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Property Rights, Tenure Security and Forest Investment Incentives: In the Context of China's Collective Forest Tenure Reform Since 2003

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Abstract

Determinants of farmers' investment incentives in forestland have a significant impact on forest management and welfare improvement, but few studies in the literature have consonantly shown the causal linkage between perceived tenure security on forestland and farmers' incentive to invest. This study explores the driving factors of forest investment and whether China's collective forest tenure reform has stimulated such investment on individually controlled plots, by developing a conceptual model and corresponding econometric strategy. In addition to property rights, tenure security and investment propensity appear to be affected by many other factors such as household and plot characteristics. Tenure security is also explained by economic wealth, political influence, local institutional evolution, while forest investments are also affected by income structure, labor distribution, and credit constraint. The outcomes of the study fill a gap in the empirical evidence of a relationship between forestland property rights, tenure security, and investment incentives, with policy discussion on raising farmer's valuing on their forestland, building infrastructure for rural credit market and land transfer market, and channels through which policy instruments work and achieve their goals.

Keywords: Property Rights, Tenure Security, Forest Investment, China's Collective Forest Tenure Reform

CONTENTS

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Introduction

The rapid economic growth in China has transformed the lives of hundreds of millions of people, but it has also created both rampant inequalities between the fast growing urban sector and the lagging rural areas as well as a demand for resources with global repercussions. Following the successful agricultural sector reform, much attention is therefore given to the potential of increasing the productivity in the forest sector. A number of environmental and development economists (e.g., Xu et al. 2010; Li and Wang, 2009; Xu and Jiang, 2009; Jacoby et al., 2002) have therefore reviewed the factors driving the emerging increase of forest coverage in China, and growth of farmers' income (especially from forest and forestry), both in absolute value and in share of total household income.

In the search for policies to stimulate investments in the forest sector, property rights regime by empowering and confirming exclusive land ownership or use rights via formal titling, has been identified as a key element to stimulate investment, and to facilitate more efficient and effective allocation of production factors and use of natural resources. This is expected to achieve economic growth and environment conservation. Policy makers have largely understood the importance of land tenure systems and realized that uncertainty weakens farmers' incentives to invest in their land, especially in the longer-term (Wen, 1995; Yao, 1995).

Most studies of land rights reform focus on rural sector and agricultural land, which is seen as a critical production factor for farmers. Farmers account for the absolute majority of the population, so agricultural land is critical to hot issues such as poverty alleviation and food security. Furthermore, many developing countries enact more tenure reforms for agricultural land than forestland, and the literature also reflects this attention.

Since China implemented the Household Responsibility System (HRS) reform in early 1980s, agricultural land in China has completely been under household management in the forms of private plots, responsibility land, ration land, and contract

land. However, forestland reform has lagged behind. A clearly and well-defined property rights regime is critical for the management of forests as common pool resources. Poor global forest management and reform performances, coupled with the current grim concerns of climate change, present great challenges for current and continued sustainability of forests and human society.

Therefore, understanding the determinants and incentives of forest investment holds great interest for both policymakers and researchers. Yet, currently the literature contains only a few studies of agricultural land-related investment and property rights (e.g., Place et al., 1994; Besley, 1995; Brasselle et al., 2002; Jacoby et al., 2002; Deininger and Jin 2006), which present inconclusive causality in the relationship of property rights, tenure security and investment incentives. Basically, three reasons account for the lack of robust findings: 1) the existence of endogenous bias in the case of investment conducted in order to enhance tenure security or property rights to make a claim on, other than the reverse causality as expected, 2) the lack of a large-enough sample with a diversified geographical coverage, and 3) the quality of proxies used for tenure security not well justified.

There are even fewer studies that specifically look at the relationship between property rights, tenure security and investment incentives in the forest sector, especially in China—a gap which this study intends to fill, and explore some empirical evidence for the causal linkage between property rights, perceived tenure security on forestland, and farmers' incentive to invest. The performance of China's collective forest tenure reform since 2003 has been assessed by a number of studies. They have also exposed unresolved challenges, the solutions for which continue to be heavily debated by both policymakers and economists (see, e.g., Kong et al., 2006; Zhao, Shuxue, 2009; Xu et al., 2010).

Due to its importance for environmental protection and social welfare improvement, as well as its implications for the next stage of deepening forest tenure reforms in China, to iterate, how well property rights reform contributes to

forestland-related investment is key to economic development in terms of increasing farmers' income from forest and agricultural land, and environment conservation (i.e., through tree planting, forest resource protection, and forest management).

Using the most recent and comprehensive survey data from the College of Environmental Science and Engineering of Peking University of China, this study examines the correlations between property rights, tenure security, and forestland-related investment by developing a conceptual model and corresponding econometric strategy. This study looks at three key factors: 1) The investment variable—the monetized summation of all forms of inputs and investments on the plot such as tree planting, silviculture, and labor input. 2) The tenure security variable—the respondent's answer on whether they still own the plot after five years—is selected based on property rights theory, earlier studies of tenure security as well as insecurity, and the availability of data. It is believed to better express farmers' perception on secure forestland tenure, thus it is a better proxy of subjective tenure security than the possession of a formal title or land certification, the length or duration of a plot, or the household's transferability of a plot, etc., all of which are used by earlier studies (e.g., see Jacoby et al., 2002; Besley, 1995). 3) The property rights variable has two forms—one is the original ones of nine specific rights[1] that household perceives they hold for a plot, the other one is the property rights index generated by summing up the scores of all the nine rights.

The main empirical strategy is specified through the following steps. First, the ordered probit and logit models are employed to examine correlated factors on forestland owners' expectation of still owning their plots after five years. The perceived tenure security, however, lacks variation in the sample as over 91% responds perceive highly secure on owning their polts, so selection bias is taken into account when estimating forestry investment. Hence, the Heckman selection two-step model is used to

[1] The nine rights are: right to convert forestland to agricultural land, right to interchange forest types, right to select tree species to plant, right to manage non-timber forest products, right to abandon forest land, right to mortgage plot as collateral with or without forestland certificate, and right to transfer plot within or outside the owner's village.

correct for selection bias and estimate determinants of forestry investment, and also to compare with the results of random effects models in the panel data.

The major findings of this study are: first of all, the new forest tenure reform after 2003 is found to significantly strengthen owners' perception of tenure security and to increase forestry investment. Second, the contracted property rights have significant and positive effects on tenure security and investment. But the more secure perception that farmers will still hold the plot does not stimulate investment in a statistically significant way. Third, previous investment on forestland (in year 2000 in this case) does not significantly affect tenure security the same way as in Ethiopia, implying the common endogenous relation between tenure security and investment does not exist. But it does increase future investment—possibly due to investment inertia. In addition, a household's income structure, credit ability, and political influence matter for both forestland tenure perception and related investment as expected.

This study mainly adds sorely lacking empirical evidence of the links between property rights, tenure security and forestland-related investment incentives in China. It also can help inform policy recommendations for the next stage of China's forest sector reform, supporting not only the on-going reform in the collective forest areas in southern China but also the state-owned forest areas in the north, where similar property rights reform is a high priority of the policy agenda.

The outline of this thesis is as follows. A brief review of existing literature and the motivation for this study are presented in section 1, followed by a brief introduction of China's forest tenure reforms. Section 3 introduces the conceptual model with details of building it up presented in Appendix A, derives the corresponding empirical strategy and hypotheses for estimation. After the data is described in section 4, section 5 presents the econometric results and discussions on the determinants of farmers' forestry investments, and how property rights reform enhances tenure security perception or/and hence investment incentives. Finally, Section 6 concludes with policy implications for the on-going forest management reform in China.

1. Literature Review and Reasons for the Study

The existing literature on land tenure security and investment mainly contains research in African countries, which focuses more on agricultural land than forestland. One main reason is that agricultural land is seen as a basic production factor that farmers live on (although, in China forestland is usually regarded more as an asset). Further, farmer population engaged in agricultural production takes the absolute majority of the world's total population. In this sense, agricultural land is a keynote to policymakers' major concerns such as poverty alleviation and food security, etc. Additionally, rural land tenure reforms have a relatively longer history because many developing countries have attempted to resolve tenure uncertainty in a variety of ways, which has provided a plethora of research opportunities.

Existing studies of the linkage between property rights, tenure security and land-related investment have shown empirically inconclusive causality. Studies in Latin American confirm a significant effect of land titling on investment, such as in Honduras (Alston et al., 1995), Nicaragua (Lopez, 1997), Paraguay (Carter and Olinto, 2003), and the Amazon frontier (Deininger and Chamorro, 2004). However, Holden and Yohannes (2002) found no such evidence that tenure insecurity has a negative effect on investment in trees in southern Ethiopia, although they did show that poverty has a statistically significant impact. Deininger and Jin (2006), also working on Ethiopia, show that transfer rights to land, associated with tenure security, enhance investment.

When estimating the effect of tenure security on agricultural or forestry investment, the problem of endogenous land rights is worth noting—tenure can be secured through security-enhancing investment behaviors. This is thought as a main source of potential reason for inconclusive results in the literature. For example, in the data collected by the World Bank in Ghana, Migot-Adholla et al. (1994) found that tenure security clearly and positively affects investment in the Anloga region, but a less noticeable impact was found in Wassa. Besley (1995), working with the same data, modeled the endogeneity of investment into tenure security perception using land rights as instruments, and is a

pioneer study. He found supportive evidence in Wassa that better land rights facilitate investment, but they are fruitless in Anloga. However, Baland et al. (1999) 's study on 36 villages in central Uganda presents evidence that investment enhances tenure security, yet the reverse relationship is not true. Furthermore, the study by Brasselle et al. (2002) in Burkina Faso demonstrated the lack of influence of tenure security on investment, and they also concluded that land-related investment appears to be undertaken primarily to increase tenure security rather than as a consequence of more secure rights.

In addition to these non-consonant outcomes, most of the existing studies rely on the evidences from small samples in limited geographical domains. For instance, Besley (1995)'s influential study in Ghana looked at 1,074 fields (of 217 households in total) in Wassa and 494 fields (of 117 households) in Anloga. Brasselle et al. (2002)'s study is based on 205 households from 9 villages located in 2 neighboring departments. Holden and Yohannes (2002) studied 505 households in 15 sites in southern Ethiopia. Small sample size may bias estimated coefficient towards zero (Deaton, 1997) because the variation in land rights is quite limited. Therefore, small sample size can be a possible explanation for the inconclusive results in the existing studies in African countries (Deininger and Jin, 2006).

In many African countries, when fallow land is not claimed by any social group or lineage, clearing the bush and planting trees is regarded as a visible investment by which settlers would like to establish their rights. Farmers who have invested in the land may be expected to have quite a good degree of tenure security (Brasselle et al., 2002). Whether this holds true in China needs more exploration with reliable data and qualitative studies of customary local systems. Nevertheless, it is worth bearing in mind that the potential endogeneity bias in this aspect, if exists, is better controlled in the empirical analysis in this study.

More generally, in China farmer households are more willing to invest for basically three reasons. First, they see their forestland as a long-term asset when they

feel more secure of maintaining their right to keep their forestland over a long period. Second, a higher return will be expected if farmers perceive more security with right or ability to maintain long-term use of their forestland, hence they have a greater incentive to undertake investment such as tree planting and land-related improvements or conservations. Third, consistent with Besley (1995: 910-12), farmers expect or realize greater return on investments in their forestland if the land can be easily converted to liquid assets through sale or transfer.

Hence, how well the forest tenure reform is dealing with tenure security and property rights is expected to increase investment incentive. It is worthwhile exploring the underlying micro-mechanisms through which property rights and tenure security influence farmers to invest in forest sector, especially in the context of China's collective forest tenure reform since 2003. The next section gives a brief introduction to China's forest property rights regime over the history since the foundation of the Chinese political system in 1949.

2. A Brief Introduction to China's Forest Tenure Reforms

Historically (since 1949), China's forestland tenure system began when private forests collectivized in 1954, which was followed by returning "ownership" or control of the trees around homesteads to individual households in early 1960s. Another long and profoundly influential change is the "Three-Fixes" policy (or "Resolution on Issues Concerning Forest Protection and Development"), announced by the State Council in 1981. By 1986, nearly 70 percent of collectively owned forestland had been transferred to farmer household management (Xu, 2009).

This round reform of forest property rights regime is featured by three forest management forms (or tenure types): family or private plots, responsibility plots or hills, and collective management. With a precondition that all forestland owned by the collectives, the first two types reflect individual households' use rights to management and ownership of tree planted on the plots. The responsibility plots/hills differ from the family plots in that the collective owns both the land and the trees, but decision-making

needs to be shared by the collective and the households. In the third type—collective management, both management and ownership of the land and trees belong to the collective, while decision-making is by village leaders (Liu and Edmunds, 2003).

