioeconomic survey of smallholder rubber farmers[2] carried out in XSBN in March 2013. The survey included detailed information on the socioeconomic characteristics of household members, land use history, natural land conditions, current land tenure status, land productivity, and farm and off-farm activities (Min et al., 2017a).

To ensure that the sample was as representative as possible for smallholder rubber farmers in XSBN, sample selection was conducted as follows. First, we applied a stratified random sampling strategy. Stratification was performed on the basis of the rubber planting area per capita and township based on 2011 data provided by the XSBN biological industry office. Taking into account the geographical distribution of rubber planting regions, 8 townships were selected from a total of 32 townships belonging to the Menghai and Mengla counties and the city of Jinghong in XSBN. Due to the relatively small intensity of rubber planting in Menghai, only two townships were selected, while three townships were selected from Jinghong and Mengla. The 8 townships and their respective counties included in the survey are shown in Fig. 1.

Second, sample villages, stratified by rubber area per capita, were randomly selected from each sample township. Considering the differences in rubber planting intensity among the three counties, six administrative villages were selected from each sample township in Jinghong and Mengla; while in Menghai, we only selected three administrative villages, from Mengwang and Bulangshan (see Fig. 1). Additionally, given that each administrative village normally includes dozens of sub-villages[3] that are widely distributed in the mountainous regions, we randomly selected one sub-village within each administrative village, thereby resulting in a total of 42 sample villages.

Finally, sample households were selected randomly from the list of rubber farmers in each natural village. During the field survey, one questionnaire took approximately 2–3 h to complete; thus, we planned that each enumerator should interview two households per day. Depending on the specific number of enumerators, the sample size of rubber farmers in one village was expected to be 14–21 households, with extra 3–6 alternative samples. In the case where a sample household refused to be interviewed or was unable to be interviewed, this household was replaced by one random alternative household.

Table A1 in the Appendix A shows the detailed sample pool and our sample sizes at the county, township, and village levels. We interviewed a total of 612 households from 42 villages across 8 townships in one city (Jinghong) and two counties (Menghai, Mengla) in XSBN. Unfortunately, due to the complex geographic situation in the mountainous region of XSBN, to date, there is no clear number of smallholder rubber farmers in XSBN. Nevertheless, from the perspective of the representation of the county, township, and village levels, we believe our samples well represent the smallholder rubber farmers in XSBN.

4. Descriptive statistics

In this section, we describe the population structure, ethnicity status, land tenure status, and farmers' participation in the land rental market as well their correlations.

4.1. Population aging and ethnicity

China is experiencing dramatic changes in its society due to the aging of its population (Min et al., 2015). As shown in Fig. 2, according to China's national population census in 2010, over 13% of the population was at an age of 60 years or older. Additionally, the demographic structure in China is rapidly changing with an increasing proportion of the population being elderly, and this aging trend is expected to continue into the future (Min et al., 2015).

In XSBN, population aging is inevitable. At the household level, over 42% of households have at least one family member who is at least 60 years old. From the perspective of the demographic structure, although only 11% of smallholder rubber farmers in XSBN are aged 60 years or older, the demographic structure is in line with the national level (Fig. 2). Hence, population aging of smallholder rubber farmers in XSBN can be also expected to continue in the future. This change likely has potentially significant implications concerning future land allocation, land operations and agricultural development. Hence, it is essential to account for the effects of population aging on farmers' participation in the land rental market.

According to the report published by the Bureau of Statistics of the Xishuangbanna Dai Autonomous Prefecture (2011), 77.61% of people living in Xishuangbanna belong to ethnic minorities, including Dai, Hani, Bulang and other upland minorities who are traditional forest dwellers (Fu et al., 2009). According to our survey results, 95% of smallholder rubber farmers are minorities, and only 5% belong to the Han majority. Various ethnicity smallholders have distinct histories, cultures, and knowledge; consequently, their agricultural practices also differ (Pierce et al., 1989; Brush and Perales, 2007). Thus, the ethnic minorities and the Han majority may behave differently with regards to participation in the land rental market. Understanding these differences will be important to design policy measures that can stimulate land market participation.

[2] Smallholder rubber farmers are defined here as farmers that plant rubber trees, for distinction from and comparison with state rubber farms.

[3] A sub-village, which is a cohort of households that form a historically grown village, is different from an administrative village, which is a collection of sub-villages determined by governmental regulation.

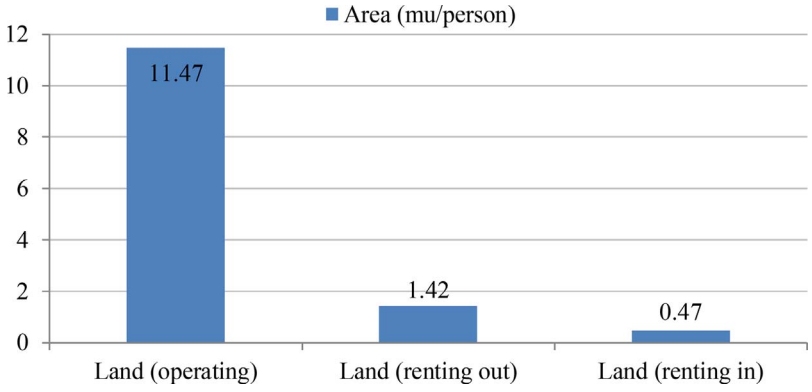

Fig. 3. Per capita land area of smallholder rubber farmers in XSBN. Data sources: Authors' survey.

