**How do Payments for Environmental Services affect land tenure?
Theory and evidence from China**

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# ABSTRACT

Recent academic endeavours have questioned whether the rapidly unfolding Payments for Environmental Services (PES) may have profound influence on land tenure which would in turn impact the conservation efficacy of PES. This paper developed a game-theory model in the context of rural China, which describes the endogenous formation of land rights as a bargaining process between ordinary villagers and village leaders. This model gave rise to theoretical predictions pertaining to the implications of two PES schemes in China for land tenure, namely the Sloping Land Conversion Programme (SLCP) and the Ecological Public-Benefit Forest Compensation Programme (EPBFCP). The theoretical predictions were tested using primary data collected through large-scale field surveys. These data were analysed using the Propensity Score Matching method and panel data models. Both the theoretical analysis and the empirical results find that the SLCP has likely enhanced land tenure security by increasing the bargaining costs of village leaders’ attempts to reallocate SLCP lands to other households. On the other hand, villagers tend to have less motivation to de-collectivise those forest lands enrolled in the EPBFCP, which somewhat stands in the way of the country’s agenda to further de-collectivise communal forests and allocate them to individual households.

**Keywords:** Payments for Environmental Services (PES), land tenure, game-theory model, policy impact evaluation, Propensity Score Matching, panel data analysis.

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# 1 INTRODUCTION

The past 15 years have witnessed rampant development of land-based Payments for Environmental Services (PES) programmes, which typically compensate land holders for the environmental benefits they provide (Ferraro & Kiss, 2002; Wunder, 2005). More than 300 PES-like programmes have been implemented worldwide (Blackman & Woodward, 2010), and billions of dollars are being poured into these schemes annually (OECD, 2010). For instance, in response to recent developments in international climate change negotiations, there have been significant support for and widespread interest in Reducing Emissions from Deforestation and Forest Degradation (REDD) programmes, the total budget of which added up to 227 million USD by 2014 (The United Nations, 2014). At the 2015 climate summit in Paris, REDD was prioritised by over 60 countries in their action plans to combat climate change.

However, rigorous impact-evaluation studies have revealed a mixed picture of the conservation efficacy of PES (Pattanayak, Wunder, & Ferraro, 2010). There are a number of different explanations but institutional imperfections are frequently suspected to be largely responsible (Burtraw, 2013), especially in developing regions. For instance, well-defined property rights of environmental services (ES), which are typically attached to land tenure in land-based PES, are widely accepted as an essential prerequisite for the success of PES (Engel, Pagiola, & Wunder, 2008). On the contrary, unclear, contested and volatile land tenure would make it difficult to identify which parties are responsible for and capable of providing the required ES in exchange for the corresponding payments. The influence of property rights on PES has been well established by conventional wisdom dating back to the Coase Theorem. Nevertheless, the reciprocal effects, namely that PES may exert a nontrivial influence on property rights, have only recently been acknowledged (Naughton-Treves & Wendland, 2014). Institutional arrangements, such as land tenure, usually represent equilibrium outcomes of interactions among multiple stakeholders pursuing their own interests (Groenewegen, Spithoven, & van den Berg, 2010). PES, as an external shock to the pre-existing equilibrium, could thus tip the balance and drive the institutional system towards an alternative equilibrium status. If this trajectory eventually leads to even more unclear and insecure land tenure which then in turn further threatens the success of PES, then PES would be trapped in a doomed institutional spiral undermining its efficacy.

As noted above the interactive nature of the PES-property rights nexus has received increasing interest in recent literature. For instance, some researchers argued that national-level REDD programmes, as a PES instrument, could threaten to recentralise forest rights because the payments could incentivise powerful rent-seekers to take away forest rights from smallholders, which would (in the long run) undermine both tenure arrangements and environmental outcomes (Agrawal, Nelson, Adams, & Sandbrook, 2010; Dressler, McDermott, Smith, & Pulhin, 2012; Hall, 2014; Larson, 2011; Phelps, Webb, & Agrawal, 2010; Sandbrook, Nelson, Adams, & Agrawal, 2010). However, others contended that PES could be an opportunity for disadvantaged land holders to strengthen their property rights, since they would be officially recognised as ES suppliers and hence land holders (Arriagada, Sills, Ferraro & Pattanayak, 2015; Palmer, 2010; Sunderlin et al., 2014; Toni, 2011; Wunder, 2010; Wunder, Engel, & Pagiola, 2008).

Taken together these strands of literature suggest largely divided opinions over the interactions between PES and land tenure. It is still early days to draw clear lessons due to lack of theoretical support and rigorous empirical evidence in existing literature, except a few rare examples such as the studies by Engel et al. (2008) and Vijge et al. (2014). There is a necessity to construct a formalised theoretical model so as to develop the isolated arguments made by previous studies into a comprehensive and generalisable analytical framework. For one thing, this would be helpful in depicting a more complete picture of the nexus between PES and land tenure without over- or under-emphasising any facet of their interactions. For another, this would to some degree overcome the case-specific nature of previous studies and facilitate *ex-ante* diagnosis for other PES cases with different features. Further, such theoretical interpretations need to be explored using hard empirical evidence. However, existing studies on this topic have disproportionately rested their arguments on narrative evidence, which calls for further efforts to accumulate more objective quantitative data derived from reliable empirical methods.

This research agenda requires continuous scientific endeavours from different study sites. As a start, this study makes one of the earliest attempts towards that direction, by undertaking both a theoretical and empirical exploration of the nexus between PES-type schemes and land tenure. This is undertaken in the context of two PES programmes in rural China, namely the Sloping Land Conversion Programme (SLCP) and the Ecological Public-Benefit Forest Compensation Programme (EPBFCP). In both cases, land tenure arrangements emerged from interactions among multiple stakeholders contesting land rights, wherein PES wielded substantial influence. Similarities and differences between the two cases can be suggestive of the conditions under which PES and land tenure become mutually reinforcing. Moreover, the sheer size of the two programmes adds to the practical significance of the findings. The two cases are therefore well positioned to exemplify the reciprocal effects of PES on land tenure.