Although the Three-Fix reform period permitted some privatization, this is not specifically stated in the resolution nor required by the villagers. At the same time, due to emerging problems—such as fire incidents, disputes over borders and ownership, lack of management skills, illegal logging, poor or no cooperation among farmers, and so forth—some villages decided to take forestland back under collective control. For example, during the author's participation in the second round survey (for the follow-up study of the reform) in Jiangxi province in March 2011, two of five surveyed counties reported that their forestland had been reclaimed by the village in the 1990s, and then in 2005 reallocated equally according to the number of household members in 2005.

In early 2003, initiated by Fujian province, a new round of reform in forestland tenure regime was formally approved by the central government, which spread rapidly to 10 other provinces, predominantly in southern China. This round of reform is characterized by the reallocation of the collective forest use rights to individual households. It included formal documentation of farmers' tenure rights to forestland through the issuance of forestland certificates with clearly specified contract lengths. For instance, the responsibility plots/hills have been given a clear duration, ranging from 30 to 70 years, while family or private plots certificates simply say "Long-term".

The use rights granted to households include harvesting and production decisions, such as converting forestland to cropland, selecting tree or plant species, interchanging different forest types, using non-timber forest products, and even abandoning plots. Rights related to gains-from-trade include forestland transfers, inheritance, mortgaging, and so on. Legal contracts in the form of forestland certificates also ensure farmers' use rights.

Both policymakers and economists expected that, when designing the recent forest tenure reform, individual management would produce stronger incentives to plant trees

and invest in forestland than other tenure types such as collective management. In general, individual households have lower costs and a stronger propensity to invest in forestry, which leads to more frequent harvesting and reforestation, and a higher income and improved social welfare.

Individual farmer households are responsible for the management of the land and the forest on their plot(s), which is not only a fundamental reform and a policy instrument to improve environmental management and the welfare of farmers. During the "Three-Fix" reform, the period of land use rights given to the family or private plots was ambiguous, while the responsibility plots/hills specified 5-15 years as contracted period—too short for most timber species (Holden et al., 2009b). The outcome was that most forestland allocated as family plots was already deforested. Many believe that this situation undermined farmers' incentive to invest because they were obliged to replant and they felt uncertain about the expected return. In other cases, when such lands were reclaimed by the collectives, or reallocated to other households, or leased out, high tenure insecurity was the result and discouraged any initiative to replant after existing trees were harvested (Holden et al., 2009b; Liu and Edmunds, 2003).

In light of dealing with such issues, the new reform has devoted in extending and giving clear specified duration of contracts, and strengthening contracted property rights to individual households. So the reform is a very interesting case to study the linkage between perceived tenure security and investment through the change of various rights. A more detailed discussion on the reform and contracted rights will be given along with descriptive analysis of the data in section 4.

3. Conceptual Model and Empirical Strategy

3.1 A Brief Introduction to the Conceptual Framework

Appendix A presents the steps of modelling the theoretical foundation, based on theoretical and comprehensive work that have examined the impacts of property rights on land-related investment. It incorporates labor and credit constraints, and also considers

the potential endogenous causality (Besley, 1995; Deininger and Jin, 2002; Carter and Olinto, 2003).

The author's intuition is to frame a dynamic household model (here only two periods are considered, subscripted by $t = 1\ or\ 2$) of farmer's investment decision on the forestland through the optimization on how to allocate labor and capital over the two periods in order to maximize profits. The investment in forestry, in competition with other sectors such as agriculture or off-farm work, depends on the expected value of the investment, which hinges decisively on the perceived security of the forest investment. In this framework the underlying endogenous causality between tenure security and investment behaviour is also taken into account and this provides the theory for testing whether investment is because of higher long-term security or the other way round, i.e., tenure security is enhanced because of the investment conducted on forestland.

3.2 Empirical Strategy

This sub-section discusses the econometric strategy to estimate the impact of forestland property rights on tenure security and forest investment. The empirical testing will be conventional.

First of all, I_{ijt} (investment of household i on plot j in period t), the major independent variable, is a continuous variable, which sums up both physical investment and money-equivalent of labor input. (It will be transformed into the log form for a more favourable and less skewed distribution.)

The tenure security variable is defined as T_{ijt}, how secure household i feels for plot j in period t. The property rights variable R_{ij}, is also a latent one, that how household i perceives its specific rights on plot j, or the whole bundle of rights he or she enjoys. Both T_{ijt} and R_{ij} are observed measurements for each and are not dummy variables but ordinal ones.

Let X and Z be two vectors of exogenous variables representing household and plot characteristics, respectively, to control for household; and let u, v, ε be uncorrelated error terms in each equation.

Step 1: To estimate tenure security, equation (5)[2] can be derived from the theoretical model in Appendix A:

$$T_{ijt} = \alpha + \gamma R_{ij} + \rho T_{ijt-1} + \tau_1 I_{ijt-1} + \delta_1 X + \theta_1 Z + u, \quad (5)$$

where tenure security T_{ijt} is thought to be endogenously determined by previous investment I_{ijt-1}, previous tenure security T_{ijt-1}, and property rights R_{ij}, controlling for household and plot characteristics. Because this study focuses on the impact of forest reform in terms of giving stronger contracted property rights to forest farmers, the previous-tenure security variable will be out of the interest due to: 1) no available data on this variable, and 2) it is formed before this round of reform, thus not affected by the reform speaking from the time span. Hence the term ρT_{ijt-1} is dropped out from equation (5), yielding equation (6) in below as ***the main estimation on tenure security***:

$$T_{ijt} = \alpha + \gamma R_{ij} + \tau I_{ijt-1} + \delta_1 X + \theta_1 Z + u, \quad (6)$$

Step 2: This step gives ***the main estimation on investment***. Note that in this second step the estimation strategy is based on the result from the first step.

In equation (7):

$$I_{ijt}{}^1 = \beta + \theta T_{ijt} + \lambda_1 I_{ijt-1} + \delta_2 X + \theta_2 Z + v, \quad (7)$$

the conventional method such as Ordinary Least Square (OLS) regressions can be used to test only if the result from equation (6) for the parameter τ is insignificant, excluding the possibility of tenure security-enhanced investment.

Otherwise (if τ in equation (6) is significant), some unconventional method will be required to deal with the endogeneity problem in equation (7) such as using instrumental variable for T_{ijt} to deal with endogenous causality, like the method that several studies have done before (Besley, 1995; Brasselle et al., 2002; Deininger and Jin, 2006; Xie et al., 2011).

The significance of τ in equation (6) implies that investment enhances tenure security. Also, in equation (7), it induces the collinearity between the two explanatory variables, T_{ijt} and I_{ijt-1}, and endogenous causality problem between I_{ijt} and T_{ijt}

[2] Numbering of equations is consecutive with the numbering in Appendix A.

because the explanatory variable will be a result of the independent variable, to some degree. This can lead to a biased and inconsistent estimation with OLS regression.

However, this can be managed with a number of econometric techniques, such two-stage least squares regressions by means of instrumental variable (dealing with endogenous causality), Heckman selection specification test (for self-selection or selection bias), and fixed-effects or random effects regressions (excluding historical and/or geographical influences in panel data). In case of the existence of endogeneity, to find good instruments that deal with endogenous causality is not easy, because a good instrumental variable (IV) must satisfy two conditions: $cov\ (IV, T_{ijt}\ ) \neq 0$ (correlation: the more highly correlated, the better) and $cov\ (IV, v) = 0$ (exogeneity).

Step 3: In this step, if the parameter of I_{ijt-1} in equation (6), τ and the parameter of T_{ijt} in equation (7), θ are both insignificant, then equation (8) is ready to be estimated.

$$I_{ijt}{}^{2} = \eta + \mu R_{ij} + \lambda_2 I_{ijt-1} + \delta_3 X + \theta_3 Z + \varepsilon \qquad (8)$$

The tendency is to see if property rights directly stimulate investment (as measured by μ) when there is not strong evidence that tenure security encourages investment propensity (implied by an insignificant θ in equation 7). Previous investment can safely be included here as both rights and the investment prior to the reform are exogenous. (Plus, I also wanted to see if there was some sort of investment inertia in this story.)

In the next sub-section, *3.3*, the hypotheses of interest are derived based on the theoretical and econometric models here in section *3.1* and *3.2*. The econometric method to test the hypotheses will be introduced after data description in section 4 when section 5 begins.

3.3 Hypotheses

The study tested these five hypotheses:

H1) Households' forest investments depend on their perception of tenure security, property rights they enjoy, labor distribution, their income structure, and liquidity constraints;

H2) Stronger property rights directly increase forest investment;

H3) Higher perceived tenure security increases forest investment;

H4) Stronger property rights increase investment because they increase perceived tenure security;

H5) Perceived tenure security is related to farmer's economic wealth, political influence and experience of local institutional evolution;

Hypothesis *H1)* is the most general intuition of key elements that determine forest-related investment. It takes into account possible household demographics and plot characteristics in addition to tenure security and property rights that households enjoy. For example, households with a higher income share from forestry tend to attach a higher value on their forestland and hence be more willing to invest in it. However, such investment decreases if the land cannot be easily transferred, or credit access is limited, and households cannot use their land as collateral.

Hypotheses *H2)* and *H3)* check whether forest investment is increased due to property rights reform in China, and whether there is any link between tenure security and forest investment. Hypothesis *H4)* focuses on the incentive to invest, whether investment increases when farmers feel they have stronger property rights, or because of securer perception of tenure that induced by stronger specific property rights or a bundle of such rights.

Hypothesis *H5)* tests how perceived tenure security is linked to other factors. Wealthier people, for example, may feel they have greater tenure security and more income for investment; more powerful people may have higher tenure security perception due to their political advantage where they more likely can obtain policy or political assistance. In contrast, higher frequency of local land redistribution or

reallocation may decrease farmers' perception of tenure security because of the imposed future risk or uncertainty.

4. Data and Descriptive Statistics

The data come from the Environment for Development (EfD) center in China (also known as the Environmental Economics Program in China, EEPC), located in Peking University. In order to evaluate the performance of China's recent collective forest tenure reform since 2003, commissioned by State Forest Administration of China, EEPC initiated its first round survey across China in early 2006 and have collected both household- and village- levels of panel data from eight reformed provinces (Fujian, Jiangxi, Zhejiang, Anhui, Hunan, Liaoning, Shandong, and Yunnan) by the end of 2007. At this time, more than 10 provinces had announced their plans for collective forest reform. In each province, the surveyed counties were randomly chosen, and interviews were conducted in 10-20 randomly selected households, in 5 or 6 villages randomly chosen in each county. Table 1 lists the sample statistics of the survey.

Table 1. Sample Distribution of the 2006-2007 Survey of Collective Forest Reform, China

Time	Province	County	Township	Village	Household
March-April 2006	Fujian	12	36	72	720
May 2006	Jiangxi	5	15	30	300
Oct-Nov 2006	Zhejiang	6	18	36	360
April 2007	Anhui	5	15	30	300
April 2007	Hunan	5	15	30	300
May-June 2007	Liaoning	5	15	30	300
May-June 2007	Shandong	5	15	30	300
August 2007	Yunnan	6	12	30	600
Total:	8	49	141	288	3180

Sources: Survey conducted by EEPC, Peking University in 2006 and 2007 (data collected for 2005 and 2006 respectively.

The comprehensive database covers information on: firstly, at the village level, forest resource change, village natural conditions, village social, economic and demographic characteristics, land use patterns, land use policies governing the village decisions, forest regulations, public programs, village political systems, etc.; secondly, at the household level, their social, economic and demographic characteristics,

production and consumption, land use practices and land rights, forest management activities and use rights, asset changes, social capital and relationships, as well as the information on participation in the reform. The time span in the questionnaires covered 2000 (before the reform) and 2005 or 2006 (after the reform).[3] Below is brief introduction and descriptive statistics on the data and variables of interest.

4.1 Property Rights Regime under the Reform

In China, the ownership of all forestlands belongs to the collectives. Individual households can contract for use rights and the ownership of trees planted on their plots. This management form (i.e., individual household management) consists of private/family plots and responsibility plots/hills, of which the latter differs from the former in that, decision-making needs to be shared by both the collective and households, although the collective owns both the land and the trees as a premise in both cases. Table 2 provides statistics about shares of different tenure types in each province, presenting the absolute dominance of individual management as a land tenure type, ranging from over 50 percent in Fujian province, to 92 percent in Hunan province. In addition to its dominance in management form, also, as the fundamental goal and means of the collective forest tenure reform after 2003, it is of great importance to study how the contracted rights that farmers enjoy affect their tenure security perceptions and investment incentives.

[3] Year 2005 or 2006 depends on the surveyed time in each province, i.e., the information for year 2005 was collected if the province was survey in 2006, such as Fujian, Jiangxi and Zhejiang, while the rest are for year 2006 in the panel.