4.2. Land tenure certification

Since the "Rural Land Contract Law" was promulgated in China in 2002, a long-term certificate for land tenure has been gradually issued to farmers by the local government. In the past, rural land reallocation was administratively implemented almost every year by the village committees (the local government at the village level). However, the "Rural Land Contract Law" requires that land reallocation is only to be permitted when the village collectives receive approval from two-thirds of the members of the villagers' conference or two-thirds of the villagers' representatives, as well as the approval of the local governments (Wang et al., 2011b). Hence, the possession of a land tenure certificate helps to improve land tenure security to some extent. While policy documents explicitly proposed that over 90% of households in rural China should be issued land tenure certificates by the end of 2007, this goal has not been reached (Huang and Ji, 2012). The results of a household survey conducted in six provinces (Liaoning, Zhejiang, Hebei, Hubei, Shaanxi, and Sichuan) in China showed that by 2008, an average of only approximately 70% of households had obtained a land tenure certificate (Huang and Ji, 2012; Deininger et al., 2014). With the progressive issuance of land tenure certificate in rural China, currently the proportion of households receiving land tenure certificate is expected to be over 90%.

In XSBN, the issuance of land tenure certificates lags behind other areas in China. According to our survey, only 26.6% of smallholder rubber farmers possessed a farmland tenure certificate, and 31.2% possessed a forestland tenure certificate; only 5% of households had both type of certificates. Hence, the proportion of households with land tenure certificates in 2013 was lower than that in 2008 according to surveys conducted in six other provinces in China (Huang and Ji, 2012; Deininger et al., 2014). One of the reasons for the slow process in XSBN is the higher costs of verifying land use rights (Huang and Ji, 2012). First, the costs of land tenure verification are high due to the complex geographic situation in this mountainous region. Second, the conversion from public forest lands is frequently constrained by unclear ownership due to traditional land use rights among the different ethnic groups. This can lead to disputes among farmers, villages, and local state farms. Furthermore, conflicts have arisen through the previous uncontrolled expansion of rubber plantations.

4.3. Participation in land rental markets

While the rural land rental market in China was still in its infancy in 2000 (Feng et al., 2010), it has rapidly developed. According to a nationwide set of household-level data in China (Huang et al., 2012), approximately 17.2% and 17.2% of households rented out and rented in cultivated land, respectively, in 2008. Through land rental markets, land is moving from those with relatively less labor and less capital to those with more labor, more capital and less cultivated land (Huang et al., 2012).

Table 1
Participation in land rental markets and its association with land tenure certification, population aging and ethnicity.
Data sources: Authors' survey.

Categories	Rent out		Rent in	
	Household (%)	Average area (mu/person)	Household (%)	Average area (mu/person)
Total sample	31.70 (46.57)	1.42 (5.33)	3.76 (19.03)	0.47 (4.84)
Land tenure certification				
Yes#	53.11 (49.98)	1.63 (3.79)	4.35 (20.42)	0.36 (3.36)
No	7.93 (27.07)***	1.18 (6.64)	3.10 (17.37)	0.59 (6.08)
Elder in household				
Yes#	32.43 (46.90)	1.74 (6.98)	2.32 (15.07)	0.15 (1.15)
No	31.16 (46.38)	1.19 (3.67)	4.82 (21.44)*	0.69 (6.29)*
Ethnicity				
Han#	35.71 (48.80)	1.04 (2.07)	7.14 (26.23)	2.12 (10.70)
Minority	31.51 (46.49)	1.44 (5.44)	3.60 (18.63)	0.39 (4.37)*

Notes: Standard deviation in parentheses; # reference group in mean-comparison tests; *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

Our survey results show that in XSBN, much more land is rented out rather than rented in by smallholder rubber farmers. Although nearly 32% of smallholder rubber farmers in XSBN rented out land in 2012, only 4% of them rented in land. As shown in Fig. 3, slightly more than 10% of the average per capita land area is rented out (1.42 mu[4]/person), while less than 5% of smallholder rubber farm land is rented out. The imbalance between renting in and renting out suggests that land in XSBN is likely to be transferred from rubber farmers to other (non-rubber) farmers.

Another finding is that land transactions facilitate specialization in rubber and cash crop farming. As shown in Fig. A1 of the Appendix A, for land rented in, most of the cleared forest land and rice, maize and other crops have been replaced by rubber and banana. While we do not know the actual use of the land rented out, land use before renting was quite similar to the use of land rented in (as shown in Fig. A2). Moreover, Figs. A1 and A2 also suggest that the transacted land includes both farmland and forest land.

Table 1 demonstrates the associations between participation in the land rental market and land tenure certification, population aging, and ethnicity. First, households with a land tenure certificate (either farmland tenure certificate or forestland tenure certificate) have a significantly higher proportion (53%) of renting out land compared with households without land tenure certificates. As for renting in land, its association with land tenure certification remains unclear. While households with land tenure certificates have a higher proportion of renting in land, they also have a lower area of renting in land. Second,

[4] 1 ha = 15 mu.

Table 2
Summary statistics of dependent and independent variables.
Data sources: Authors' survey.