# 2 THE SLOPING LAND CONVERSTION PROGRAMME AND CROPLAND TENURE

This section presents the first case study, which delves into the impact of China’s SLCP on cropland tenure. It starts with an outline of the policy background. This is followed by a game-theory framework, which models the impact of the SLCP on cropland tenure as an outcome of strategic interactions between village leaders and ordinary villagers contesting land rights. The proposition derived from this theoretical model is empirically tested using data at the cropland-plot and household levels collected in Gansu and Yunnan provinces where the SLCP has been influential.

## 2.1 Policy Context of the SLCP and Cropland Tenure

In the late 1990s, China was hit by severe floods in the Yangtze River basin (as shown in Figure 1). The severity of these floods was predominantly attributed to extensive deforestation and cultivation of sloped lands in the upper reaches of the Yangtze and Yellow Rivers. This triggered the initiation of a series of large-scale ecological restoration programmes in rural China in order to mitigate soil erosion and provide additional watershed services, chief among which was the SLCP. This programme was intended to retire highly sloped (usually greater than 25 degrees) and marginal cropland from agricultural production, and to convert such cropland to forests. By the end of 2006, this programme had set aside and afforested more than 9 million hectares of cropland in 25 provinces.[[1]](#footnote-1) This translates into a roughly 10% decrease in the country’s cultivated land. As a reference point, the cumulative enrolment (unexpired contracts) of the world-renowned Conservation Reserve Program of the US amounted to approximately 10 million hectares by the end of 2013 (Stubbs, 2014). The SLCP thus rivals the size of its American counterpart and represents one of the most influential land-based PES schemes in the world (Uchida, Xu, Xu, & Rozelle, 2007; Xu, Tao, Xu, & Bennett, 2010).

The SLCP provides both in-kind and cash payments to enrolled land holders on an annual basis to cover the loss of cropping revenues, in addition to free tree seedlings. On account of the considerable difference between crop yields in the south and north of China, the annual in-kind compensation was 2.25 tonnes of grain per hectare for the Yangtze River basin, and 1.50 tonnes for the Yellow River basin.[[2]](#footnote-2) The annual cash subsidy was set at the same level for both regions (CNY 300 per hectare). The duration of payments was initially five years if ‘economic trees’ (capable of providing additional incomes through fruits and nuts, etc.) were planted, and eight years if ‘ecological trees’ (to be managed merely for the provision of environmental services and would not directly lead to any substantial economic benefits for land holders) were planted. The compensation period was extended in 2007 for five (eight) more years for economic (ecological) trees, although the payment rate was halved. The programme requires ecological trees to be planted on a minimum of 80% of enrolled cropland in any given location (Groom, Grosjean, Kontoleon, Swanson, & Zhang, 2010). This ratio is even higher in Gansu and Yunnan provinces, where we collected our data (as shown by Figure 1). The two mountainous provinces accommodate the fast-running upper courses of the Yellow River and Yangtze River. Owing to lack of flat and fertile cropland, subsistence peasants have resorted to cultivating (previously forested) mountain slopes, making terrace farming a common practice in these regions. This has considerably exacerbated loss of soil and siltation of rivers. The two provinces are thus regarded as priority areas of the SLCP, where a higher ratio of ecological trees has been mandated.



Figure 1 Locations of the surveyed provinces and villages on a land-use map of China

Note. Source of the land-use map: Chinese Academy of Sciences.

 For cropland enrolled in the SLCP, the county or township government is responsible for signing contracts with land use rights holders, which are usually individual households. In the early years of the Chinese communist regime, collective farming was promoted in the early 1950s and reached its prime by the end of that decade. This collective farming system was widely accused of being responsible for the widespread famine and starvation in the late 1950s. (Rozelle & Swinnen, 2009). When the SLCP was introduced in the late 1990s, the collective cropland tenure system had been replaced by the Household Responsibility System (HRS) in the vast majority of China’s rural areas (Brandt, Huang, Li, & Rozelle, 2002). Under the HRS, village collectives still officially own the cropland, but individual households have fixed term contracts to use the cropland for their own agricultural production. In some places, however, village collectives occasionally redistribute their cropland among households in the same village. This practice was originally intended to improve equity and agricultural productivity by transferring uncultivated or less efficiently managed cropland to other households with insufficient land or higher productivity. Nowadays, cropland reallocation persists, although the frequency and scale have significantly decreased (Deininger & Jin, 2009; Mullan, Grosjean, & Kontoleon, 2011; Wang, Riedinger, & Jin, 2015; Wang, Tong, Su, Wei, & Tao, 2011). According to our data collected from Gansu and Yunnan provinces, nearly 10% of the surveyed households experienced cropland reallocation between 1997 and 2012, which was regarded by many respondents as one of the main causes of land dispossession. Irrespective of the actual extent of the practice of land re-allocation it nevertheless casts a significant shadow over people’s *perceptions* of land tenure security.

Village affairs such as cropland reallocation are usually initiated by the villagers’ committee, which typically consists of the party secretary, the village head and a few other committee members who share the village leadership. These village leaders, though subject to some sort of democratic elections, receive their wages (at least the party secretary and the village head) from higher levels of government and are obligated to fulfil certain administrative duties. Many of these duties could be quite unpopular, such as agricultural tax collection and birth control. Accomplishment of these tasks usually comes with certain political and financial benefits to village leaders – at a minimum this materialises in the form of the support from higher government for them staying in office. Village leaders usually have strong motivation to extend their power over collective resources (such as cropland, forestland and village enterprises), which would enable them to resort to the ‘carrot and stick’ approach to accomplish their political goals as well as to enforce other village norms (Brandt et al., 2004; Rozelle & Li, 1998; Wang et al., 2011). Therefore, village leaders have certain idiosyncratic interests associated with cropland reallocation compared to other villagers. However, the HRS has effectively made the village collective (represented by village leaders) and villagers the *de facto* joint holders of cropland rights, and thus endowed both groups with the ability to influence cropland tenure. Hence, there usually exists a bargaining process between village leaders and villagers over cropland reallocation in pursuit of asymmetric interests.

Use rights of SLCP land and the attached SLCP contract are transferable. The implications of the SLCP for land reallocation and land tenure security thus remain an open question.