Table 2. Share of Forest Tenure Type, China, 2006/2007 (%)

Province	Year	Individual	Partnership	Villager cluster	Outsider contract	Collective	Eco-reserve	Total
Fujian	2005	50.63	7.81	5.62	4.72	13.78	17.44	100
Jiangxi	2005	62.97	2.77	4.16	9.95	12.47	7.67	100
Zhejiang	2005	82.66	1.37	7.48	0.25	7.37	0.87	100
Anhui	2006	85.07	0.4	3.06	1.28	2.07	8.12	100
Hunan	2006	92.43	0.27	4.46	0.74	0.98	1.11	100
Liaoning	2006	55.21	7.04	3.08	11.9	22.09	0.68	100
Shandong	2006	54.3	0	0	7.05	3.08	35.56	100
Yunnan	2006	69.87	3.68	16.63	0.45	5.03	4.35	100
Total	2006	69.14	2.92	5.56	4.54	8.36	9.48	100

Sources: Survey conducted by EEPC, Peking University in 2006 and 2007.

The data for contracted property rights provides information on: 1) forestland use rights: *converting to agricultural land*, *converting to other forest types, selecting tree species to plant*, *managing non-timber forest products*, *abandoning forestland*; and 2) gains-from-trade rights: *mortgaging plots* or *forestland certificates as collaterals*, and *transferring plots within or outside* their own village. Following Holden et al. (2009b), I also create a property rights index representing the strength of the bundle of rights farmers enjoy, by summing up the scores of each perceived right. A score of 0 means that respondents did not feel they had one specific right, 0.5 if they were uncertain, and 1 if they were sure about this right. Table 3 shows the summary statistics of each disaggregated right and the rights index.

Table 3. Disaggregated forestland rights at household forest plot level, China

	Fujian		Jiangxi		Zhejiang		Ahhui	
Type of Forestland Right	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Right to convert forestland to cropland	0.443	0.48	0.512	0.486	0.535	0.489	0.462	0.497
Right to change forest type	0.709	0.439	0.804	0.386	0.739	0.421	0.533	0.493
Right to select tree species	0.744	0.424	0.821	0.372	0.768	0.412	0.553	0.492
Right to use non-timber products	0.836	0.367	0.869	0.332	0.798	0.399	0.599	0.489
Right to abandon forestland	0.598	0.367	0.772	0.317	0.71	0.398	0.584	0.452
Right transfer plot to other villagers	0.622	0.464	0.652	0.465	0.648	0.455	0.512	0.483
Right to transfer plot to outsiders	0.51	0.481	0.627	0.473	0.579	0.47	0.478	0.482
Right to mortgage forestland as collateral with certificate	0.139	0.337	0.057	0.229	0.192	0.386	0.115	0.317
Right to mortgage forestland as collateral without certificate	0.391	0.469	0.337	0.467	0.26	0.429	0.207	0.402
Property Rights Index (Sum of Scores)	4.986	2.612	5.452	2.383	5.229	2.883	4.044	3.344

	Hunan		Liaoning		Shandong		Yunnan		Full Sample	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Right to convert forestland to cropland	0.013	0.115	0.079	0.259	0.782	0.41	0.423	0.49	0.412	0.484
Right to change forest type	0.016	0.124	0.418	0.437	0.821	0.38	0.642	0.474	0.614	0.471
Right to select tree species	0.016	0.124	0.547	0.459	0.824	0.378	0.667	0.465	0.65	0.465
Right to use non-timber products	0.016	0.124	0.77	0.402	0.861	0.345	0.771	0.418	0.728	0.441
Right to abandon forestland	0.019	0.136	0.66	0.363	0.806	0.351	0.687	0.387	0.619	0.414
Right transfer plot to other villagers	0.016	0.124	0.584	0.453	0.745	0.421	0.518	0.488	0.566	0.478
Right to transfer plot to outsiders	0.013	0.111	0.532	0.458	0.618	0.467	0.466	0.487	0.596	0.481
Right to mortgage forestland as collateral with certificate	0.007	0.072	0.227	0.402	0.023	0.149	0.091	0.284	0.117	0.314
Right to mortgage forestland as collateral without certificate	0.027	0.157	0.209	0.38	0.651	0.469	0.325	0.459	0.323	0.456
Property Rights Index (Sum of Scores)	0.142	0.848	4.026	2.289	6.13	2.671	4.59	2.919	4.527	3.005

Notes: 1= if have use righs, 0.5=if use rights requires approval, 0=if no use rights. Property Rights Index=sum of scores of each right.

On average, farmers' perceptions on forestland use rights are stronger than gains-from-trade rights in all eight provinces (indicated by the mean values of the first five rights are larger than the rest four). Forestland owners in Fujian, Jiangxi, Zhejiang, and Shandong enjoy significantly stronger rights than others, as seen by comparing the mean value of the property rights index of the full sample, 4.527, where the scores range from 0 to 9. Forestland transfer and mortgage rights are perceived to be weaker than the basic land-use rights in each province. Owners in Hunan province perceive the weakest

property rights (with an index score of 0.142) and the right to mortgage forestland certificate as collaterals are allowed only on 0.7 percent of plots (the lowest in the whole sample) and more than 2 percent of plots have no perceived land-use rights.

In addition to looking at whether perceived land rights increase owners' inclination to invest, this study also investigates *whether holding a forestland certificate (or contract) or not*, and the *length of the certificate (or contract)* affects investment, especially since China's forestland reform extended the allowable contract period by 30 to 70 years. In the survey data, the average contract length is 69.66 years, but unfortunately only 23 percent of plots have forestland certificates. (This excludes 11 percent of the respondents reporting that they did not know whether they held forestland certificates or not.)

4.2 Farmer's Perception on Tenure Security

To measure tenure security, existing literature has used various proxies: possession of formal title, length of time a plot has been used (Jacoby et al., 2002), possession of documents certifying land rights (Brasselle et al., 2002), and use of transfer rights (Besley, 1995), for example. Deininger and Jin (2006) introduced a new subjective indicator for tenure security—whether a household perceives a risk of land redistribution in the future, e.g., the next five years; and Holden et al. (2009) found a more precise subjective indicator that express households' perceptions of tenure security, i.e., whether a household still owns the specific land after five years. Both Deininger and Jin (2006) and Holden et al. (2009) used households' perceived ability to transfer, mortgage, or sell land to indicate the transferability of land in their studies.

In EEPC's survey, farmers were asked about their perceptions on whether they think they will still hold a specific land or plot after three, five or ten years. This is a satisfactory proxy for perceived tenure security, mainly because tenure security is a subjective variable, and yet there hardly exists an objective measurement on it. Holden et al. (2009b)'s assessment approach used whether a household will hold a plot after five years as the dependent variable in their analysis of plot-level tenure security in

three provinces of China (Fujian, Jiangxi, and Yunnan). Hence, this study also adopts this variable to see whether property rights reform affects farmers' expectations that they will retain their holding of specific forestland in the future, and whether their incentive to invest is induced by more secure perception "ownership" or directly by stronger contracted rights. The aim is to derive a more generalized outcome from a larger sample of eight provinces than the three assessed by Holden et al. (2009b).

Holden et al. (2009b)'s way to score the answer to whether holding the plot after five years (instead of the other two variables of three or ten years)[4] is followed. A score of 2 is given to the perceived tenure security variable if the respondents answered yes, 1 if they were uncertain, and 0 if they were sure that they would not hold this plot after five years. Table 4 gives the summary statistics of farmers' perceived tenure security.

Table 4. Summary Statistics of Perceived Tenure Security

Province	Mean	Std. Dev.	Min	Max	Observations
Fujian	1.887	0.347	0	2	10088
Jiangxi	1.918	0.332	0	2	5409
Zhejiang	1.919	0.318	0	2	6955
Anhui	1.86	0.434	0	2	1700
Hunan	1.699	0.524	0	2	4400
Liaoning	1.89	0.348	0	2	6499
Shandong	1.847	0.427	0	2	6235
Yunnan	1.867	0.446	0	2	3171
Total	1.869	0.39	0 (1.9%)	2 (89%)	44457

Notes: Variable specification: If owners perceive they will hold the plot after five years. (0=no, 1=uncertain, 2=yes)

In each province, a majority of owners felt secure in holding their plots after five years, as all the mean values are close to 2. In the full sample, almost 89 percent of respondents reported they were sure to own the plot after five years while only 1.9 percent would not, and the rest were uncertain about their ownership. This implies a lack of variation in tenure security perception and a possible selection bias when measuring its effect on investment behavior because this might be either selected by

[4] The variables for holding plots after three years or ten years were dropped because a large number of values were missing. There were 15,497, 44,457, and 28,920 observations for holding plots after three, five, or ten years, respectively.

intention or sample self-selection. Hence it would be necessary to take this into account when empirically estimating its impact on investment.

4.3 Forestland-related Investment

The investment variable is aggregated from the survey data. Table 5 shows the total expenditure on existing forestland in the eight provinces for 2000 and 2005/2006 (before and after China's collective forest tenure reform), including: 1) physical investment on fertilizer, pesticide, irrigation, machinery, etc., plus farmer households' afforestation related investments consisting of trees, areas, seedlings, and 2) labor input related on forestland.

Table 5. Distribution of Forestland Investment in China under Individual Management in 2000 and 2005/2006

Province	2000 (*In Chinese Yuan*)			2005/2006 (*In Chinese Yuan*)		
	Mean (Std. Dev.)	**Min**	**Max**	**Mean (Std. Dev.)**	**Min**	**Max**
Fujian	280.69 (945.72)	0	7740	559.52 (1821.04)	0	20550
Jiangxi	4.41 (33.39)	0	397.5	8.79 (60.12)	0	800
Zhejiang	79.63 (660.5)	0	11050	73.71 (311.09)	0	3540
Anhui	130.42 (464.25)	0	5340	682.13 (6571.97)	0	100499
Hunan	0 (.)	0	0 (.)	0 (.)	0	0 (.)
Liaoning	50.61 (452.97)	0	6400	182.09 (770.71)	0	16300
Shandong	95.64 (431.76)	0	4410	224.2 (678.03)	0	7440
Yunnan	32.54 (147.22)	0	1500	151.3 (413.39)	0	4125
Total	116.24 (619.69)	0	11050	258.82 (1734.8)	0	100499

Source: Survey conducted by EEPC, Peking University in 2006 and 2007.

Except for Hunan, in all the other provinces, both the average investment and the maximum invested amounts in 2005 are significantly higher than the levels in 2000, while no such differences occur in Zhejiang. This may be because Zhejiang has a more advanced industrial economy and well-functioning off-farm job market. In Hunan province, there was no investment in forestland under individual household control either before or after the reform. However, looking at the samples for forestland of other tenure types, Hunan showed some investment of 15,400 yuan in 2005 (mean 230 yuan), and no investment in 2000. This may be explained by the strikingly poor perception of

property rights (an average property rights index score of 0.14), compared to the other provinces' scores, which were greater than 4. Although tenure security overall is quite high in all eight provinces, Hunan has the lowest with an average of 1.7.

There are two main reasons for totaling all capital investment (or expenditure) and money-equivalent labor inputs to measure forestry investment. First, it is obvious that, farmers who live on their cropland or off-farm jobs earnings consider forestland to be an extra asset given to them during the reform. In other words, because the return of input on forestland is expected in a longer term than from cropland or off-farm employment, capital inputs (such as trees, seedlings, fertilizer, pesticide, irrigation, machinery) are seen as investments. Second, farming is more labor intensive while forestry activities does not require labor at the same time as agricultural activities. For individual households, the shadow price is thus lower in forestry labor, resulting in a fairly lower labor cost for forestland-related investment, which implies a higher return in the near future.

This is an improvement to the existing literature in terms of this monetized investment variable. By taking the log forms of investment variable, the effect of owners' tenure security perceptions on the elasticity of their investment can directly be captured; in addition, its distribution is less skewed or heteroskedastic. In contrast, previous studies either use a binary investment variable or only consider tree planting behaviors or land-related improvements to measure land-related investment.

To see how the reform after 2003 affected farmers' investment, a dummy variable representing whether the *village has implemented the reform or not after 2003* is generated (1=yes and 0=no) according to the most recent year of forest tenure reform in the village. It is not easy to separate the effect between this round of reform and historical influence, which could affect people's future investment behavior. So, to control for the inertia influence from previous investment behavior, the investment in 2000 is included in the investment estimation.

4.4 Other Explanatory Variables

Table 6 gives the means and standard deviations of the household-level and individually controlled forest plot-level variables, as well as other control variables. The first category is **household socio-economic characteristics**, including household size, household head's age, sex, and education; total household income and forestry income share, liquidity constraints (i.e., house value, borrowed money or not), political power proxies (i.e., party membership, village leadership, once having job in forestry sector), and a proxy for social capital (i.e., whether they can successfully borrow 500 yuan within one week). Another category is **plot characteristics** under individual management, such as plot size, total number of plots in 2005, irrigation condition, distance to home and road, slope, forest type, year when contracted, the length of a rotation period, certificate received for plot, and length of contract for plot (the second category of characteristics), are also included.