Variable	Definition and description	Mean	Std. Dev.	Min	Max
Dependent variables					
y1	Rent out land (1 = Yes; 0 = No)	0.32	0.47	0	1
y2	Rent in land (1 = Yes; 0 = No)	0.04	0.19	0	1
Independent variables					
Hhsize	Household size	5.12	1.46	2	11
Demographic structure					
Age 16	% of family members (age < 16)	0.18	0.15	0	0.6
Age 16–40	% of family members (16 ≤ age < 40)	0.41	0.15	0	1
Age 40–60	% of family members (40 ≤ age < 60)	0.30	0.18	0	1
Age 60	% of family members (age ≥ 60)	0.11	0.16	0	1
Certificate	Land tenure certificate (1 = Possess; 0 = No)	0.53	0.50	0	1
Ethnic	Ethnicity (1 = Minority; 0 = Han)	0.95	0.21	0	1
Land	Land area (mu/person)	12.89	12.33	0	145.8
Rubber	Percent rubber planting area	0.87	0.16	0.06	1
Employment	Family member engaged in wage employment (1 = Yes; 0 = No)	031	0.46	0	1
Wealth	Value of household assets (1000 Yuan/person)	69.54	81.07	0.47	1252.1
Altitude	Altitude of household location (MASL)	756.11	160.27	541	1468

households with at least one elder more frequently rent out land and less frequently rent in land, i.e., approximately 32% (2%) of them rented out (in) land, whereas for those without an elder in the household, the value was 31% (5%). The households without elders have a significantly higher proportion of renting in land, and they rent in larger land areas. Finally, ethnic minorities less frequently participate in land rental markets (both renting out and renting in); however, the average area is higher than non-minority land market participants. This may be because the indigenous minorities normally possess greater land area than the Han majority in XSBN.

In summary, three observations can be made. First, the age structure with population aging among smallholder rubber farmers in XSBN is similar to the overall demographic structure in China. Second, the process of land tenure verification lags behind other regions in China. Third, in addition to the age structure of the population, participation in the land rental market appears to be associated with the availability of land tenure certificates and differs by ethnicity.

5. Empirical models

Following our conceptual models, in this section, we propose the establishment of two econometric models that represent farmers' behavior related to the renting out and in of land. In the second part of this section, we discuss our approach to estimate these models.

5.1. Model specification

To capture the impacts of population aging, land tenure certification and ethnicity on farmers' participation in the land rental market by controlling for other independent variables, which is in line with our conceptual models (2.5) and (2.6) as well as the general model of farmers' participation in the land rental market used in previous studies e.g., Deininger and Jin (2005) and Huang et al. (2012), we specify the following econometric models:

$$y_{i1} = \alpha_1 + \beta_1 D_i + \gamma_1 C_i + \delta_1 E_i + \theta_1 Z_i + \varepsilon_i \quad (5.1)$$

$$y_{i2} = \alpha_2 + \beta_2 D_i + \gamma_2 C_i + \delta_2 E_i + \theta_2 Z_i + \mu_i \quad (5.2)$$

where the subscript i represents the i^{th} household. Eqs. (5.1) and (5.2) are specified to identify the determinants of the behaviors associated with the respective renting out and in of land. In Eq. (5.1), the dependent variable y_{i1} is a dummy variable; $y_{i1} = 1$ represents the i^{th} household that rented out land in 2012; otherwise, y_{i1} is equal to 0. Likewise, the dependent variable y_{i1} in Eq. (5.2) is also a dummy variable. If the i^{th} household rented in land in 2012, y_{i2} is equal to 1; otherwise, y_{i2} is equal to 0.

The independent variables included in Eqs. (5.1) and (5.2) are identical. D_i represents a vector of variables of the household demographic structure, which consists of the proportions of family members belonging to different age groups. The proportion of family members aged 60 years and older is defined as the population aging variable. The independent variable C_i is a dummy variable; it is equal to 1 if the i^{th} household owns a land tenure certificate; otherwise, it equals 0. E_i denotes the ethnicity of the i^{th} household; $E_i = 1$ if the household belongs to ethnic minorities i.e., Dai, Hani, Bulang and so on, while $E_i = 0$ indicates that the household is the Han majority. Z_i is a vector of control variables that might influence the behavior of renting out or renting in land. α_1, β_1, γ_1, δ_1, θ_1, α_2, β_2, γ_2, δ_2, and θ_2 are parameters to be estimated; ε_i and μ_i are the disturbance terms.

The detailed definitions and statistical descriptions of all variables used in the regression are summarized in Table 2. In addition to the explanatory variables of interest in Eqs. (5.1) and (5.2), such as demographic structure, land tenure certification and ethnicity, a vector of control variables Z_i includes five other independent variables to account for their possible impacts on participation in the land rental market. As shown in Table 2, ***Hhsize*** denotes the size of the household, measured as the number of family members; ***Land*** is defined as the household land area, which excludes the land rented in; therefore, this variable is exogenous. To detect the possible impacts of rubber farming on land rental behavior, we included a variable ***Rubber***, which is defined as the percent rubber planting area relative to the household land area. Considering the relatively high labor intensity required for rubber farming, we expect that specialization in this type of farming is likely to facilitate the renting out of land and to impede the renting in of land. Consistent with previous studies (Huang et al., 2012), we also included the employment of family members as well as household wealth as control variables. Since XSBN is a mountainous region, we also controlled for the altitude of the household location (Min et al., 2017b). We hypothesize that the variable ***Altitude*** will have a negative effect on the decision of households to participate in the land rental market.

5.2. Estimation approach

To estimate the models, three potential problems must be considered. First, the equations of renting out (5.1) and renting in (5.2) may be correlated; hence, a bivariate probit model was used to test the possible correlations between the error terms of Eqs. (5.1) and (5.2). Second, because the issuance of land tenure certificates could be influenced by previous land conflicts, the land tenure certificate variable

is likely to be endogenous in explaining farmers' land transfer decisions. Third, considering that sample selection is one of the frequent causes of bias in non-experimental studies (Arendt and Holm, 2006), we need to check for a possible selection bias pertaining to land tenure certification. Following previous studies (Lokshin and Glinskaya, 2009; Gregory and Coleman-Jensen, 2013; Ayuya et al., 2015), we further employed an endogenous switching probit model (ESP) to tackle the second and third problems.