## 2.2 Theoretical Analysis of the SLCP and Cropland Tenure

This section presents a game-theoretic framework developed from the studies of Burton (2004) and Engel et al. (2006; 2013). This framework models land tenure in rural China as outcomes of bargaining between village leaders and ordinary villagers over land rights, and describes how the equilibrium would be impacted by exogenous PES interventions. We only sketch the key elements of the theoretical framework with the formal proofs provided in Appendix A.

 Suppose there is a cropland plot managed by a household with a total area of *r*. The village leaders intend to reallocate part of the cropland () to an alternative household in the same village, leaving with the original household. Through cropland reallocation, the village leaders seek to obtain political and financial benefits [] by showing that they remain influential in the allocation of collective resources. Denote the production output and input of the original household respectively as and , and the counterparts of the alternative household as and . The net benefits of the village leaders and the original household can be written as:

, Eq. 1

, Eq. 2

If the two sides were able to independently make decisions on cropland reallocation, they would choose the area of reallocated cropland () which maximises their own net benefits. Let and respectively represent the optimal choices of the village leaders and the original household. It can be proved that .

 As a result, there is a conflict over the area of reallocated cropland between village leaders and the original household. The conflict starts when the total area of the cropland relinquished by the original household achieves , in which case the original household would prefer to retain the rest of the cropland () whilst the village leaders favour further reallocation. Engaging in the conflict would incur a cost for both the village leaders () and the original household (), mainly arising from the time and other resources spent on confrontation with each other. Since the formal and perhaps defendable rationale of cropland reallocation is to improve equity and agricultural productivity, the original household is assumed to be incapable of making a higher profit out of the disputed cropland in comparison with the alternative household []. and are assumed to be influenced by the difference [] in the cropping benefits between the two households:

. Eq. 3

Further we assume that , ; , . This suggests that if the alternative household outperforms the original household to a greater extent, it would be easier for the village leaders to defend against , whilst more difficult for the original household to reject and insist on . We assume if only one stakeholder (either the original household or village leaders) remains in the confrontation, the cropland reallocation conflict would be resolved in the best interests of this stakeholder ( for the original household or for village leaders). If both sides pull out and the conflict disappears, or neither of them withdraws which means the conflict is unresolved, the status quo () would persist and further land reallocation would not take place. Denote the probabilities of the village leaders and the original household quitting the conflict respectively as and (, ), and the discount rate of the net benefits of the two sides as and . Further we define:

 Eq. 4

 Eq. 5

This model adopts the complete information assumption, which assumes that the stakeholders are aware of each other’s parameters.

 As delineated by the solid lines in Figure 2, if (Regions I and III), then this implies that the confrontation cost of the village leaders in one period is greater than the net benefit of setting at forever, and the village leaders would never get involved in the conflict regardless of the behaviour of the original household. Knowing this, the household would also stay out of the conflict because can be achieved if both stakeholders withdraw, in which case the household does not even have to bear any confrontation costs which would further enhance the net benefits. Similarly, if (Regions III and IV), then this implies that the confrontation cost of the household in one period is greater than the net benefit of setting at forever, and the household would quit immediately regardless of the behaviour of the village leaders. Knowing this, if , the village leaders would remain in the conflict and set at (Region IV).

III

IV

?

I

II

Figure 2 Optimal strategies of stakeholders regarding cropland reallocation

Note. and : Changes in the net benefits of the village leaders and original land holder owing to land reallocation. and : Costs of engaging in the conflict for the village leaders and original land holder (baseline scenario without the SLCP). and : Costs of engaging in the conflict for the village leaders and original land holder (SLCP scenario). and : Discount rates of the village leaders and original land holder. and : Probabilities of the village leaders and the original land holder quitting the conflict. and : Area of reallocated cropland preferred by the village leaders and original land holder.

 When the values of the parameters fall into Region II, both the village leaders and the original household could enter the conflict, in which case the stakeholder who stays longer would win. As proved by Appendix A, the maximum time the village leaders () and the household () can afford to remain in the conflict can be expressed as:

, Eq. 6

. Eq. 7

 Under the complete information assumption, even in Region II, the two stakeholders are able to make an immediate decision on whether to enter the conflict by comparing *TL* and *TH*. The stakeholder who cannot afford to remain as long would not enter the conflict since the success of the battle is doomed to be out of reach.

 With this basic model in hand, we can then proceed to draw theoretical predictions about the impact of the SLCP on cropland reallocation. In spite of the heterogeneous compensation rates across much larger geographic areas (i.e. the Yangtze and Yellow River basins), the programme offers identical payment rates within each village (Yin & Zhao, 2012). Therefore, for any households within the same village, the benefits of managing SLCP land would most likely be the same.

 In our cropland reallocation model, this suggests that if the disputed cropland is enrolled in the SLCP, would be brought down to zero, which would then lower the confrontation cost of the original household () during cropland reallocation but face the village leaders with a higher cost (). As shown by Figure 2, the pure strategy regions in the SLCP scenario are now delineated by the dashed lines. If the values of the benefit and cost parameters fall into Regions I, III and IV, the original household is more likely to win the dispute compared to the baseline scenario: the expansion of the total area of Regions I and III implies that is more likely to be set at , whilst the shrinkage of Region IV suggests that is less likely to be set at . In Region III, since the SLCP payments would at least cover the loss of cropping benefits, we have , whereas village leaders’ benefits from land reallocation would not be affected (). According to Eq. 6 and Eq. 7, it is straightforward that, and , implying that the original household has a better chance of staying longer in the conflict and setting at .

Based on these discussions we posit the following hypothesis:

***Hypothesis 1****: Land plots enrolled in the SLCP are less likely to be reallocated to other households.*

## 2.3 Empirical Analysis of the SLCP and Cropland Tenure

The hypothesis proposed in the previous section was tested using a dataset collected through face-to-face questionnaire surveys. Respondents were sampled using the stratified random sampling method. Field surveys were conducted in collaboration with the Environment for Development (EfD) Initiative. This dataset was collected in 2013 through interviews with rural households, containing detailed information of 1,310 land plots of 300 households from 30 villages in 10 counties in Gansu and Yunnan provinces (as shown by Figure 1). This is basically a cross-sectional dataset with 2012 being the base year, but the respondents were asked to recall certain memorable information of their households in 1997 (prior to the SLCP), mainly involving demographic characteristics, off-farm workdays, land usage and durables ownership etc., which can be reasonably recalled over a long time period without introducing much error. During the fieldwork, we made every effort to reduce recall bias to a minimum, by thoroughly training enumerators in interview skills for recall questions and by following best practice guidelines (Poverty Environment Network, 2007). For instance, we intentionally linked the base year (1997) to particular events in the family (such as the birth/death of a family member), or a major village or country event (the SLCP itself is a historic event).