It can be seen that income level is higher in Zhejiang, Anhui, and Yunnan provinces, while forestry income share is the highest in Fujian (6%). In Jiangxi and Zhejiang, forestry contributes 4 percent to total household income, and 2 percent in Anhui and Yunnan. It can be also seen that forest plot size is largest in Fujian and smallest in Shandong. More of the forest is on steeper land in Zhejiang, Liaoning, and Yunnan. Distances to home and road are more than 1 kilometer on average, except for Shandong, where these distances are shorter.

Length of a rotation period is the longest in Liaoning (35 years) and Hunan (30 years), but is only 12 years in Jiangxi.[5] This is primarily due to agro-ecological circumstances, and Liaoning is the only one province located in northeastern China—the dominant tree species are black pine, larch, and robur —and its forests were previously managed by state-owned forest enterprises. The overall forest age was younger in Anhui, Shandong, and Yunnan when individual owners began managing their forestland. (Data for Hunan is missing or unknown.) Households hold forestland

[5] The variable of length of a rotation period has a great number of missing values, so the author replaced the missing ones by the county's average length of rotation.

certificates for an average of 23 percent of the plots under individual management, with the lowest in Shandong (merely 1%) and the highest in Zhejiang (41%) and Liaoning (47%).

Due to such great diversity in the sample geographical distribution, province dummies were created to control for geographical fixed effects that is not captured by the other explanatory variables. **Other explanatory factors** include household's total cropland area, total working days in off-farm jobs, number of times villages made small land adjustment by 2006 or 2007, and their expectation on future small land adjustment which might affect one's perception of tenure security. Households in Jiangxi and Zhejiang have the largest number of working days in off-farm jobs, in addition to its contribution to household total income, this is also seen as an opportunity cost for forestry activities. Meanwhile, total cropland area is larger in Hunan and Yunnan, close to 20 *mu* per household.[6] Number of small land adjustments in the village is perceived relatively higher in Hunan and Liaoning than the rest.

Table 6.Descriptive Statistics of Basic Characteristics

Variable	National Mean (Std.D.)	Fujian Mean (Std.D.)	Jiangxi Mean (Std.D.)	Zhejiang Mean (Std.D.)	Anhui Mean (Std.D.)	Hunan Mean (Std.D.)	Liaoning Mean (Std.D.)	Shandong Mean (Std.D.)	Yunnan Mean (Std.D.)
Household Characteristics									
Household size, (number of people)	4.31 (1.64)	4.65 (1.67)	4.69 (1.61)	4.06 (1.68)	4.71 (1.71)	4.31 (1.71)	3.65 (1.25)	3.9 (1.33)	5.04 (1.76)
Age of household head, (years)	50.5 (10.97)	49.33 (10.78)	50.14 (10.91)	51.63 (10.46)	51.66 (11.82)	51.92 (10.82)	52.42 (10.05)	50.94 (11.62)	46.01 (11.43)
Educated years of household head	5.89 (3.16)	5.01 (3.21)	5.93 (2.64)	5.33 (3.11)	6.04 (3.52)	6.97 (2.94)	7.19 (2.56)	6.16 (3.37)	5.71 (3.32)
Gender of household head. 1=male, 0=female	0.96 (0.19)	0.97 (0.16)	0.96 (0.2)	0.97 (0.18)	0.97 (0.16)	0.96 (0.21)	0.98 (0.15)	0.94 (0.24)	0.92 (0.27)
Household head is member of the Communist Party [a]	0.18 (0.39)	0.17 (0.37)	0.17 (0.38)	0.19 (0.39)	0.24 (0.43)	0.18 (0.39)	0.24 (0.43)	0.16 (0.36)	0.13 (0.33)
Household head is village leader [a]	0.06 (0.24)	0.07 (0.25)	0.05 (0.22)	0.09 (0.29)	0.12 (0.32)	0.03 (0.18)	0.03 (0.16)	0.06 (0.24)	0.06 (0.24)
Household head once has job in forestry sector [a]	0.01 (0.11)	0.02 (0.15)	0.003 (0.06)	0 (0)	0.01 (0.09)	0 (0)	0.04 (0.19)	0.01 (0.1)	0.01 (0.1)

[6] 1 mu=1/15 hectare.

Total household income,	38637	34129	27373	54402	48795	16937	17937	13277	56033
(yuan)	(143799)	(38110)	(27399)	(122215)	(135735)	(14169)	(23394)	(19247)	(372920)
Log of total household income	9.97	9.997	9.86	10.12	10.16	9.45	9.45	8.99	9.85
in yuan	(1.01)	(0.99)	(0.9)	(1.14)	(1.01)	(0.79)	(0.8)	(1.02)	(1.06)
House value in 2005, (10,000	5.08	4.52	3.09	8.57	5.56	5.6	4.58	3.77	4.43
yuan)	(9.01)	(7.57)	(4.04)	(12.35)	(9.42)	(10.74)	(8.07)	(4.23)	(12.29)
Borrowed money or not. [a]	0.39	0.45	0.4	0.35	0.32	0.32	0.45	0.33	0.49
	(0.49)	(0.5)	(0.49)	(0.48)	(0.47)	(0.47)	(0.49)	(0.47)	(0.5)
Can successfully borrow 500	1.79	1.72	1.75	1.86	1.88	1.89	1.82	1.87	1.62
yuan within one week [b]	(0.57)	(0.53)	(0.66)	(0.51)	(0.48)	(0.46)	(0.58)	(0.5)	(0.78)
Forestry income share	0.04	0.06	0.04	0.04	0.02	0.013	0.012	0.005	0.02
	(0.13)	(0.14)	(0.11)	(0.14)	(0.08)	(0.06)	(0.06)	(0.03)	(0.07)
Forest Plot Characteristics									
Forest plot area (mu)	38.1	48	12.13	5.4	4.2	6.6	156.5	0.83	13.85
	(302.5)	(349.5)	(37.3)	(8.76)	(14.51)	(13.39)	(642.3)	(1.18)	(54.68)
Household's total plot number	2.69	2.89	2.99	3.64	3.93	2.38	2.09	1.61	2.53
in 2005	(2.33)	(2.33)	(2.12)	(3.23)	(3.02)	(1.55)	(1.67)	(1.08)	(2.14)
Irrigation dummy [a]	0.19	0.13	0.16	0.21	0.07	0.14	0.02	0.58	0.11
	(0.39)	(0.34)	(0.37)	(0.41)	(0.26)	(0.35)	(0.15)	(0.49)	(0.32)
Slope (1 = >25, 0=<25)	0.56	0.67	0.64	0.71	0.39	0.4	0.75	0.05	0.68
	(0.5)	(0.47)	(0.48)	(0.45)	(0.49)	(0.49)	(0.43)	(0.22)	(0.46)
Distance to home, (km)	1.59	1.97	1.82	1.84	1.3	1.09	1.67	0.32	2.56
	(1.9)	(1.75)	(1.72)	(1.95)	(1.28)	(1.8)	(1.83)	(0.48)	(3.05)
Distance to road, (km)	1.34	1.28	1.4	1.64	1.49	0.99	1.89	0.36	1.96
	(1.87)	(1.47)	(1.57)	(1.99)	(1.88)	(1.83)	(2.34)	(0.58)	(2.71)
Forest type [c]	1.24	1.68	1.77	1.71	0.96		1.16	0.14	0.79
	(1.05)	(0.97)	(0.97)	(0.97)	(1.15)	.	(0.63)	(0.56)	(0.84)
Length of one rotation period	19.47	19.16	12	12.2	18.09	30	34.99	14	12.99
(years)	(8.66)	(3.36)	(0.38)	(3.46)	(3.49)	(0)	(2.03)	(0.33)	(1.08)
Start year of managing forest	1993.2	1993.2	1992.8	1991.6	1989.6	1990.4	1993.1	1995.2	1995.3
plot	(11.9)	(15.3)	(9.2)	(11.2)	(10.9)	(9.4)	(10.5)	(9)	(11)
Has certificate or not for forest	0.23	0.16	0.13	0.41	0.26	0.4	0.47	0.01	0.15
plot [a]	(0.42)	(0.36)	(0.33)	(0.49)	(0.44)	(0.49)	(0.5)	(0.12)	(0.36)
Length of contract for forest	69.67	63.3	81.89	74.17	64.41	27.75		68.94	66.04
plot (years)	(46.15)	(45.15)	(46.9)	(42.02)	(44.53)	(37.53)	.	(49.72)	(46.43)
Other Control Variables									
Household's total cropland	12.19	10.79	10.3	7.8	12.84	19.09	13.71	16.73	19.47
area (mu)	(27.17)	(10.53)	(9.04)	(53.27)	(10.47)	(14.99)	(10.65)	(12.81)	(16.9)
Household's total working days	534.5	540.5	614.1	666.2	557.1	546.7	431.3	444.1	398.1
in off-farm jobs	(530)	(517.6)	(554.4)	(615.3)	(428.5)	(539.4)	(477.4)	(410.2)	(534.4)
Number of times of small land	1.54	1.26	1.98	1.36	1.16	2.36	2.62	1.07	0.38
adjustment in the village	(2.21)	(1.94)	(2.2)	(2.31)	(1.25)	(2.54)	(2.26)	(2.27)	(0.77)

Expectation of small land	1.1	0.81	1.23	1.15	0.81	1.21	1.08	1.5	0.95
adjustment in the future [b]	(0.89)	(0.86)	(0.83)	(0.9)	(0.83)	(0.83)	(0.93)	(0.78)	(0.88)

Notes: 1 mu= 1/15 hectare.

[a] Dummy variables (1 = yes, 0 = no)

[b] Ordinal variables (0 = no, 1 = unsure, and 2 = yes)

[c] Forest type, based on availability of forest harvesting (0 = no forest, 1 = young forest, 2 = nearly mature forest, 3 = overmature forest)

5. Econometric Results and Discussions

The empirical discussion in this section focuses first on determining the impact of contracted forestland rights on perceived tenure security. The potential impact is estimated, which greater tenure security or stronger contracted rights, or stronger contracted rights through enhanced tenure security, has on forest related investment. Table 7 presents the results from ordered probit (models 1 and 3) and ordered logit (models 2 and 4) models for tenure security perception determinations, using the contracted rights index versus disaggregated rights variables. Table 8 reports estimated results for determinants of forest investment, where model 5 represents the Heckman selection two-step results in the cross section data for 2005[7], and models 6 and 7 represent the results of random effects models of rights index or disaggregated rights in the panel data with year 2000 and 2005/2006 information available.

The new forest tenure reform has a salient effect in enhancing tenure security and stimulating forest investment. There is no strong evidence supporting the endogenous relation between investment and tenure security, as in some African countries, where investment is usually undertaken to enhance tenure security. However, in the case of China, previous investment seems to increase future inputs due to some investment inertia, with a fairly small marginal effect (0.03% or 0.06%, estimated by the Heckman selection two-step model and random effects models, respectively). Stronger contracted property rights, not only enhanced tenure security, can also directly stimulate investment directly (not necessarily through enhanced tenure security). Furthermore, tenure security is related to household's economic wealth, political influence, and

[7] Only the result of the second step of Heckman selection two-step regression is reported in the column under model 5 in Table 8.

experience of local institution evolution, while forest investment also depends on labor distribution, income structure, and credit constraint, as expected.

5.1 On Perceived Tenure Security

Because of the ordinal dependent variable with more than two outcomes—whether household still owns plot after five years (0=no, 1=unsure, and 2=yes)—maximum likelihood ordered probit and logistic regressions are applied to assess the factors correlated with perceived tenure security. The maximum likelihood method adopts a nonlinear formulation and uses cumulative probability functions [8] to assume distributions of error terms, so non-linear effects in estimating probabilities are corrected. This method is believed as better designed for models with ordinal outcomes than least squares regressions, especially in large samples.

With respect to household heterogeneity, robust White/Sandwich estimation is used to correct heteroskedastic standard errors through Taylor-series linearization method. Provincial dummies are included to control for geographical fixed effects or unobserved specific factors. It is also worthwhile to point out that, coefficients of the ordered probit or logistics regressions reported by STATA are merely interpretable by their signs and *z*-statistics, so marginal effects of the estimators are computed and presented in Table 7, while the original regression results is presented in Table 9 in Appendix B.

A key finding for all individually controlled forestland is the significant difference of tenure security perception between villages accepting the new reform (after 2003) versus those without any new reform. The marginal effect suggests households in reformed villages perceive a higher probability (2.5%) of owning their plots five years later. Both the contracted property rights and the aggregated index of contracted property rights are highly significant (at 1%) in both probit and logit models and have a positive sign, demonstrating a strong enhancing correlation between the number and strength of contracted rights and the feeling of tenure security.