5.2.1. Bivariate probit model

Following a bivariate probit regression (Greene, 2003), which allows estimation of Eqs. (5.1) and (5.2) together, the unobserved error terms ε_i and μ_i are assumed to follow standard bivariate normal distributions with unit variance $var(\varepsilon_i) = var(\mu_i) = 1$ and zero mean$E(\varepsilon_i) = E(\mu_i) = 0$. Thus, the correlation coefficient between ε_i and μ_i can be written as $\rho = cov(\varepsilon_i, \mu_i)$, which identifies whether unobserved heterogeneities of the renting out and renting in of land are correlated. If the correlation coefficient ρ is significantly different from zero, estimating Eqs. (5.1) and (5.2) jointly using maximum likelihood estimation would be more efficient (Meng and Schmidt, 1985; De Luca, 2008); otherwise, the two equations can be estimated separately.

5.2.2. Endogenous switching probit model

Following the setup of an endogenous switching probit model (Lokshin and Sajaia, 2011), Eqs. (5.1) and (5.2) can be reconstructed as follows:

$$C_i = 1 \quad \text{if } a + bD_i + cE_i + dZ_i + hIV_i + \phi_i > 0 \tag{5.3a}$$

$$C_i = 0 \quad \text{if } a + bD_i + cE_i + dZ_i + hIV_i + \phi_i \le 0 \tag{5.3b}$$

$$y_{1ij}^* = \alpha_{1j} + \beta_{1j}D_{1i} + \delta_{1j}E_{1i} + \theta_{1j}Z_{1i} + \varepsilon_{1i}y_{1ij} = I(y_{1ij}^* > 0) \tag{5.4a}$$

$$y_{0ij}^* = \alpha_{0j} + \beta_{0j}D_{0i} + \delta_{0j}E_{0i} + \theta_{0j}Z_{0i} + \varepsilon_{0i}y_{0ij} = I(y_{0ij}^* > 0) \tag{5.4b}$$

where the subscript j is equal to 1 or 2 when representing the renting out of land ($j = 1$) or the renting in of land ($j = 2$). y_{1ij}^* and y_{0ij}^* are latent variables (latent continuous propensity for renting out or renting in land) that determine the observed behaviors of participating in the land rental market y_{1j} and y_{0j} (whether the household rented out or rented in land). Observed y_{ij} is defined as $y_{ij} = y_{1j}$ if $C_i = 1$ and $y_{ij} = y_{0j}$ if $C_i = 0$. IV_i is an instrumental variable defined as the proportion of households owning land tenure certificates relative to all households in the same village.

Assume that ϕ_i, ε_{1i}, and ε_{0i} are normally distributed with a mean of zero; thus, the correlation matrix can be written as:

$$_j = \begin{pmatrix} 1 & \rho_{0j} & \rho_{1j} \\ & 1 & \rho_{10j} \\ & & 1 \end{pmatrix} \tag{5.5}$$

where ρ_{0j} is the correlation between ϕ_i and ε_{1i}, ρ_{1j} is the correlation between ϕ_i and ε_{0i}, while ρ_{10j} is the correlation between ε_{1i} and ε_{0i}. Following the procedure of an endogenous switching probit model (Lokshin and Sajaia, 2011), the simultaneous system of Eqs. (5.3a), (5.3b), (5.4a) and (5.4b) can then be estimated using maximum likelihood estimation. Where either ρ_{0j} or ρ_{1j} differ significantly from zero, there is selection bias in land tenure certification. Moreover, the likelihood ratio test for $\rho_{0j} = \rho_{1j}$ can be used to test the joint independence of Eqs. (5.4a) and (5.4b).

Additionally, the specified endogenous switching probit model allows the derivation of probabilities in counterfactual cases (Ayuya et al., 2015). The treatment effect on the treated (TT) and the treatment effect on the untreated (TU) can be calculated using formulas (5.6) and (5.7):

$$TT_j = Pr(y_{1j} = 1|C = 1) - Pr(y_{0j} = 1|C = 1) \tag{5.6}$$

$$TU_j = Pr(y_{1j} = 1|C = 0) - Pr(y_{0j} = 1|C = 0) \tag{5.7}$$

where TT_j is the expected effect of land tenure certification on households with observed characteristics that participated in the land rental market, whereas TU_j is the expected effect on participation in the land rental market if the households without land tenure certification received a land tenure certificate.

6. Results

6.1. Estimation results of the bivariate probit model

The results for Eqs. (5.1) and (5.2) that were jointly estimated using the bivariate probit regression are reported in Table 3. The estimates were implemented four times by controlling for different independent variables. Among the four results (a–d), the correlated coefficients (Rho) between the residuals of the equations for renting out (5.1) and renting in land (5.2) were 0.1, 0.14, 0.13 and 0.12, respectively; none of these differed significantly from zero according to the results of the Wald chi2 test of Rho = 0. Hence, the joint estimate based on the bivariate probit regression was not more efficient than the separate regression, implying that the two equations regarding the renting out and in of land are independent, and the two models can also be estimated separately, while the estimation results of the bivariate probit model are not significantly superior to those of the separate estimate.