 Table B1 in Appendix B describes the variables involved in the empirical test of Hypothesis 1 regarding the impact of the SLCP on land tenure. This hypothesis was examined by measuring the treatment effect of the SLCP respectively on land reallocation and land tenure security. We repeated the analysis at the land-plot and household levels, and thereby generated four sets of results. Our field survey gathered information about the land plots currently held by the respondents’ households (at the time when the survey took place), as well as those once in their hands (between 1997 and 2012) but lost afterwards due to land reallocation or other reasons. This enabled us to construct a binary variable (‘land reallocation’) that takes the value one if land reallocation was observed at the land-plot or household level. Further, we looked into the implications of the SLCP for land tenure security. Since it is commonly perceived that secured tenure encourages sustainable land management in the long term whilst easing off the pressure of ‘exploit it or lose it’, the environmental efficacy of the SLCP could be influenced if the programme affected the tenure security of enrolled land, which is the first concern of this study. We used a subjective proxy of tenure security. This binary variable (‘tenure security’) indicates whether a household felt confident about holding a land plot after 20 years. A similar proxy was used in the studies of Holden et al. (2011) and Yi et al. (2014) to reveal the implications of forestland tenure security for forestry investment in the context of China.

Since SLCP contracts were not randomly assigned to land holders, a direct comparison between the outcome variables (land reallocation/land tenure security) of the treated and control groups may generate biased estimates of the treatment effects. We thus adopted the Propensity Score Matching (PSM) method to combat such bias. The other variables in Table B1 served as control variables in our PSM analysis. In order to derive valid estimates of the treatment effects, there is a necessity to control for those attributes that can both characterise the treated group and influence land tenure. To serve this purpose, the control variables themselves cannot be outcomes of the treatment. That is to say, the control variables should either be time-invariants or measured before the treatment (Angrist & Pischke, 2009; Caliendo & Kopeinig, 2008; Imbens & Wooldridge, 2009). In this study, the control variables were selected on the basis of our theoretical model and previous studies on determinants of land tenure and SLCP participation (as per Deininger, Ali, & Alemu, 2011; Groom et al., 2010; Holden & Yohannes, 2002; Rozelle & Li, 1998; Uchida et al., 2007; Xu et al., 2010; Xu, Yin, Li, & Liu, 2006; Yi et al., 2014; Yin & Zhao, 2012). We next specify these control variables, and justify their connections with both SLCP participation and land tenure.

In our theoretical model, the original land holder’s agricultural productivity [] is closely associated with the net benefits of both village leaders () and the original land holder () that can be potentially gained from engaging in the conflict over land reallocation. This is an influential determinant of land reallocation. Meanwhile, disadvantaged agricultural productivity implies lower opportunity cost of land retirement, which would incline land holders to join the SLCP. Nevertheless, it was difficult to collect reliable retrospective data on agricultural productivity previous to the SLCP. Comparatively, it was much less challenging for the respondents to recall their durables (e.g. vehicles and appliances) and off-farm workdays. The two variables respectively represent a household’s total income and off-farm income, the latter of which is the foremost livelihood source other than agricultural production. Therefore, the difference between the two variables should be largely attributable to agricultural production. We, thus, used these two variables to proxy agricultural productivity.

Furthermore, a household’s political and economic power would intuitively affect the confrontation cost () in the bargaining process with village leaders over land reallocation and SLCP participation. Local authorities seek to retire a certain amount of land, given the predetermined objectives and budget ceiling of the SLCP at the local level. In that case, households which are wealthier and politically more powerful would be in a better position to strike a preferable deal with village leaders on whether to participate and the amount of land to retire. We proxied a household’s political and economic power by the household size, ethnicity, membership of the Chinese Communist Party (CCP) and value of its durables.

Moreover, geophysical features of land plots, especially the slope and soil quality, were recommended by the SLCP policy documents as priority criteria for enrolment. In the meantime, as indicators of land quality, these features were frequently found correlated with land tenure. Take soil quality as an example. As suggested by our theoretical model, village leaders would be keener to reallocate lands with fertile soil, as a means to flex their political muscle and thereby to secure the practical benefits that come of it []. On the other hand, the holders of such lands could be more powerful agents with higher agricultural productivity. In our theoretical model, this implies higher gains () and lower confrontation costs () for a household to hold on to its lands. Lastly, the regional identifier ‘Yunnan’ was included to reflect different compensation rates and opportunity costs of SLCP participation across Yangtze and Yellow River areas.

 In the first stage of the PSM procedure, we estimated a binary model of SLCP participation, using the aforementioned control variables as regressors. Models B3 and B4 in Table B5 in Appendix B respectively present the SLCP participation models at the land-plot and household levels. Based on the participation model, propensity scores were calculated as the probabilities of participation for both treated and untreated observations. Treated observations were then matched with those untreated observations with similar propensity scores. In this stage, different matching techniques were used to check the robustness of the findings, including the one-to-one nearest-neighbour matching, radius matching and kernel matching. The average treatment effects were estimated as the mean difference in land reallocation or land tenure security between the two groups of matched observations (Khandker, Koolwal, & Samad, 2010).