[8] It assumes the logistic cumulative distribution function of the former and standard normal cumulative distribution function of the latter.

This finding is consistent with Holden et al. (2009b)'s study in Fujian, Jiangxi and Yunnan. The right to change forest type, the transfer right to outsiders, and the right to mortgage forestland without certificates are insignificant, and even the right to transfer to outsiders has a negative sign. However, the right to transfer plots to other villagers, and the right to mortgage plots with certificates are positive and significant. This may imply an emerging market for land transfers in rural China, so households perceived this and hence a significant probability to use their right to transfer, which apparently depends on how well the land transfer market is functioning. Comparing this fact to the literature, perceptions of transferability rights or even a bundle of rights can be a good indicator of tenure security, but it does not provide the whole story if used as a proxy for tenure security.

It is also noteworthy that the coefficient of previous investment (in year 2000) is not statistically significant in any of the four models: perceived forestland tenure security seems not to be enhanced by investment operations in the same way as in some African countries (e.g., Ethiopia). This turns out that the parameter τ in equation (6) in section 3.2 is insignificant and hence the investment equation (7) is safe to test (of which the results are presented in Table 8 and discussed in the next subsection 5.2).

The hypothesis *H5)* that, *perceived tenure security is related to farmer's economic wealth, political influence and experience of local institutional evolution,* is supported in all the four models. First of all, the log of household total income (significant at 10% level) and plus the 2005 house value (indicator of wealth level in rural China, and significant at 1%) are positively associated with more secure feeling on tenure, but with a very small magnitude of marginal effects.

Second, the extent of land tenure security is influenced by the social status or bargaining power of the household (Brasselle et al., 2002). However, their study did not include these variables in their estimation, because they did not have the directly measured data. The political influence in this study is measured by whether household head is member of the Communist Party or is a village leader. The former has a positive

sign in each model but is insignificant, and the latter is highly significant in models 1, 2, 3. (In model 4, it is significant at 10%.) This result is interesting in the case of rural China where village leaders are considered as the functional ones who implemented the reform and make decisions.

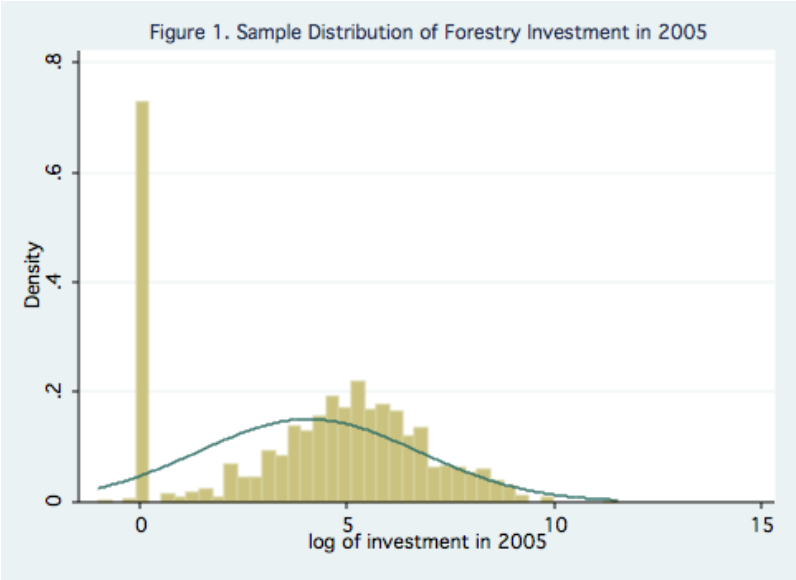
Third, the experience of local institutional evolution is measured by number of times of small land adjustment with regard to cropland and owner's expectation of such adjustment in the near future. The former is positively correlated and the latter is negative, both highly significant (at 1% level). This may be because in rural China, cropland adjustment usually occurs every three or five years in response to new births and deaths. However, the rural population growth implies that owners perceive such cropland adjustments as gains. Interestingly, the negative relationship between expectation of future small adjustments and tenure security perception seems confusing, but suggests some risk and uncertainty regarding forestland as an extra asset for individual households.

Several other interesting findings emerged from this study. First, the importance of forestry in household income share, household's total number of plots, plot's irrigation condition, distance to road, are highly significant and positively correlated with tenure security. For example, the farther a plot sits from a main road indicates a smaller probability of land acquisition by the government or companies to build a high way, for example. Second, more years of education implies a greater possibility of working off-farm jobs, which is also consonant with the coefficient of household's total working days in off-farm jobs. Although a larger family size indicates more gain of plots allocated from the government, it also means more population for inner household reallocation for forestland (inheritance), which is a traditional culture in rural China. Both these two factors undermine tenure security perception in a statistical significant way (at 1% level), but still the magnitude of marginal effects is rather small (0.2% and -0.07%). In addition, Jiangxi significantly enjoys higher tenure security than other provinces while Zhejiang the opposite.

Brasselle et al. (2002), Baland and Platteau (1999) have found in particular that, highly visible investment behavior such as fences building or trees planting, are often made to enhance the owner's property rights to the specific plot of land, which makes it difficult to clarify whether the observed investment outcomes are a cause or a consequence of more secure property rights. In this study, the respondents provided information on these two variables at the same time. Thus, a future research interest is set on the possible causality between tenure security perception and investment in the same period (2005/2006). This requires looking deeper into the data, and finding a good instrument to be correlated with the explanatory variable but exogenous to the error term.

5.2 Determinants of Forestland-related Investment

There are several econometric issues to consider in estimating investment. Although the EEPC survey was designed based on the random sampling rule, potential selection bias is still a concern because: 1) there are a significant number of plots without any investment or input, as depicted in Figure 1; 2) the tenure security perception variable has a limited variation (the mean is 1.87 with 2 as max, and standard deviation is 0.39). Self-selection or rationing may be caused by other factors, such as perceived rights or household socio-economical characteristics (Heckman 1990). So selection bias was checked first by a Heckman selection specification test. Since the test result rejects the hypothesis of no selection bias in the model, a two-step approach suggested by Deaton (1997) was applied to correct for the model and obtain unbiased estimates, as reported in the column of model 5 in Table 8.



Another concern is possible endogeneity in households' expectation/perception of tenure security when estimating investment incentives, which is a common case in Ethiopia, and one of Brasselle et al. (2002)'s findings. It is not certain whether farmers in China's also invest in their plots to enhance tenure security, but this can be checked by econometric methods.

The third concern refers to Hypotheses *H2)*, *H3)* and *H4)*, i.e., whether stronger contracted property rights stimulates investment directly or through enhanced tenure security. The Heckman two-step regression (model 5) is run to correct for selection bias in the sample, presenting the corrected marginal effects of each coefficient in the column of model 5 and showing the effect of perceived tenure security on investment. Model 6 and 7 use the property rights index and each specific right in random effects models using the panel data (for year 2000 and 2005/2006), to estimate their direct effect on investment. (Due to the missing values of investment in 2000, 5292 observations were lost for random effects models.)

The most significant result from Table 8 is that either the property rights index (model 6) or each of the contracted rights except the right to transfer out (model 7) appear to have a significant impact on investment behaviour. (Brasselle et al. (2002), however, did not reach the same finding.) This result provides strong evidence for the

equation of *Case 2* in Appendix A (i.e., $\frac{\partial k_1 + \partial l_1^f}{\partial R} > 0$) and hypothesis *H2)* that stronger property rights directly increase forest investment. The coefficient of property rights index in model 6 implies that a higher score is estimated to increase investment by 5.9%. In model 7, the marginal effects induced by gains-from-trade rights are relatively greater than those use rights. For example, stronger perceived rights of the ability to transfer a plot to other villagers, and to mortgage a plot as collateral significantly increase investment by more than 33%. Except for the right to change forest type, the other use rights reduce the incentive to invest, and the effects are very significant at a 1% and 5% levels. This provides policymakers some hints as to farmers' willingness to manage forest based on their consideration for economic benefits, which is significantly stimulated by their rights to interchange among timber forest, economic forest, bamboo forest, or other.

Model 5 shows that, when selection bias is well controlled, enhanced tenure security does not have any significant effect on investment incentive. In other words, although contracted property rights enhance tenure security perception (from models 1-4), which is also consistent with the first step result in Heckman selection two-step regression, they do not necessarily affect investment through tenure security. Hence hypotheses *H3)* and *H4)* are rejected due to lack of evidence supporting the impact of tenure security on investment, as the coefficient of the variable "Household still owns plot after five years" is 0.113 and its *z*-statistic only 0.91, not significant even at 10% level. Holden and Yohannes (2002) reached a similar result that tenure insecurity had no direct effect on whether households purchased farm inputs or not (pp. 585).

Rather, households with a larger plot size and fewer number of plots, plots without irrigation condition and plots sitting closer to home and road are more likely to invest in forestland, as implied by their significance in models 5, 6 and 7. The forest type variable[9] and its coefficients demonstrate the belief that individual management

[9] The forest type variable is generated according to the availability of forest harvesting when owners start managing their plot, as its value of 0 means no forest on plot, 1 is young forest, 2 means nearly mature forest, and 3 means overmature forest standing on plot and ready for harvest.

stimulates harvesting and reforestation, hence more investment and input are undertaken in forestland. This finding complements Xie et al. (2011)'s study on the reform's effect on planation at the village level. (Here this study uses household- and plot-level data.)

Rotation age and the average length of one rotation period are assumed to prompt different investment behaviors. In addition to timber values provided by a standing forest, there are also some externalities offered by ecosystem services such as recreation, flood control, carbon sequestration, etc. Thus, *ceteris paribus*, the optimal rotation age differs among forestland owners, as those who consider only the timber value are likely to choose a shorter rotation age than the owners who also consider the external values (Bowes and Krutilla, 1985), where more harvests are possible, and more inputs investment per year are added to the land. This study proves that, controlling for initial forest type, the longer rotation age is, the more investment is required, roughly by 1.2% (significant in a 95% confidence interval).

In addition to the tenure security factor and property rights and to look at how hypothesis *H1)* is tested, the primary focus is on models 6 and 7. These are random effects regressions with data for the years 2000 and 2005/2006, and a satisfactory estimating power of explaining roughly 67% of the variation of investment in such a large sample. Again, the new forest tenure reform is significant for encouraging forest investments, when 85% higher investment is found in villages embracing reform compared with those without reform. The reform's effect is distinctive and consistent with that of forestland certificate (31.2% and 1% significant) and how recently owners began to manage their plots (1.5% and 1% significant). Respondents' expectations of future land adjustments discourage forest investment by 15% (significant at 1%) due to potential risk of land acquisition.

Household demographical and socio-economical characteristics affect investment propensity. Larger household size implies more labor is available for forestry activities and its coefficient (0.04) is significant at 1% level. Age (-2.5% and 1% significant), gender (-37% and 1% significant) and education (-2% and 1% significant) of household

head are negatively correlated with investment because older people may perceive less labor and time, males or higher educated people may be engaged more in off-farm jobs. This is consistent with the negative coefficient of household's total cropland area, implying farming as a substitute for forestry activities.

A household's total working days in off-farm jobs have a small positive effect on investment. This is not as expected as the opportunity cost theory indicates for forest investment, but implies that, forestry activities, different from being seen as a substitute for farming, are more like a complementary for off-farm jobs. This effect may be a result of increased household income, as off-farm employment averagely contributes 45% of the total household income in China.[10] Intuitively, higher income should provide more incentive for investment, but the evidence is not strong, since the sign of household total income is negative.

The variables of whether a household head is a Communist Party member or a village leader are included in the models because these attributes may indicate strong bargaining power and access to more information. Being a Communist Party member is estimated to significantly increase investment by over one third than those are not, predicting by models 5, 6, and 7. The negative coefficient of household head as a village leader may be explained by having less time available for forestry activities (substitution effect). To look at the income effect on forest investment from a government salary as a village leader, it becomes ambiguous given by the insignificant total household income (in log from) and the significantly small positive effect of household's total working days in off-farm jobs. Nevertheless, labor distribution is found to significantly affect forest investment.

Household's economic wealth and income structure in the models are defined by: household total income and the share from forestry income, and by house value in 2005 as an indicator of income level and credit availability. It is worth noting that a potential endogenous causality might be imposed by the forestry income share variable because

[10] The figure 45% is computed through household off-farm income divided by their total income in the data.

the share value is computed by the 2005 forestry income as a share of total household income. Unfortunately, data for the forestry income variable is not available for previous years, even no such information in 2000, causing too many missing values to run the regression. However, household income structure in rural China does not vary much across years; forestry income shares no more than 5 percent, so there is no better alternative to measure the importance of forestry in a rural family. The result is that a 1% increase in forestry income share can definitely encourage investment by 1.92%.