The results presented in Table 3 show that a higher proportion of older people (age ≥ 60 years) in a household increases the likelihood of renting out land and reduces the likelihood of renting in land. Hence, it can be confirmed that population aging fosters land rental market development by transferring land from older to younger farmers. Furthermore, having a land tenure certificate significantly affects the probability of participating in land rental markets, with a positive coefficient for renting out land, compared with an insignificant probability of renting in land. Interestingly, participation is sensitive to ethnicity, whereby, as expected, ethnic minority groups are significantly less likely to rent out land (result (d)) if controlling all given independent variables. This underlines the complexity of land transfer procedures in ethnic minority villages, which can differ from the ethnic majority in China.

Table 3 also shows that several other independent variables, e.g., specialization in rubber farming, wage employment, household wealth, and altitude, significantly influence the participation of smallholders in the land rental market. In line with our expectations, due to the relatively high labor demand, specialization in rubber farming positively fosters the renting out of land and negatively impacts the renting in of land (result (c)). However, the impact of specialization on the renting out of land becomes insignificant after controlling for altitude and adjusting the standard error for clustering at the village level. Wage employment is positively correlated with renting in land, which wage income can support. Households with more wealth are more likely to rent out land. This might be because relatively rich households have more alternative opportunities to earn money instead of specializing in farming. Finally, households located at higher altitudes are less likely to rent out land, reflecting the constraints of land rental market development in a mountainous region.

6.2. Results of endogenous switching probit regression

Tables 4 and 5 present the results of the endogenous switching probit regression for the respective renting out and in of land. The likelihood ratio tests for the joint independence of the equations show that Eqs. (5.4a) and (5.4b) are not independent in the models (Tables 4 and 5), confirming the validity of using endogenous switching probit regression. Moreover, according to our results, $\rho_{11} = -0.50$ and $\rho_{12} = 0.91$ are significantly different from zero, while $\rho_{01} = 0.39$ and $\rho_{02} = 0.42$ are not significant; hence, selection bias pertaining to land

Table 3
Estimation results of the bivariate probit regression.

Variables	(a)		(b)		(c)		(d)	
	Rent out	Rent in	Rent out	Rent in	Rent out	Rent in	Rent out	Rent in
Hhsize	−0.03	−0.09	−0.04	−0.08	−0.01	−0.10	−0.03	−0.10
	(0.04)#	(0.07)	(0.04)	(0.07)	(0.04)	(0.08)	(0.05)	(0.09)
Age 16	−0.05	−0.35	−0.11	−0.35	0.21	0.21	0.27	0.21
	(0.53)	(0.88)	(0.53)	(0.90)	(0.56)	(0.85)	(0.58)	(0.84)
Age 40–60	0.96	−1.07	0.90	−0.99	0.97	−0.89	0.99	−0.91
	(0.43)**	(0.69)	(0.44) **	(0.69)	(0.45) **	(0.70)	(0.49) **	(0.62)
Age 60	1.01	−1.79	0.99	−1.76	1.30	−1.45	1.31	−1.46
	(0.48) **	(0.82) **	(0.49) **	(0.81) **	(0.52) **	(0.82) *	(0.54) **	(0.79) *
Certificate	1.54	0.13	1.68	0.10	1.73	0.13	1.75	0.13
	(0.13) ***	(0.20)	(0.15) ***	(0.19)	(0.15) ***	(0.20)	(0.24) ***	(0.19)
Ethnic	−0.27	−0.26	−0.41	−0.14	−0.40	−0.10	−0.44	−0.09
	(0.27)	(0.35)	(0.27)	(0.37)	(0.28)	(0.36)	(0.17)**	(0.45)
Land			−0.01	−0.01	−0.01	−0.01	−0.01	0.00
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Rubber			1.52	−0.79	1.19	−1.00	0.74	−1.11
			(0.42)***	(0.56)	(0.43)***	(0.55)*	(0.60)	(0.61)*
Employment					0.16	0.55	0.15	0.55
					(0.14)	(0.20)***	(0.16)	(0.17)***
Wealth					0.004	0.0001	0.003	−0.00004
					(0.001)***	(0.001)	(0.001)***	(0.001)
Altitude							−0.001	−0.0003
							(0.001)*	(0.001)
Constant	−1.46	−0.65	−2.52	−0.07	−2.83	−0.23	−1.40	0.12
	(0.40)***	(0.58)	(0.56)***	(0.73)	(0.58)***	(0.75)	(0.99)***	(1.07)
Rho	0.1		0.14		0.13		0.12	
	(0.14)		(0.14)		(0.14)		(0.14)	
Number of observations	612		612		612		612	
Wald chi2	157.52***		162.67***		172.70***		222.48***	
Log pseudo likelihood	−389.99		−379.22		−366.08		−363.34	
Wald chi2 test of Rho = 0	0.56		1.01		0.78		0.74	

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively; Robust standard errors in parentheses; # Standard errors are adjusted for clustering at the village level.

tenure certification likely exists. This selection bias problem tends to skew the impact of land tenure certification on renting out land in a negative, and renting in land, in a positive direction. This is an indication that households possessing a land tenure certificate are less likely to rent out land and more likely to rent in land, which is due to unobservable household characteristics. In other words, the selection bias will underestimate the positive impact of land tenure certification on the renting out of land and overestimate the positive impact of this certification on the renting in of land. Hence, it is essential to control for selection bias associated with land tenure certification in cross-sectional data.

The instrumental variable (IV) in Tables 4 and 5 had a significant and positive effect on owning a land tenure certificate. This suggests that if a rubber farmer is located in a village with a high proportion of households that own a land tenure certificate, this increases the likelihood of obtaining such a certificate. We also checked the validity of IV, "the proportion of households owning land tenure certificates among all other households in the village", in three steps. First,

Table 4
Estimation results of endogenous switching probit regression for renting out land.