 Table 1 summarises the SLCP treatment effects estimated by the PSM method with different matching techniques. In general, these estimation results provide sufficient empirical evidence in favour of Hypothesis 1: SLCP land is less likely to be reallocated to other households. This finding aligns with previous studies which conjectured more stable land tenure attributable to the SLCP (Groom et al., 2010; Uchida et al., 2009). At the land-plot level (Panel 1), the estimates in the second column are derived from a direct comparison between the treated and control groups. These estimates find a positive effect of the SLCP on the stability of land tenure: the enrolled land plots are less likely to be reallocated to other villagers, and the land holders feel more confident about retaining possession of these lands. The treatment effects on land reallocation (-0.03) and land tenure security (0.18) are not only statistically different from zero, but also considerable in magnitude, compared with their overall mean values in the sample (0.06 and 0.75 respectively, as shown by Table B1 in the appendix). Columns 3-6 illustrate the PSM estimates after controlling for the potential confounders. These estimates are highly consistent with the previous findings in terms of the direction, statistical significance and magnitude. In order to further test the robustness of the findings, all estimation was replicated at the household level. As shown by Panel 2 in Table 1, the household-level estimates of the treatment effects on land tenure security remain positive and significant, albeit slightly smaller in comparison with those at the land-plot level. However, the estimated treatment effects on land reallocation become insignificant, although their absolute values are similar with the plot-level estimates. This is because only a small proportion (10%) of the households in our sample experienced land reallocation, and the estimated treatment effects (around -3%) are inevitably close to zero. After aggregating the plot-level data to the household level, our sample size shrinks from 1,310 to 300, making it more difficult to pick up the statistical significance of those estimates.[[3]](#footnote-3),[[4]](#footnote-4)

Table 1 Impact of the SLCP on land tenure a

|  |  |  |
| --- | --- | --- |
| **Outcome of interest** | **Simple meancomparison** | **PSM estimates** |
| **NN b 1-1** | **NN 1-5** | **Radius** | **Kernel** |
| *Panel 1: Land-plot level (obs. 1,310)* |
| Reallocation | -0.03 | \*\* | -0.03 | \*\* | -0.02 | \* | -0.02 | \*\* | -0.02 | \*\* |
|  | (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  |
| Tenure security | 0.18 | \*\*\* | 0.18 | \*\*\* | 0.21 | \*\*\* | 0.20 | \*\*\* | 0.20 | \*\*\* |
|  | (0.04) |  | (0.04) |  | (0.04) |  | (0.03) |  | (0.03) |  |
| *Panel 2: Household level (obs. 300)* |
| Reallocation | -0.03 |  | -0.04 |  | -0.03 |  | -0.03 |  | -0.03 |  |
|  | (0.03) |  | (0.04) |  | (0.04) |  | (0.04) |  | (0.04) |  |
| Tenure security | 0.13 | \*\*\* | 0.10 | \*\* | 0.16 | \*\*\* | 0.15 | \*\*\* | 0.15 | \*\*\* |
|  | (0.05) |  | (0.05) |  | (0.06) |  | (0.05) |  | (0.05) |  |

Notes.

a \* *p*-value < 0.10, \*\* *p*-value < 0.05, \*\*\* *p*-value < 0.01. Standard errors are in brackets.

b NN: nearest neighbour.

 As shown by Figure B1 in the appendix, the propensity scores of the treated and control observations are much more balanced after matching, which implies the matched observations become more comparable in terms of the probabilities of being treated. Moreover, it is worth noting that the validity of the PSM estimates is conditional on the balance of covariates between the treated and control groups after matching (Austin, 2009; Caliendo & Kopeinig, 2008; Dehejia & Wahba, 1999; Khandker et al., 2010). We used the conventional *t* test and the standardised percentage difference test to measure the balance of each individual covariate (as shown by the appended Table B4). The overall covariate balance can be assessed by the mean and median standardised percentage differences, as well as the Rubin’s B and Rubin’s R statistics. At the land plot level, two thirds of the covariates are significantly unbalanced before matching, leading to considerable overall unbalance between the treated and control groups. In contrast, the post-matching statistics find substantial improvement in covariate balance, especially after radius and kernel matching. At the household level, the situations are almost identical.

Moreover, as previously described, the first stage of the PSM procedure involved a binary model of SLCP enrolment. The regression results can be informative when assessing the credibility of the PSM estimates. As displayed by Models B3 and B4 in the appended Table B5, the regression results of the SLCP enrolment models are highly explicable in the institutional and field contexts. For instance, the positive and strongly significant coefficient of ‘slope’ represents the programme’s top priority to retire highly-sloped cropland. The positive coefficient of ‘cropland area 1997’ implies that households with more cropland are more willing to join the SLCP. This is likely because when holding other factors of production fixed (such as labour reflected by ‘household size’), the marginal returns of cultivating more cropland are diminishing, which suggests lower opportunity costs of land retirement. Further, the likelihood of SLCP participation is found higher for politically or economically advantaged households. SLCP participants were frequently found better off by previous studies, not only because of the payments, but also due to certain favourable changes in their livelihood portfolios induced by the programme. For instance, there has been evidence showing that the SLCP has the effect of facilitating off-farm labour supply (which is usually more lucrative) by providing the liquidity to finance the shift to off-farm employment and alleviating the pressure to cultivate (Groom et al., 2010; Lin & Yao, 2014; Uchida et al., 2009). These potential benefits have likely triggered competition among land holders for enrolment, since the contracts are limited at the local level, and those households with more bargaining power would stand a better chance.

# 3 THE ECOLOGICAL PUBLIC-BENEFIT FOREST COMPENSATION PROGRAMME AND FORESTLAND TENURE

The previous sections showed the theoretical conditions required for a PES programme to positively influence tenure security. Our empirical study suggests that this positive relationship does in fact hold for the case of the SLCP in China. Yet, our finding may not be generalisable to all types of PES programmes. To probe more deeply into the generality of our result we next turned to exploring the relationship between PES payments and tenure security under a different policy context, namely the Ecological Public-Benefit Forest Compensation Programme (EPBFCP). The EPBFCP was rolled out on lands with more collective tenure rights. It thus provides a telling comparison study to the SLCP which operated in areas with mostly private land use rights.