All the credit and liquidity variables, however, such as house value in 2005, whether the family borrowed money or not in 2005/2006, and whether they can successfully borrow 500 yuan within one week, are insignificant. This may be explained by the lack of well-designed and functioning credit markets in rural China at this moment. Again, as stronger mortgage rights strengthen the incentive to invest, government policy should support this trend by building infrastructure and implementing enforceable mechanisms for credit markets.

According to the author's participation in the pilot survey in Jiangxi in March 2011 (as a follow-up study on the reform after six years since the reform was implemented), formal credit and forestland transfer market only exists in Chongyi county, out of five counties visited. Moreover, limited land transfer transactions in magnitude suggest the shadow price of demand for forestland is below the owner's reserve price. More research is needed to study the land transfer market and owners' willingness to accept by estimating a supply and demand curve for such market. Also, taking account the government's concern for the poorest people and poverty reduction, welfare loss, and market/seller/buyer characteristics (whether sellers care who is buying, if they are richer or poorer than themselves, or what kind of jobs they have, etc.) are interesting research issues in behavioural economics.

The robustness of the results of models 6 and 7 were tested through adding provincial dummy variables to control geographical or other unobservable factors and the estimations do not vary. Because of collinearity, Hunan, Liaoning, Shandong and

Anhui dummies were dropped from the tenure security estimations, Fujian, Hunan and Liaoning dummies were dropped from the investment estimations. In estimating investment, the others show distinctive and significant effects: Anhui and Shandong have higher investment in forestry (at 1%), while Jiangxi, Zhejiang and Yunnan have less.

Table 7. Factors Correlated with Forestland Tenure Security: Results from Ordered Probit and Logit Models

Dependent variable:	**Property Rights Index**				**Disaggregated Rights Variables**			
Household still owns plot after five years	**(1) Ordered Probit**		**(2) Ordered Logit**		**(3) Ordered Probit**		**(4) Ordered Logit**	
Variable	**dy/dx**	***P*>|*z*|**	**dy/dx**	***P*>|*z*|**	**dy/dx**	***P*>|*z*|**	**dy/dx**	***P*>|*z*|**
Household size, number of people	-0.002 **	0.025	-0.002 ***	0.006	-0.002 **	0.017	-0.002 ***	0.008
Age of household head (years)	-0.0007 ***	0.000	-0.0006 ***	0.000	-0.0008 888	0.000	-0.0006 ***	0.000
Educated years of household head	0.007 ***	0.000	0.006 ***	0.000	0.007 ***	0.000	0.005 ***	0.000
Gender of household head (dummy: 1=male, 0=female)	0.009	0.166	0.013 **	0.014	0.007	0.233	0.012 **	0.023
Household head is member of CCP [a]	0.007 *	0.098	0.003	0.511	0.006	0.146	0.002	0.703
Household head is village leader [a]	0.015 ***	0.009	0.012 **	0.044	0.015 ***	0.008	0.01 *	0.084
Log of total household income	0.003	0.224	0.004 *	0.073	0.004 *	0.073	0.005 **	0.010
House value in 2005 (yuan)	0.001 ***	0.000	0.0008 ***	0.003	0.001 ***	0.000	0.0007 ***	0.009
Forestry income share	0.079 ***	0.000	0.088 ***	0.000	0.083 ***	0.000	0.09 ***	0.000
Forest plot area in mu	0.00004	0.423	0.00007	0.316	0.00003	0.505	0.00006	0.423
Household's total plot number in 2005	0.009 ***	0.000	0.0087 ***	0.000	0.009 ***	0.000	0.009 ***	0.000
Irrigation dummy [a]	0.023 ***	0.000	0.017 ***	0.000	0.023 ***	0.000	0.016 ***	0.000
Slope (dummy: 1 =>25 and 0 = <25)	0.002	0.603	-0.002	0.460	0.004	0.314	-0.001	0.736
Distance to home (km)	0.002	0.133	0.001	0.198	0.002	0.203	0.001	0.199
Distance to road (km)	0.004 ***	0.001	0.004 ***	0.000	0.004 ***	0.000	0.004 ***	0.000
Forest type [d]	-0.009 ***	0.000	-0.009 ***	0.000	-0.009 ***	0.000	-0.008 ***	0.000
Length of one rotation period (years)	-0.0002	0.465	-0.0002	0.438	-0.0003	0.263	-0.0002	0.288
Start year of managing forest plot	0.00004	0.654	-0.00003	0.774	0.00001	0.920	-0.00006	0.574
Has certificate or not for forest plot [a]	-0.003	0.456	-0.0009	0.816	-0.003	0.546	0.0004	0.933
Length of contract for forest plot (years)	0.0001 ***	0.005	0.0001 ***	0.001	0.0001 ***	0.002	0.0001 ***	0.001
Household's total cropland area (mu)	-0.0001 ***	0.000	-0.0001 ***	0.000	-0.0001 ***	0.000	-0.0001 ***	0.000
Household's total working days in off-farm jobs	-0.00001 ***	0002	-7.81 **	0.018	-0.00001 ***	0.004	-6.77 **	0.035
Number of times of small land adjustment in the village	0.006 ***	0.000	0.005 ***	0.000	0.006 ***	0.000	0.005 ***	0.000
Expectation of small adjustment in land in the future [b]	-0.004 **	0.014	-0.004 **	0.029	-0.005 ***	0.003	-0.004 **	0.017
Village has new reform after 2003 [a]	0.025 ***	0.000	0.022 ***	0.000	0.021 ***	0.000	0.019 ***	0.000
Investment on forestland in 2000 (yuan)	1.92	0.257	6.72	0.659	1.84	0.243	7.87	0.591
Property rights index (sum of scores)	0.017 ***	0.000	0.015 ***	0.000				
Right to convert forestland to cropland [c]					0.024 ***	0.000	0.025 ***	0.000
Right to change forest type					0.005	0.413	0.007	0.139

Right to select tree species					0.039 ***	0.000	0.031 ***	0.000
Right to use non-timber products					0.017 **	0.017	0.007	0.325
Right to abandon forestland					0.018 ***	0.002	0.013 **	0.010
Right transfer plot to other villagers					0.033 ***	0.000	0.03 ***	0.000
Right to transfer plot to outsiders					-0.002	0.700	-0.007	0.256
Right to mortgage forestland as collateral with certificate					0.014 **	0.012	0.011 **	0.037
Right to mortgage forestland as collateral without certificate					0.003	0.405	0.005	0.191
Fujian (dummy)	0.008	0.327	0.003	0.705	0.006	0.448	0.004	0.608
Jiangxi (dummy)	0.039 ***	0.000	0.033 ***	0.000	0.039 ***	0.000	0.033 ***	0.000
Zhejiang (dummy)	-0.038 ***	0.003	-0.04 ***	0.003	-0.049 ***	0.001	-0.045 ***	0.002
Yunnan (dummy)	0.004	0.672	0.005	0.543	0.004	0.704	0.008	0.304
Pseudo *R*-squared	0.1540		0.1504		0.1602		0.1580	
Number of observations	12037		12037		12037		12037	

Notes: Anhui, Hunan, Liaoning, and Shandong provinces predicted tenure security perception perfectly. Their dummies were dropped from the estimation due to colinearity.

[a] Dummy variables (1 = yes, and 0 = no)

[b] Ordinal variables (0 = no, 1 = unsure, and 2 = yes)

[c] Forest type, based on availability of forest harvesting (0 = no forest, 1 = young forest, 2 = nearly mature forest, 3 = overmature forest)

[d] Forest type, based on availability of forest harvesting (0 = no forest, 1 = young forest, 2 = nearly mature forest, 3 = overmature forest)

* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8. Determinants of Forestry Investment: Tenure Security Perception or Property Rights Directly

Dependent variable: Log of investment in 2005	**(5) Heckman (Two-step)**		**(6) RE with Rights Index**		**(7) RE with Rights**	
Variable	**Coef.**	***z***	**Coef.**	***z***	**Coef.**	***z***
Household size, number of people	0.437 ***	11.58	0.049 ***	3.74	0.044 ***	3.29
Age of household head (years)	-0.058 ***	-10.20	-0.025 ***	-11.33	-0.024 ***	-10.89
Educated years of household head	0.024	1.25	-0.022 ***	-2.96	-0.02 ***	-2.66
Gender of household head (dummy: 1=male, 0=female)	-0.818 ***	-2.83	-0.367 ***	-3.20	-0.379 ***	-3.27
Household head is member of CCP [a]	0.297 **	1.98	0.358 ***	5.97	0.338 ***	5.54
Household head is village leader [a]	-1.067 ***	-5.19	-0.285 ***	-3.26	-0.307 ***	-3.51
Household head once has job in forestry sector [a]	0.792 ***	3.27	-0.227	-1.47	-0.318 **	-2.06
Log of total household income	-0.017	-0.26	-0.023	-0.83	-0.029	-1.02
House value in 2005 (yuan)	-0.024 ***	-2.77	0.003	0.85	0.003	0.76
Borrow money or not [a]	-0.391 ***	-4.60	-0.073	-1.61	-0.071	-1.56
Can successfully borrow 500 yuan within one week [b]	-0.066	-0.92	0.044	1.19	0.051	1.35
Forestry income share	5.425 ***	11.57	1.923 ***	10.82	1.964 ***	10.71
Forest plot area (mu)	0.0002	0.16	0.003 ***	4.71	0.003 ***	5.01
Household's total plot number in 2005	-0.203 ***	-7.65	-0.057 ***	-5.54	-0.072 ***	-6.78
Irrigation dummy [a]	-0.132	-0.86	-0.324 ***	-5.38	-0.385 ***	-6.34
Slope (dummy: 1 = >25 and 0 = <25)	-0.085	-0.72	0.026	0.55	0.015	0.31

Distance to home (km)	0.217 ***	4.66	-0.007	-0.64	-0.004	-0.36
Distance to road (km)	-0.067 **	-1.98	-0.025 *	-1.83	-0.026 *	-1.95
Forest type [d]	-0.161 ***	-2.85	0.14 ***	6.17	0.136 ***	5.88
Length of one rotation period (years)	0.314 ***	14.18	0.012 **	2.12	0.012 **	2.13
Start year of managing forest plot	0.034 ***	6.40	0.015 ***	6.38	0.015 ***	6.36
Has certificate or not for forest plot [a]	1.162 ***	8.05	0.312 ***	5.69	0.206 ***	3.38
Length of contract for forest plot (years)	-0.002	-1.49	-0.0007	-1.24	-0.0006	-1.10
Household's total cropland area (mu)	-0.006 ***	-6.09	-0.0008 **	-2.22	-0.001 ***	-2.97
Household's total working days in off-farm jobs	-0.0001	-0.98	0.0002 ***	4.42	0.0003 ***	4.74
Number of times of small land adjustment in the village	-0.103 ***	-3.36	0.013	1.00	0.009	0.67
Expectation of small adjustment in land in the future [b]	-0.227 ***	-3.34	-0.15 ***	-5.85	-0.158 ***	-6.00
Village has new reform after 2003 [a]	1.954 ***	11.75	0.85 ***	15.78	0.854 ***	15.83
Investment on forestland in 2000 (yuan)	-0.0003 *	-1.80	0.0006 ***	26.57	0.0006 ***	26.01
Household still owns plot after five years [b]	0.113	0.91				
Property rights index (sum of scores)			0.059 ***	5.43		
Right to convert forestland to cropland [c]					-0.181 ***	-3.25
Right to change forest type					0.468 ***	3.94
Right to select tree species					-0.265 **	-2.06
Right to use non-timber products					-0.312 ***	-2.83
Right to abandon forestland					0.041	0.44
Right transfer plot to other villagers					0.334 ***	3.92
Right to transfer plot to outsiders					-0.06	-0.78
Right to mortgage forestland with certificate					0.361 ***	5.06
Right to mortgage forestland without certificate					0.122 **	2.37
Jiangxi (dummy)			-1.71 ***	-10.76	-1.71 ***	-10.70
Zhejiang (dummy)			-3.96 ***	-55.88	-3.89 ***	-51.50
Anhui (dummy)			0.547 ***	6.41	0.54 ***	6.03
Shandong (dummy)			0.731 ***	3.35	0.78 ***	3.59
Yunnan (dummy)			-0.191 **	-2.33	-0.18 **	-2.17
Constant	-62.20 ***	-5.93	-23.37 ***	-5.11	-23.50 ***	-5.04
Wald chi2	2615.15		11428.23		11627.90	
Prob>chi2	0.0000		0.0000		0.0000	
R-squared			0.6659		0.6700	
Number of observations	11062		5770		5770	

Notes: Fujian, Hunan, Liaoning provinces predicted investment perfectly. The provincial dummies of them were dropped from the estimation due to colinearity.