Variables	Land tenure certificate		Rent out (Certificate = 1)		Rent out (Certificate = 0)	
	Coef.	R. Std. Err.	Coef.	R. Std. Err.	Coef.	R. Std. Err.#
Hhsize	0.01	0.05	−0.03	0.06	−0.07	0.07
Age 16	−0.26	0.51	0.91	0.57	−0.57	1.12
Age 40–60	−0.54	0.43	1.38	0.56**	0.30	0.62
Age 60	−0.54	0.45	1.57	0.71**	0.74	0.72
Ethnic	0.08	0.20	−0.63	0.21***	−0.15	0.32
Land	0.01	0.00**	−0.03	0.01***	0.01	0.01
Rubber	−1.60	0.50***	1.57	0.69**	−0.84	0.55
Employment	−0.23	0.11**	0.09	0.17	0.41	0.26
Wealth	0.00002	0.001	0.004	0.001***	0.002	0.001*
Altitude	−0.001	0.0003***	−0.001	0.001	−0.001	0.001*
IV	2.67	0.22***				
Constant	0.91	0.76	−0.21	1.10	0.33	0.99
Rho (ρ_{11}, ρ_{01})			−0.50	0.20**	0.39	0.26
Number of observations				612		
Wald chi2 (Joint significance)				230.2***		
Log pseudo-likelihood				−568.35		
Wald chi2 (Wald test of independent eqns.)				5.44*		

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively; #Robust standard errors are adjusted for clustering at the village level.

Table 5
Estimation results of endogenous switching probit regression for renting in land.

Variables	Land tenure certificate		Rent out (Certificate = 1)		Rent out (Certificate = 0)	
	Coef.	R. Std. Err.	Coef.	R. Std. Err.	Coef.	R. Std. Err.#
Hhsize	0.02	0.05	−0.17	0.09*	0.02	0.14
Age 16	−0.24	0.53	1.01	0.93	−1.16	1.59
Age 40–60	−0.38	0.43	−1.04	0.72	−1.22	0.98
Age 60	−0.43	0.44	−0.87	0.87	−2.72	1.55*
Ethnic##						
Land	0.01	0.01**	0.01	0.01	−0.03	0.02
Rubber	−1.67	0.50***	−1.73	0.75**	−1.12	0.69
Employment	−0.21	0.11**	0.57	0.22**	0.32	0.26
Wealth	−0.0001	0.001	0.001	0.002	−0.0003	0.001
Altitude	−0.001	0.0003***	−0.001	0.001	0.001	0.001
IV	2.73	0.22***				
Constant	0.93	0.73	0.98	1.21	−0.25	1.12
Rho (ρ_{12}, ρ_{02})			0.91	0.15***	0.42	0.27
Number of observations				612		
Wald chi2 (Joint significance)				238.86***		
Log pseudo-likelihood				−389.93		
Wald chi2 (Wald test of independent eqns.)				4.70*		

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively; # Robust standard errors are adjusted for clustering at the village level; ##Due to the small sample size of households renting in land, the endogenous switching probit regression for the originally specified empirical model was not concave. Consequently, we dropped the ethnic variable, which has an insignificant impact on the renting in of land.

Table 6
Treatment effects of land tenure certification.
Data sources: Authors' calculations.

Categories	Observations	Mean			
		Rent out		Rent in	
ATT	322	0.378	***	−0.042	***
ATU	290	0.710	***	−0.030	***

Notes: *** indicates significance at the 1% level, respectively.

intuitively, issuing a land tenure certificate to other households in the same village can affect the issuance of a land tenure certificate for an individual household, i.e., a household is more likely to obtain land tenure certification if more households in the same village own land tenure certificates. However, the IV did not have a direct effect on a household's decision to transfer land; instead, this variable had an indirect effect on a household's land transaction decision by affecting the issuance of the land tenure certificate. Second, following previous studies (Di Falco et al., 2011; Ayuya et al., 2015; Huang et al., 2015; Parvathi and Waibel, 2016), we performed a simple falsification test: if a variable is a valid selection instrument, it will affect the owing of a land tenure certificate, but it will not affect the decision to rent out/in land among the households that do not own land tenure certificates. Table A2 of the Appendix A shows the results of our falsification test, verifying that the proposed IV is valid. Third, the results of an F-statistics test show statistical significance at the 1% level of the IV in the first-stage selection model in both Tables 4 and 5 (F-stat. = 142.86 and 152.17, which exceed the threshold of 10); thus, we can reject the presence of a weak instrument. Overall, our proposed IV to assess the impact of land tenure certification on participating in the land rental market showed to be valid such that the estimation results using the instrumental variable are assumed to be appropriate.

6.2.1. Land tenure certification

The selection Eqs. (5.3a) and (5.3b) regarding land tenure certification (Tables 4 and 5) was significantly correlated with the household land area, the percent rubber planting area relative to the household land area, the altitude of the household location, and the instrumental variable "the proportion of households owning land tenure certificates in the village". As expected, the issuing of land tenure certificates in the village had a positive impact on the probability of a household obtaining such a certificate. Households with more land area were more likely to obtain a land tenure certificate. On the one hand, this to some extent implies the inequality of land tenure certificate issuance in XSBN, that is, households with small land areas are falling behind with respect to receiving official confirmation pertaining to land use rights. On the other hand, households with small land areas may care less about land tenure security than households with larger land areas. Hence, they do not actively participate in the process of land tenure certification. Moreover, households planting more rubber are less likely to obtain a land tenure certificate. This result confirms our hypothesis that the expansion of natural rubber plantations leads to conflicts about land use rights in XSBN and thereby hinders the issuance of land tenure certificates. Finally, altitude had a negative impact on the likelihood of obtaining a land tenure certificate. This shows that the issuance of such a certificate in mountainous regions is lagging due to the relatively high costs of verification.