## 3.1 Policy Context of the EPBFCP and Forestland Tenure

The EPBFCP case study focuses on China’s communal forestland in rural areas, which is owned by village collectives. Such forestland accounts for about 60% of the country’s total forestland area (The State Forestry Administration, 2015), whilst the other 40% is held by the state. Formally launched in 2001, the Ecological Public-Benefit Compensation Programme (EPBFCP) was originally geared towards existing national ecological public-benefit (EPB) forests at that time. These forests were intended to be managed primarily for the provision of environmental services and thus subject to strict restrictions on forestry production activity, particularly logging. The EPBFCP was thus hatched to compensate forest holders for the costs of custodial management. For communal forests, compensation payments are uniform across communities (initially CNY 75 per hectare each year and later raised to 225). However, the compensation funds sourced from the exchequer have incentivised local governments to expand the scope of the programme by enrolling more forests (Bennett, 2009; Li, Li, Li, & Liu, 2006; Xu, Jiang, & Yi, 2007; Yin, Yao, & Huo, 2013b). Province-level forestry authorities are responsible for the designation of national EPB forests, and they are supposed to enrol forests on steep slopes, or close to river sources or biodiversity hotspots, out of consideration of their ecological significance (The State Forestry Administration, 2010). By 2012, the total area of national EPB forests had exceeded 124 million hectares, representing nearly 40% of the country’s total forestland area. According to our data collected from Fujian province (as shown in Figure 1), an average of more than 20% of the communal forests in the surveyed villages were enrolled as EPB forests in 2010.

 For those communal forests enrolled in the EPBFCP, the contract could either be signed by a village collective (usually represented by the villagers’ committee) or a village household, since either of them could be entitled to the use rights of communal forests (although village collectives have never loosened their grip on the ownership of these forests). Parallel to collective farming, collective forestry production was also dominating in China’s rural regions during the commune era. In contrast with agricultural production, there were neither catastrophic events such as the great famine in the late 1950s nor sufficient hard evidence to justify the de-collectivisation of forestry production. The HRS was first expanded to forestland in the mid-1980s presumably based on the triumph of the cropland tenure reform. Nevertheless, this first wave of forestland tenure reform was shadowed by furious debates over pros and cons of de-collectivised forestland tenure. Bureaucratic reluctance to de-collectivise forestland was commonly observed: in Fujian province, large areas of communal forests were placed under a shareholding system instead of being allocated to individual households, which was later criticised as being little more than a disguised collective tenure system. Eventually the reform was brought to a halt by purported evidence of ‘excessive logging’ associated with de-collectivised forestland tenure (Yin, Yao, & Huo, 2013a).

The forestland tenure reform was back on the agenda when the 2002 rural land contract law sent out strong signals in support of household-based forestland tenure. The second wave of forestland tenure reform was first piloted in the next year in Fujian province, the last fortress of collective forestry. By 2006, 99% of the province’s villages claimed to have reformed their forestland tenure towards the direction of de-collectivisation. This reform sought to bestow upon village households the use rights of more communal forests via fixed term contracts (between collectives and households), although these forests would remain in the ownership of village collectives. In other words, the ownership and use rights of communal forests could be separately granted to different stakeholders. Despite this, it provided flexibility for villages to decide how to reshape their forestland tenure at the will of the majority of villagers (The National People's Congress, 2002; The State Council, 2008). By 2014, 65.2% of the country’s communal forestland had been allocated to individual households and became privately managed (The State Forestry Administration, 2015). However, there is still a considerable proportion of forestland remaining under collective management, even in Fujian province which is supposed to have experienced significant de-collectivisation of forestland (Xu et al., 2010). The main source of uncertainties in forestland tenure appears to be the ongoing debate between collective and household based tenure systems, instead of reallocation as in the case of cropland discussed in the SLCP case study.

As can be seen from the chronology of these developments, the EPBFCP was introduced almost concurrently with the de-collectivisation reform of forestland in Fujian province. If EPB forests are de-collectivised, obligations and rights laid down by the EPBFCP would usually be transferred to individual households. This may have a profound impact on de-collectivisation of forest rights, since the uniform payment of the EPBFCP may undermine the incentive for private forestry. We next formally discuss these implications, under the theoretical framework developed in Section 2.

## 3.2 Theoretical Analysis of the EPBFCP and Forestland Tenure

Suppose in one village there is a communal forest with a total area of *R*, which is collectively managed by all the households in this village with a share of benefits [] for each household. In the forestland tenure reform, the forest could be formally de-collectivised, in which case each household would hold part of the forest (). Further, define: . Different output (*PC*, *PH*) and input (*EC*, *EH*) functions were employed for collectively managed and de-collectivised forests, assuming different input-output patterns for them (e.g. compared to de-collectivised forests, according to the tragedy of the commons theory, villagers may have motivation to over-exploit collective forests but make less restocking investment which may further influence the marginal productivity of these collective forests). The benefits to an ordinary villager obtained from the forests refer to the net benefits of forestry production:

. Eq. 8

Meanwhile, a village leader also benefits from the power [] seized by keeping more resources under collective management aside from the incomes earned from forestry production.

. Eq. 9

If the two players were able to make the forestland tenure arrangement independently, they would choose the area of collectively managed forestland () that maximises their own benefits. Denote the optimal choices of the ordinary villager and the village leader respectively as and . It can be proved that , which represents a divergence between the two sides. When the village starts to de-collectivise the forestland ( at the starting point), the conflict would not emerge until , when the village leader would prefer things to stay as they are whilst the ordinary villager would favour further de-collectivisation. Engaging in the conflict would incur a cost for both village leaders () and ordinary villagers (), influenced by the difference in the benefits of disputed forestland being collectively or privately managed. If household-based forestry is more productive than collective forestry, it would be easier for ordinary villagers to argue in favour of further de-collectivisation until , but more difficult for village leaders to defend against .

If the disputed forests are enrolled in the EPBFCP, forestry production activity would be prohibited or at least strictly restricted, and the revenues from managing these forests would only come from the compensation payments, the rate of which is the same no matter whether the forest is under collective or household management. In our theoretical model, this implies that the ordinary villager in pursuit of further de-collectivisation has to bear a higher confrontation cost only to obtain the same benefits. In light of that, neither stakeholder would enter the conflict, and would be set at . We hence propose the second hypothesis:

***Hypothesis 2****: Ecological public-benefit forests are more likely to be placed under collective management.*

## 3.3 Empirical Analysis of the EPBFCP and Forestland Tenure

Our empirical analysis of the EPBFCP relied on a highly balanced panel dataset at the village level, reflecting detailed information regarding demographic features, institutions, land use and other economic activity of 48 villages in 8 counties in Fujian province (as shown by Figure 1). This three-period (2000, 2005 and 2010) panel dataset was collected through two repeated field surveys with village leaders which respectively took place in 2006 and 2011, with the 2000 data being recall information collected from the 2006 survey based on village statistics recorded and filed by village leaders.