[a] Dummy variables (1 = yes, and 0 = no)

[b] Ordinal variables (0 = no, 1 = unsure, and 2 = yes)

[c] Forest type, based on availability of forest harvesting (0 = no forest, 1 = young forest, 2 = nearly mature forest, 3 = overmature forest)

[d] Forest type, based on availability of forest harvesting (0 = no forest, 1 = young forest, 2 = nearly mature forest, 3 = overmature forest)

* significant at 10%; ** significant at 5%; *** significant at 1%.

6. Conclusion

This paper assesses how tenure reform in China's collective forest sector affects the Chinese farmer households' perception of tenure security and the impact on capital and labor investments on their forestland. A large database obtained from comprehensive surveys in eight provinces where the reform was implemented is used to quantitatively explore factors correlated with stronger tenure security perception and determinants of forest related investment.

The evidence from this study adds to the literature in three aspects. First, in China, there is limited evidence supporting the endogenous causality between investment and tenure security, like that seen in some African countries, where investment usually be undertaken to enhance tenure security. However, the potential endogenous causality between perception of tenure security and the inclination to invest will be addressed in a later, more in-depth examination of the data.

Second, the data allows an explicit differentiation between tenure security and contracted use and transferability rights. These are two concepts have largely been treated as proxies and deemed interchangeable in the literature (Deininger and Jin, 2006). Overall, stronger contracted rights provide important and direct investment incentives, but it seems not necessarily through perceived enhanced tenure security. This may be due to the lack of variation in tenure security variable. When looking at each contracted rights, use rights enhances tenure security more significantly than transferability-related rights. Rights to change forest type, to transfer forestland to other villagers, and to mortgage, do significantly stimulate investment, while other use rights undermine the incentive to invest in forestry or forestland. This suggests that farmer households attach less importance to forestland or forestry. It also suggests that a well-defined market and enforceable rules would work well for forestland transfer.

Third, the direct impact of property rights on the incentive to invest is good news for policymakers. Farmers' perceptions of tenure security are not only correlated with contracted rights and contract duration, but are also affected by many other factors, such

as household wealth, political influence, and local institutional evolution, etc. Given this finding that transferability and gains-from-trade rights significantly increase investment propensity, the next step of reform should focus on building infrastructure and devising mechanisms that create and support formal credit and land transfer markets in rural China.

Last but not least, the changes from China's forest tenure reform—where individual households can manage forest land, empowered by legal (recognized) certification and stronger contract rights—that enhance tenure security and encourage forest investment hold out good prospects for the reform of state-owned forest areas, which have long struggled to overcome poor efficiency, heavy social burden, and forest resource degradation. Policy makers' concern of land insecurity harming investment seems eased, but be careful, as the vulnerability of tenure security perception is also correlated with many factors. Meanwhile, the emerging increased investment and growth in the rural and forestry sector, coupled with the importance of forestry for global markets given China's largest share of global demand for timber and forest products, will provide China opportunities as well as challenges. The government should pay closer attention to channels (and mechanisms) that policy instruments work through, hence better balancing cost, efficiency, and equity trade-offs.

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Appendix A: The Theoretical Framework

This appendix builds a conceptual model based on theoretical and comprehensive work that have examined the impacts of property rights on land-related investment, incorporating labor and credit constraints, and also considering the potential endogenous causality (Besley, 1995; Deininger and Jin, 2002; Carter and Olinto, 2003). A dynamic household model (i.e., here only two periods are considered, subscripted by $t = 1\ or\ 2$) of farmers' investment decision on their forestland according to a profit maximization problem is built up through the following steps:

Step 1:

Basically the aim is to

$$\text{Max}\ (1+r)y_1\left(\bar{A}, \overline{F}, K_1, L_1\right) + E\left(y_2\left(\bar{A}, \overline{F}, K_2, L_2\right)\right) - rB + r(W - K_2 + B)$$

where $\bar{A}$, $\overline{F}$, K_t, L_t are agricultural land, forestland, capital stock, and labor, the main interested production factors for each household in each period. Agricultural land is seen as given and fixed. Forestland is modeled as an extra asset that can induce expected returns from capital or labor investment by augmenting total capital stock, hence in turns production or profit in period two.

Now turn to the other two production factors: capital stock (K_t) and labor (L_t):

Defining k_1 as the physical capital investment and l_1^f as the labor input on forestland, where the superscript f means forest and the subscript 1 means in the first period. The underlying assumption here is that farmer's main income sources are agriculture and off-farm jobs, where capital investment (k_1) and labor input (l_1^f) on forestland augment total capital stock and hence the yield in the next period.[11] I am interested in how household allocate their labor time and capital in agriculture, forestland and off-farm jobs. Assuming total labor available in each period is fixed, i.e., $\overline{L_1}$, $\overline{L_2}$, and a well functioning labor market exists, labor can thus be allocated on agriculture (l_t^a),

[11] Capital investment on forestland such as afforestation or reforestation including trees, areas, seedlings, silviculture, etc. plus fertilizer, pesticide, irrigation, machinery, etc

forestland (l_t^f), and off-farm jobs (l_t^o), satisfying the constraints of $l_1^a + l_1^f + l_1^o \leq \overline{L_1}$, and $l_2^a + l_2^o \leq \overline{L_2}$.[12] The labor allocated in off-farm employment (l_t^o) gets w_i as wage.

$y_t(\cdot)$ is payoff function of household's decision on allocation of labor and capital according to a short-run production function for each period. With a given level of agricultural production technology and capital augmentation path/technology (represented by $f(\cdot)$ and $g(\cdot)$ respectively, satisfying the standard concavity assumption: $f_1, g_1 > 0, f_2, g_2 < 0$), the payoff in the first period is $y_1 = Y_1 + l_1^o w_1 = f(K_1, l_1^a) + l_1^o w_1$, where Y_1 denotes agricultural yield in period one. In a dynamic way, the household wants to maximize their total payoff in two periods, I multiply y_1 with $(1+r)$. Hence I get $(1+r)y_1 = (1+r)(f(K_1, l_1^a) + l_1^o w_1)$ as the first period's payoff function. In the second period the agricultural yield corresponds to $Y_2 = f(K_2, l_2^a)$, where $K_2 = K_1 + g(k_1, l_1^f)$ because the capital investment (k_1) and labor input (l_1^f) in the initial period on forestland will augment the capital stock in the second period through the same technology as $g(\cdot)$, so that $y_2 = f(K_1 + g(k_1, l_1^f), l_2^a) + l_2^o w_2$.

However, the part $f(K_1 + g(k_1, l_1^f), l_2^a)$ in y_2 is not obtainable for certainty, due to the probability of the forestland being taken away. So $E(y_2)$ gives the expected payoff in period two taking the probability of losing their forestland plot into consideration. $\xi\left(T_2(T_1(R), k_1, l_1^f)\right)$ specifies such probability, where $\xi(\cdot) \in (0,1)$ measures tenure security as a probability that the forestland will not be taken away for any reason in the second period, and the perceived tenure security in period two (T_2) is a function of the household's perception (T_1), labor input (l_1^f) and capital investment (k_1) in period one, and in turn tenure security in the first period (T_1) is a function of the property rights it

[12] Although there may be labor input in forestry, here for the simplification of modeling and analyzing we only focus on the labor input in the initial period. The probability of losing forestland is also considered. Otherwise there would be no such input. The second period of labor is allocated to agriculture and off-farm jobs only.

enjoys (R). Therefore, the expected payoff in the second period is $E(y_2) = \xi\left(T_2\left(T_1(R), k_1, l_1^f\right)\right) f\left(K_1 + g\left(k_1, l_1^f\right), l_2^a\right) + l_2^o w_2$.[13]

Finally, the rest of the expressions, $-rB + r(W - K_2 + B)$, specifies the household's cost of credit and capital. B is the amount that the household borrow at an exogenously given interest rate r, and $r(W - K_2 + B)$ represents the return on those capital that are not used in forest-related investment, where W is the initial wealth as the household's endowment, K_2 is the capital stock in the second period satisfies the condition $K_2 \leq K_1 + g\left(k_1, l_1^f\right)$.[14] The amount that the household can borrow is limited by its initial wealth, the value of forestland at hand, and if they have the right to use their forestland as collateral, mortgage, or transfer out their forestland with payment. Thus the credit constraint is defined as $B \leq S(R, F, W)$, of which the right-hand side is a non-negative function with $S_R, S_F, S_W \geq 0$ and $S_R^2, S_F^2, S_W^2 \geq 0$.

Step 2:

Given the payoff functions regarding the household's investment decision in ***Step 1***, now let C_1, C_2 be the household's consumption in each period, and $\delta \in [0,1]$ the discount factor, and consider a standard household utility maximization problem in a two-period model:

$$Max\ U(C_1, C_2) = \ln(C_1) + \delta \ln(C_2)$$

subject to: $(1 + r)[(f(K_1, l_1^a) + l_1^o w_1 - C_1)] + [\xi\left(T_2\left(T_1(R), k_1, l_1^f\right)\right) f\left(K_1 + g\left(k_1, l_1^f\right), l_2^a\right) + l_2^o w_2 - rB + r(W - K_2 + B) - C_2] = 0,$

$l_1^a + l_1^f + l_1^o \leq \overline{L_1},\ l_2^a + l_2^o \leq \overline{L_2},$

$K_2 = K_1 + g\left(k_1, l_1^f\right)$, and

---

[13] This $E(\pi_2)$ equation is derived from $E(\pi_2) = \xi\left(T_2\left(T_1(R), k_1, l_1^f\right)\right) f\left(K_1 + g\left(k_1, l_1^f\right), l_2^a\right) + (1 - \xi\left(T_2\left(T_1(R), k_1, l_1^f\right)\right) * 0 + l_2^o w_2 = \xi\left(T_2\left(T_1(R), k_1, l_1^f\right)\right) f\left(K_1 + g\left(k_1, l_1^f\right), l_2^a\right) + l_2^o w_2$, because if the land is taken away by some reason, the yield will be 0 in this case. The payment from off-farm jobs, $l_2^o w_2$, is assumed to be not affected by the possibility of land loss, because w_t is exogenously given.

[14] Here the difference between interest rate and rate of return has no bearing, so r is used in both cases to measure the cost of borrowing and the rate of return.

$B \leq S(R, F, W)$.

Step 3:

Because the main purpose of this study is not on consumption and it distinguishes between consumption and production, the theoretical framework in ***Step 2*** can then be simplified as:

$$\max_{k_1, l_1^f, l_1^a, l_1^o, l_2^a, l_2^o} \quad (1+r)(f(K_1, l_1^a) + l_1^o w_1) + \xi\left(T_2\left(T_1(R), k_1, l_1^f\right)\right) f\left(K_1 + g\left(k_1, l_1^f\right), l_2^a\right) + l_2^o w_2 - rB + r(W - K_2 + B)$$

Subject to:

$l_1^a + l_1^f + l_1^o \leq \overline{L_1},\ l_2^a + l_2^o \leq \overline{L_2}$,

$K_2 = K_1 + g\left(k_1, l_1^f\right)$, and

$B \leq S(R, F, W)$.

Prior to solving this maximization problem, it is worthwhile clarifying the following assumptions by assuming the concavity of $T(\cdot)$ and $\xi(\cdot)$ is the same as $f(\cdot)$, $g(\cdot)$, therefore:

$\frac{\partial \xi}{\partial T_2} > 0, \frac{\partial^2 \xi}{\partial^2 T_2} < 0, \frac{\partial T_2}{\partial T_1} > 0, \frac{\partial T_2}{\partial k_1} > 0, \frac{\partial T_2}{\partial l_1^f} > 0, \frac{\partial^2 T_2}{\partial^2 T_1} < 0, \frac{\partial^2 T_2}{\partial^2 k_1} < 0, \frac{\partial^2 T_2}{\partial^2 l_1^f} < 0, \frac{\partial^2 T_2}{\partial k_1 \partial l_1^f} < 0, \frac{\partial^2 T_2}{\partial T_1 \partial k_1} < 0, \frac{\partial^2 T_2}{\partial T_1 \partial l_1^f} < 0$, and $\frac{\partial T_1}{\partial R} > 0$.