6.2.2. Participating in the land rental market

In the model for renting out land (Table 4), explanatory variables such as population aging, ethnicity, specialization in rubber farming and household wealth were significantly associated with the probability of renting out land by households with land tenure certificates. This illustrates the interactive effects between land tenure certification and these explanatory variables on the decision to rent out land. Additionally, the proportion of family members aged between 40 and 60 years also had a significant and positive impact on renting out land for households with land tenure certification. Interestingly, if a household has a land tenure certificate, the household land area is negatively related to the probability of renting out land. This implies that the issuance of land tenure certificates may be conducive to the formation of large-scale land operations. However, for households without land tenure certificates, only household wealth and altitude had significant impacts on the renting out of land (Table 4).

In the model for renting in land (Table 5), the determinants between the households with and without land tenure certificates were also quite different. For instance, the estimated coefficient of population aging was significantly negative only for households without land tenure certificates, while the negative effect of specialization in rubber farming on renting in land was only significant for households with land tenure certificates. The households with land tenure certificates

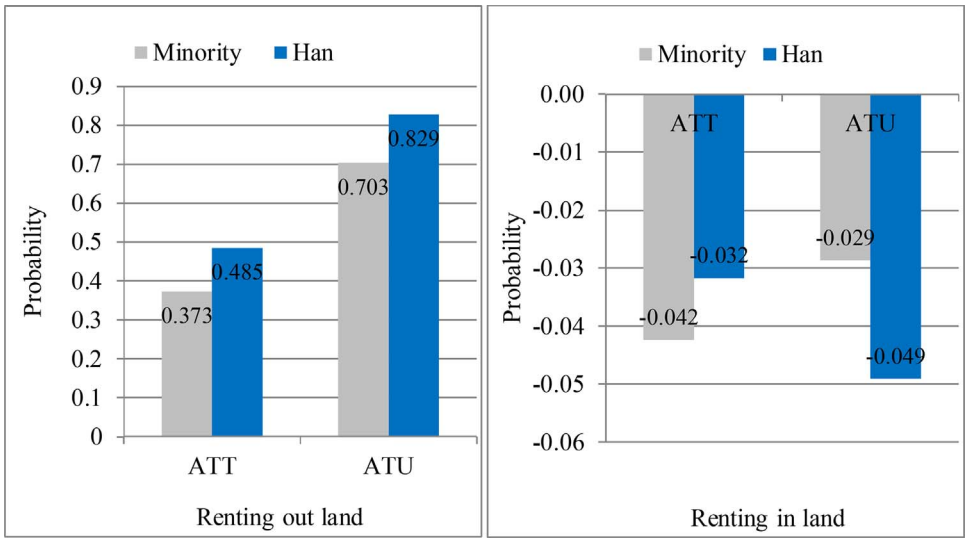

Fig. 4. Treatment effects of issuing land tenure certificates on the probabilities of renting out and renting in land according to ethnicity.

had more family members that were less likely to rent in land.

In summary, the possession of land tenure certificates along with other explanatory variables such as population aging, ethnicity, the household land area, specialization in rubber farming, household wealth, wage employment and altitude play important roles in farmers' participation in the land rental market in XSBN. The heterogeneity of the sample households and the existence of interactive effects between land tenure certification and other explanatory variables resulted in differences in the factors that influenced participation in the land rental market between households with and without land tenure certification. The use of the endogenous switching probit model not only controlled for the selection bias associated with land tenure certification but also provided more insights and a better understanding of the relationships between land tenure security and the development of rural land rental markets.

6.2.3. *Counterfactual analysis*

Based on the estimation results of the endogenous switching probit models, we further conducted a counterfactual analysis to quantify the impacts of land tenure certification on the probability of participating in land rental markets. As shown in Table 6, the results of the average treatment effect on the treated (ATT) show that households possessing a land tenure certificate have a 37.8% higher probability of renting out land. Moreover, the results of the average treatment effect on the untreated (ATU) suggest that if farmers possess a land tenure certificate, this would result in a 71% increase in the likelihood of renting out land. While possessing a land tenure certificate is negatively correlated with renting in land, the magnitude of this correlation is very low. Clearly, improving land tenure security encourages farmers to rent out land and hence, issuing a land tenure certificate can contribute to the advancement of rural land rental markets.

The results in Fig. 4 also reveal that the effects of land tenure certification on participation in land rental markets differ by ethnicity. From the perspective of renting out land, ATT and ATU for Han households were consistently higher than those of minorities. With respect to renting in land, land tenure certification also resulted in a more negative ATU for Han households. Hence, issuing land tenure certificates may be more effective for Han households, allowing them to participate in land rental markets, as is the case for minorities.

7. Summary and conclusions

In this study, we explored the rural land rental market in the Xishuangbanna Dai Autonomous Prefecture in Southern China. This is a mountainous region where rapid changes in land use have taken place with the transition from a tropical rainforest to rubber monoculture. Our results suggest that the advancement of land rental markets in XSBN faces constraints due to the sometimes poor compatibility between traditional land use rights and modern rural land legislation. This potential conflict has been augmented by the expansion of rubber farming, which has slowed the process of issuing land tenure certificates, resulting in XSBN lagging behind other regions of China. We also found a much higher proportion of smallholder rubber farmers that rent land out rather than renting land in. This could mean that land is transferred from rubber farmers to those who do not farm rubber. Therefore, a well-developed land rental market could become an instrument to reduce the inequality between rubber farmers and other farmers in this region.