 Hypothesis 2 was tested at the village level by measuring the programme’s impact on the share of collectively managed forests (as opposed to privately managed forests) in the total area of communal forests.[[5]](#footnote-5) This is perhaps the most significant influence likely caused by the EPBFCP on forestland tenure as suggested by the policy context as well as our theoretical model. Meanwhile, the EPBFCP treatment was measured as the share of communal forests enrolled in the programme. This was because the vast majority of the villages in our sample were intervened by the EPBFCP, which prevented us from constructing a pure control group with adequate observations. In spite of that, the intervention was not delivered at the same strength or intensity to all villages, since the share of ecological forests varies from one village to another. We thus retreated to assessing the differential effects of the intervention at different levels of intensity (i.e. the impact of the share of ecological forests on the share of collectively managed forests), which is a commonly accepted empirical strategy when evaluating the impact of full-coverage programmes [see for example studies by Rossi, Lipsey and Freeman (2004) and Sims (2010)].

Table B2 in Appendix B defines the variables involved in the EPBFCP analysis and presents the descriptive statistics. When selecting the other explanatory variables, we referred to our theoretical model as well as existing studies on land tenure in rural China (Brandt et al., 2004; Rozelle & Li, 1998; Wang et al., 2011; Xu et al., 2010; Yin et al., 2013a). As described by Eq. 9 in our theoretical model, the motivation of village leaders to strengthen their power over collective resources largely arises from their intention to secure their position as village leaders and the wages that come with the post. We did not control for such wages in our empirical analysis because they were homogenous across different villages according to our data. When engaged in the bargaining process over forest rights, village leaders would bear a confrontation cost (), not least the opportunity cost of their time, which was proxied by their off-farm employment status.

On the villagers’ side, as discussed in our theoretical model, their additional benefits - which could be potentially seized from contesting the property rights of communal forests - are contingent upon the outperformance of private forestry production relative to the collective system. When forests are collectively managed as a common pool resource (CPR), conventional wisdom typically predicts over-exploitation and under-investment, which would eventually lead to sub-optimal outcomes of forestry production and even a collapse of forest resources in the long term. However, extensive experimental studies have found cooperation among CPR users to overcome the temptation to over-harvest and under-invest, especially if self-organised institutions (such as punishment for excessive logging) are in place (Ostrom & Nagendra, 2006). Moreover, communication among CPR users and the group size were frequently regarded as salient factors affecting the prevalence of cooperation in CPR management (Ostrom, 2006; Richter, van Soest & Grasman, 2013). Therefore, the difference in the benefits of private and collective forestry production can be expressed as:

, Eq. 10

where , and respectively denote self-organised institutions, communication among villagers and the village population. In our empirical analysis, such difference was captured by the variables ‘household forestry income’ (benefits of private forestry production), ‘punishment’, ‘villagers’ conferences’ and ‘village population’. The opportunity cost of villagers’ time spent on the bargaining process was represented by ‘household total income’.

 Aside from these determinants, the confrontation cost () is also influenced by villagers’ political and economic power. These factors were proxied by ‘household total income’ and ‘share of CCP members’. We also controlled for some other village-specific characteristics, including the share of labour (villagers between the ages of 16 and 60) in the village population, household size, total area of cropland and forests, education, average slope of the village territory and distance to urban areas, which are likely correlated with the foregoing variables.

 The departure point of the empirical analysis is an OLS model estimated on pooled data (Model 1 in Table 2). However, the censored nature of the dependent variable can be better described by the Tobit model, which may produce significantly different estimates compared to the OLS model if the censoring rate is high (Greene, 2012). We thus estimated a Tobit model on pooled data (Model 2 in Table 2) to examine the validity of the findings from the linear model. In an effort to control for unobserved confounders, we exploited the panel nature of our data and estimated two fixed effects (FE) linear models (Models 3 and 4 in Table 2), which progressively included village and year fixed effects. Unfortunately, fixed effects Tobit estimates would introduce new biases, especially when the length of the panel is short and fixed (Greene, 2004) as in our case. We hence estimated two random effects models respectively in linear and Tobit specifications (Models 5 and 6 in Table 2), assuming unobserved village-specific confounders to be orthogonal to the EPBFCP treatment and normally distributed in the random effects Tobit model (Wooldridge, 2010)].

 Table 2 displays the estimated impact of the EPBFCP on forest tenure. Throughout Models 1-6, the coefficient of ‘EPBFCP’ is positive and significant, corroborating Hypothesis 2: ecological public-benefit forests are more likely to be placed under collective management. The estimates of the pooled OLS and random effects linear regressions (Models 1 and 5) are only slightly different from their counterparts in the Tobit regressions (Models 2 and 6),[[6]](#footnote-6) which is likely due to the limited censoring rate (12%) of the data. In view of that, linear regressions can perhaps produce reasonable approximations to Tobit estimates in our case. We thus resort to the fixed effects linear regressions (Models 3 and 4) to gain insight into the potential confounding effects of village-specific and year-specific unobservables, since modelling fixed effects in a Tobit setting would lead to biased and inconsistent estimates (Greene, 2004). After controlling for the village and year fixed effects, the estimated effect of the EPBFCP (0.45) becomes much smaller in magnitude. Even so, we can still discern a noteworthy effect of the EPBFCP on forest tenure. Interpreted as elasticities, this estimate implies that a 1% increase in the share of ecological forests would increase the share of collectively managed forests by 0.3%.[[7]](#footnote-7)