After substituting the labor binding conditions $l_1^a = \overline{L_1} - l_1^f - l_1^o,\ l_2^a = \overline{L_2} - l_2^o$, and credit constraints,$K_2 = K_1 + g\left(k_1, l_1^f\right),\ B = S(R, F, W)$ into the objective function in ***Step 3*** yields:

$$\max_{k_1, l_1^f, l_1^a, l_1^o, l_2^a, l_2^o} \ (1+r)\left(f\left(K_1, \overline{L_1} - l_1^f - l_1^o\right) + l_1^o w_1\right) + \xi\left(T_2\left(T_1(R), k_1, l_1^f\right)\right) f\left(K_1 + g\left(k_1, l_1^f\right), \overline{L_2} - l_2^o\right) + l_2^o w_2 + rW - r(K_1 + g\left(k_1, l_1^f\right)) \quad (1)$$

The First Order Conditions with respect to k_1, l_1^o, l_2^o, l_1^f are derived for the solution to the farmer household's maximization problem in equation (1):

FoC 1): $\xi'\left(T_2\left(T_1(R),k_1,l_1^f\right)\right)f\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)+[\xi\left(T_2\left(T_1(R),k_1,l_1^f\right)\right)f'\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)-r]g'\left(k_1,l_1^f\right)=0$

FoC 2): $w_1=(1+r)f'(K_1,l_1^a)$

FoC 3): $w_2=\xi\left(T_2\left(T_1(R),k_1,l_1^f\right)\right)f'\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)$

FoC 4): $-(1+r)f'(K_1,l_1^a)+\xi'\left(T_2\left(T_1(R),k_1,l_1^f\right)\right)T_2'\left(T_1(R),k_1,l_1^f\right)f\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)+[\xi\left(T_2\left(T_1(R),k_1,l_1^f\right)\right)f'\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)-r]g'\left(k_1,l_1^f\right)=0$

FoC 2 and FoC 3 tell us the underlying economic theory about the opportunity cost of engaging in forestland related investment behaviors: the marginal product of labor and capital input should be equal to the wages from off-farm employment. In this special case, the probability of losing forestland is taken into account, so the marginal product in the second period is also multiplied by the term $\xi\left(T_2\left(T_1(R),k_1,l_1^f\right)\right)$ in FoC 3. For the convenience of differentiation in below and based on of course the opportunity cost theory, FoC 2 and FoC 3 can be transferred into F2 and F3:

F 2): $\omega_1=f'(K_1,l_1^a)$, where $\omega_1=\frac{w_1}{1+r}$;

F3): $\omega_2=f'\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)$, where $\omega_2=\frac{w_2}{\xi\left(T_2\left(T_1(R),k_1,l_1^f\right)\right)}$.

***Case 1*:** If the endogenous causality between tenure security and investment does not exist, (i.e., tenure security is exogenously given and not related to previous tenure security or capital/labor investment), then $T_2'\left(T_1(R),k_1,l_1^f\right)=0$. It is reasonable to assume that $T_2\left(T_1(R),k_1,l_1^f\right)$ can be replaced by $T_1(R)$ because property rights can have a positive impact on tenure security. Rearranging FoC 4 produces:

$$-(1+r)f'(K_1,l_1^a)+[\xi(T_1(R))f'\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)-r]g'\left(k_1,l_1^f\right)=0 \qquad (2)$$

Here another assumption needs to be made: $\xi(T_1(R))f'\left(K_1+g\left(k_1,l_1^f\right),l_2^a\right)-r>0$, implying that the marginal product in the second period is larger than the marginal cost of borrowing, r, (or, the return of savings). This assumption is reasonable to make because if marginal product of the second period's agricultural yield is less than

marginal return of capital, hardly any labor or capital would be invested in forestland or cropland.

Substituting F2 and F3 into equation (2) yields:

$$-(1+r)\omega_1 + [\xi(T_1(R))\omega_2 - r]g'\left(k_1, l_1^f\right) = 0.$$

Total differentiating this equation with respect to T_1 and k_1 yields:

$$\xi'(T_1(R))\omega_2 g'\left(k_1, l_1^f\right)dT_1(R) + [\xi(T_1(R))\omega_2 - r]g''\left(k_1, l_1^f\right)dk_1 = 0$$

$$\Rightarrow \frac{\partial k_1}{\partial T_1(R)} = -\frac{\xi'(T_1(R))\omega_2 g'\left(k_1, l_1^f\right)}{[\xi(T_1(R))\omega_2 - r]g''\left(k_1, l_1^f\right)} = -\frac{(+)(+)}{(+)(-)} > 0 \qquad (3)$$

Total differentiating this equation with respect to T_1 and l_1^f yields:

$$\xi'(T_1(R))\omega_2 g'\left(k_1, l_1^f\right)dT_1(R) + \xi(T_1(R))\omega_2 g''\left(k_1, l_1^f\right)dk_1 = 0$$

$$\Rightarrow \frac{\partial l_1^f}{\partial T_1(R)} = -\frac{\xi'(T_1(R))\omega_2 g'\left(k_1, l_1^f\right)}{[\xi(T_1(R))\omega_2 - r]g''\left(k_1, l_1^f\right)} = -\frac{(+)(+)}{(+)(-)} > 0 \qquad (4)$$

Summing up equations (3) and (4) shows the marginal effect of tenure security on total investment $\frac{\partial k_1 + \partial l_1^f}{\partial T_1(R)} > 0$, which implies that higher tenure security leads to more investment on forestland through stronger or better property rights, and is of my interest to find evidence for.

***Case 2*:** If the endogenous causality between tenure security and investment does not exist as in *Case 1*, and more importantly if stronger property rights do not necessarily affect investment through tenure security, it is reasonable to replace $T_2\left(T_1(R), k_1, l_1^f\right)$ by R, which yields $\frac{\partial k_1 + \partial l_1^f}{\partial R} > 0$, implying that stronger or better property rights directly encourage investment on forestland.

***Case 3*:** Suppose, in contrast to the above, tenure security is endogenous, in other words, investment in the first period enhances future tenure security:

$$T_2 = T_2\left(T_1(R), k_1, l_1^f\right).$$

But, given its effect through production function as $K_2 = K_1 + g\left(k_1, l_1^f\right)$, the impact of property rights through tenure security on investment becomes not so obvious.

In the same way by total differentiation of FoC 4 with respect to T_1 and k_1, and T_1 and l_1^f separately, after a lot of calculation work, finally yields:

$$\frac{\partial k_1}{\partial T_1(R)} = -\frac{(-)+(-)+(+)}{(-)+(-)+(-)+(+)}, \text{ and } \frac{\partial l_1^f}{\partial T_1(R)} = -\frac{(-)+(-)+(+)}{(-)+(-)+(-)+(+)},$$

of which the combination of these two terms, $\frac{\partial k_1 + \partial l_1^f}{\partial T_1(R)} = -\frac{(-)+(-)+(+)}{(-)+(-)+(-)+(+)}$, still gives the same ambiguous sign as in the two above equations. Thus, the net effect of tenure security depends on the relative weight of negative and positive terms.

This conceptual framework at this moment may have flaws, as it is built up out of intuition and based on the main interest of this research. The author may be shed from the light of some other important, or necessary, and interesting factors that should be considered. So I would say that still a long way is under path to form a well defined, flawless theoretical framework required for this study. Therefore, all related comments and advice from any academic opponents and discussants, as well as from the audience are heartfeltly welcome and gratefully acknowledged by the author.

Appendix B: Results from Ordered Probit and Logit Models on Tenure Security (Table 9)

Table 9. Factors Correlated with Forestland Tenure Security: Results from Ordered Probit and Logit Models with Property Rights Index vs. Disaggregated Rights Variables

Dependent variable:	Property Rights Index				Disaggregated Property Rights			
Household still owns plot after 5 years	(1) Ordered Probit		(2) Ordered Logit		(3) Ordered Probit		(4) Ordered Logit	
Variable	Coef.	*z*	Coef.	*z*	Coef.	*z*	Coef.	*z*
Household size, number of people	-0.026 **	-2.25	-0.067 ***	-2.75	-0.028 **	-2.38	-0.066 ***	-2.67
Age of household head (years)	-0.009 ***	-4.44	-0.016 ***	-3.80	-0.01 ***	-4.97	-0.018 ***	-4.16
Educated years of household head	0.081 ***	12.14	0.152 ***	10.76	0.081 ***	11.87	0.154 ***	10.67
Gender of household head (dummy: 1=male, 0=female)	0.105	1.38	0.369 **	2044	0.088	1.19	0.33 **	2.27
Household head is member of CCP [a]	0.083	1.59	0.073	0.65	0.075	1.40	0.044	0.38
Household head is village leader [a]	0.21 **	2.21	0.368 *	1.74	0.214 **	2.24	0.322	1.52
Log of total household income	0.03	1.22	0.109 *	1.79	0.044 *	1.79	0.155 **	2.54
House value in 2005 (yuan)	0.014 ***	4.08	0.023 ***	3.03	0.013 ***	3.73	0.019 ***	2.66
Forestry income share	0.95 ***	4.56	2.414 ***	4.96	1.015 ***	4.69	2.55 ***	4.94
Forest plot area (mu)	0.0005	0.80	0.002	1.00	0.0004	0.67	0.002	0.80
Household's total plot number in 2005	0.111 ***	9.98	0.239 ***	9.48	0.116 ***	10.42	0.252 ***	9.77
Irrigation dummy [a]	0.343 ***	6.65	0.559 ***	5.20	0.353 ***	6.82	0.544 ***	5.00
Slope (dummy: 1 = >25 and 0 = <25)	0.022	0.52	-0.067	-0.73	0.043	1.02	-0.031	-0.33
Distance to home (km)	0.024	1.50	0.04	1.28	0.021	1.27	0.042	1.27
Distance to road (km)	0.05 ***	3.47	0.1 ***	3.60	0.051 ***	3.49	0.1 ***	3.62
Forest type [d]	-0.105 ***	-5.21	-0.247 ***	-5.82	-0.108 ***	-5.17	-0.232 ***	-5.21
Length of one rotation period (years)	-0.002	-0.73	-0.005	-0.78	-0.004	-1.12	-0.007	-1.07
Start year of managing forest plot	0.0006	0.45	-0.0008	-0.29	0.0001	0.10	-0.002	-0.56
Has certificate or not for forest plot [a]	-0.037	-0.76	-0.024	-0.23	-0.033	-0.61	0.01	0.08
Length of contract for forest plot (years)	0.001 ***	2.79	0.003 ***	3.21	0.001 ***	3.07	0.004 ***	3.30
Household's total cropland area (mu)	-0.002 ***	-7.73	-0.003 ***	-7.65	-0.001 ***	-6.64	-0.003 ***	-6.48
Household's total working days in off-farm jobs	-0.0001 ***	-3.12	-0.0002 **	-2.36	-0.0001 ***	-2.89	-0.0002 **	-2.11
Number of times of small land adjustment in the village	0.066 ***	5.85	0.128 ***	5.24	0.071 ***	6.48	0.128 ***	5.22
Expectation of small adjustment in land in the future [b]	-0.052 **	-2.47	-0.1 **	-2.22	-0.062 ***	-3.00	-0.107 **	-2.44
Village has new reform after 2003 [a]	0.263 ***	6.19	0.524 ***	5.98	0.229 ***	5.58	0.477 ***	5.63
Investment on forestland in 2000 (yuan)	0.00002	1.14	0.00002	0.44	0.00002	1.17	0.00002	0.54
Property rights index (sum of scores)	0.208 ***	20.21	0.404 ***	19.12				
Right to convert forestland to cropland [c]					0.29 ***	6.39	0.707 ***	6.97
Right to change forest type					0.061	0.82	0.211	1.47
Right to select tree species					0.474 ***	5.73	0.864 ***	5.45
Right to use non-timber products					0.214 **	2.39	0.187	0.99
Right to abandon forestland					0.221 ***	3.08	0.372 **	2.56
Right transfer plot to other villagers					0.401 ***	5.19	0.841 ***	5.11

Right to transfer plot to outsiders					-0.03	-0.39	-0.189	-1.14
Right to mortgage forestland with certificate					0.166 **	2.54	0.318 **	2.10
Right to mortgage forestland without certificate					0.038	0.83	0.13	1.31
Fujian dummy	0.097	1.00	0.079	0.38	0.077	0.77	0.111	0.52
Jiangxi dummy	0.881 ***	6.55	1.522 ***	5.01	0.903 ***	6.39	1.684 ***	5.08
Zhejiang dummy	-0.365 ***	-3.57	-0.839 ***	-3.92	-0.452 ***	-4.24	-0.931 ***	-4.16
Yunnan (dummy)	0.048	0.41	0.141	0.58	0.045	0.37	0.243	0.94
Pseudo *R*-squared	0.1540		0.1504		0.1602		0.1580	
Number of observations	12037		12037		12037		12037	

Notes: Anhui, Hunan, Liaoning, and Shandong provinces predicted tenure security perception perfectly. Their dummies were dropped from the estimation due to colinearity.

[a] Dummy variables (1 = yes, and 0 = no)

[b] Ordinal variables (0 = no, 1 = unsure, and 2 = yes)

[c] Forest type, based on availability of forest harvesting (0 = no forest, 1 = young forest, 2 = nearly mature forest, 3 = overmature forest)

[d] Forest type, based on availability of forest harvesting (0 = no forest, 1 = young forest, 2 = nearly mature forest, 3 = overmature forest)

* significant at 10%; ** significant at 5%; *** significant at 1%.