We assessed the determinants of farmers' participation in the land rental market. The results confirm our three main hypotheses, namely: 1) population aging fosters the advancement of the rural land rental market by transferring land from older to younger farmers, 2) the availability of a land tenure certificate increases farmers' participation in the land rental market by improving land tenure security, and 3) participation in the land rental market is sensitive to ethnicity, i.e., ethnic minority groups are significantly less likely to rent out land. We also found that specialization in rubber farming, household wealth, and altitude may play a role in farmers' participation in the land rental market. Moreover, the results of the endogenous switching probit model and the counterfactual analysis imply that among the factors influencing participation in the land rental market, land tenure certification appears to have the strongest effect on those households that do not yet possess a land tenure certificate; farmers with a land tenure certificate have a 71% higher likelihood of renting out land.

Finally, our results have implications beyond the study region and can help to better understand the diversity of rural land rental markets in other areas in China. We confirmed that population aging and land tenure certification facilitate the advancements of rural land rental markets. However, in a mountainous and ethnically diverse area, the establishment of well-functioning land rental markets is more difficult and will take more time. To advance rural land rental markets in XSBN, we recommend that government agencies speed up the issuance of land tenure certificates and give higher priority to ethnic minority groups and smallholder farmers located in mountainous locations.

Acknowledgements

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Appendix A

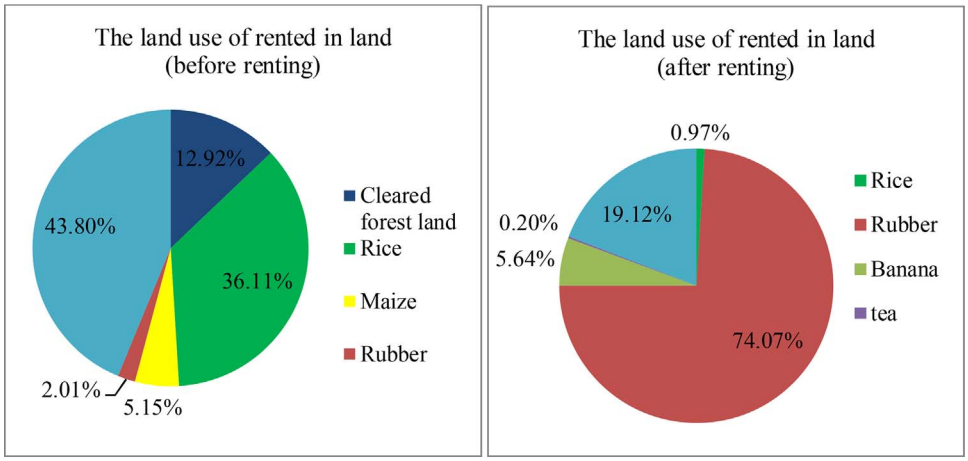

Fig. A1. The land use of rented in land (before and after renting in).

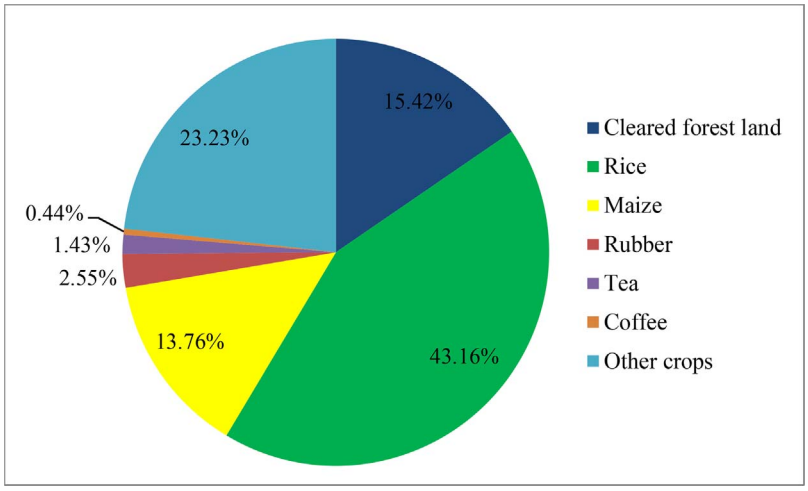

Fig. A2. The land use of rented out land (before renting out).

Table A1
Sample sizes of the socio economic survey of rubber farmers in XSBN.
Source: Authors' survey.

County	Sample pool			Sample size			
	Townships	Administrative villages	Villages	Townships	Administrative villages	Villages	Households
Menghai	11	85	911	2	6	6	84
Jinghong	11	85	723	3	18	18	279
Mengla	10	52	505	3	18	18	249
Total	32	222	2139	8	42	42	612

Table A2
Validity test of instrumental variables.

Variables	Land tenure certification		Rent out (Certificate = 0)		Rent in (Certificate = 0)	
	Coef.	R. Std. Err.	Coef.	R. Std. Err.	Coef.	R. Std. Err.
IV	2.70	0.23***	−0.83	0.54	−0.75	0.63
Control for other variables	Yes		Yes		Yes	
Constant	0.85	0.73	−0.26	1.04	−0.97	1.06
Number of observations	612		290		290	
Wald chi2	239.18***		27.87***		56.11***	
Log pseudo likelihood	−309.10		−69.95		−34.73	
Pseudo R2	0.2699		0.1295		0.1236	

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

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