Table 2 Impact of the EPBFCP on the share of collectively managed forestland

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Dependent variable:** Share of collectively managed forests | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** | **Model 6** |
| **Explanatory variable:** | **Pooled OLS** | **Pooled Tobit (dy/dx)** | **FE Linear** | **FE Linear** | **RE Linear** | **RE Tobit (dy/dx)** |
| EPBFCP  | 0.60 | \*\*\* | 0.55 | \*\*\* | 0.44 | \*\* | 0.45 | \*\* | 0.60 | \*\*\* | 0.55 | \*\*\* |
|  | (0.11) |  | (0.10) |  | (0.19) |  | (0.19) |  | (0.09) |  | (0.08) |  |
| Off-farm employment of village leaders | -0.10 | \*\*\* | -0.08 | \*\*\* | -0.09 | \*\* | -0.04 |  | -0.08 | \*\* | -0.08 | \*\* |
| (0.03) |  | (0.03) |  | (0.04) |  | (0.04) |  | (0.03) |  | (0.03) |  |
| Household forestry income | -0.01 |  | -0.01 |  | -0.02 | \*\* | -0.02 |  | -0.01 |  | -0.01 |  |
| (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  |
| Punishment | 0.01 | \*\*\* | 0.01 | \*\*\* | 0.01 | \*\*\* | 0.01 | \*\*\* | 0.01 | \*\*\* | 0.01 | \*\*\* |
|  | (1.60 × 10-3) |  | (1.29 × 10-3) |  | (1.70 × 10-3) |  | (1.80 × 10-3) |  | (1.57 × 10-3) |  | (2.33 × 10-3) |  |
| Villagers’ conferences | 2.60 × 10-3 |  | 2.67 × 10-3 |  | -1.90 × 10-4 |  | 1.60 × 10-3 |  | 2.50 × 10-3 |  | 2.67 × 10-3 |  |
|  | (3.30 × 10-3) |  | (3.43 × 10-3) |  | (4.00 × 10-3) |  | (3.50 × 10-3) |  | (3.69 × 10-3) |  | (3.04 × 10-3) |  |
| Village population | -0.01 |  | -0.01 |  | -0.22 | \*\*\* | -0.16 | \*\* | -0.01 |  | -0.01 |  |
|  | (0.04) |  | (0.03) |  | (0.06) |  | (0.06) |  | (0.04) |  | (0.03) |  |
| Household total income | 0.02 |  | 0.01 |  | 0.02 |  | 0.04 | \*\* | 0.02 |  | 0.01 |  |
| (0.01) |  | (0.01) |  | (0.02) |  | (0.01) |  | (0.01) |  | (0.01) |  |
| Share of CCP members  | -2.40 | \* | -2.05 | \* | -4.98 | \* | -3.04 |  | -2.46 | \* | -2.05 |  |
|  | (1.40) |  | (1.22) |  | (2.55) |  | (2.33) |  | (1.47) |  | (1.28) |  |
| Household size | 0.05 | \*\*\* | 0.04 | \*\*\* | 0.08 | \*\*\* | 0.06 | \*\*\* | 0.05 | \*\*\* | 0.04 | \*\*\* |
|  | (0.02) |  | (0.01) |  | (0.02) |  | (0.02) |  | (0.02) |  | (0.01) |  |
| Share of labour | 0.12 |  | 0.10 |  | -0.06 |  | 0.07 |  | 0.12 |  | 0.10 |  |
|  | (0.12) |  | (0.11) |  | (0.18) |  | (0.18) |  | (0.16) |  | (0.11) |  |
| Forest area | 2.60 × 10-3 | \* | 2.34 × 10-3 | \*\* | 0.02 |  | 0.02 |  | 2.59 × 10-3 | \* | 2.34 × 10-3 | \* |
|  | (1.40 × 10-3) |  | (1.18 × 10-3) |  | (0.01) |  | (0.01) |  | (1.34 × 10-3) |  | (1.33 × 10-3) |  |
| Cropland area | 0.02 |  | 0.02 |  | -0.01 |  | -2.50 × 10-3 |  | 0.02 |  | 0.02 |  |
|  | (0.04) |  | (0.03) |  | (0.04) |  | (0.05) |  | (0.05) |  | (0.03) |  |
| Education | -0.15 | \*\*\* | -0.13 | \*\*\* | -0.09 |  | -0.06 |  | -0.15 | \*\*\* | -0.13 | \*\*\* |
|  | (0.04) |  | (0.03) |  | (0.10) |  | (0.11) |  | (0.04) |  | (0.03) |  |
| Slope | 0.02 | \* | 0.02 | \*\* |  |  |  |  | 0.02 |  | 0.02 | \*\* |
|  | (0.01) |  | (0.01) |  |  |  |  |  | (0.01) |  | (0.01) |  |
| Distance to urban areas | -1.10 × 10-3 |  | -8.92 × 10-4 |  |  |  |  |  | -1.17 × 10-3 |  | -8.92 × 10-4 |  |
| (9.40 × 10-4) |  | (8.08 × 10-4) |  |  |  |  |  | (8.58 × 10-4) |  | (7.57 × 10-4) |  |
| Constant | -0.07 |  |  |  | 0.06 |  | -0.13 |  | -0.06 |  |  |  |
|  | (0.12) |  |  |  | (0.26) |  | (0.24) |  | (0.13) |  |  |  |
| Village fixed effects | No |  | No |  | Yes |  | Yes |  | No |  | No |  |
| Year fixed effects | No |  | No |  | No |  | Yes |  | No |  | No |  |
| Model significance (*p*-value) | 0.00 |  | 0.00 |  | 0.00 |  | 0.00 |  | 0.00 |  | 0.00 |  |
| R2  | 0.47 |  |  |  | 0.42 |  | 0.48 |  | 0.47 |  |  |  |
| Observations | 144 |  | 144 |  | 144 |  | 144 |  | 144 |  | 144 |  |

Notes. \* *p*-value < 0.10, \*\* *p*-value < 0.05, \*\*\* *p*-value < 0.01. Standard errors are in brackets. In Models 3 and 4, time invariants ‘slope’ and ‘distance to urban areas’ were absorbed into village fixed effects.

The empirical findings with respect to other covariates are mostly consistent with our theoretical predictions. For instance, village leaders with off-farm occupations ought to have higher opportunity costs of engaging themselves in the bargaining process over forest rights. This may have put them in a disadvantaged position to retain communal forests under collective control, as revealed by the negative coefficient of ‘off-farm employment of village leaders’. On the other hand, if a village has self-organised institutions which can effectively enforce sanctions for excessive exploitation of collective forests, the presumed inefficiency of collective forestry would be corrected to some extent (Ostrom & Nagendra, 2006). This would in turn reduce villagers’ motivation for further de-collectivisation of forest rights, due to lower efficiency gains from switching to household-based forestry production. This explains the positive effect of ‘punishment’ on the share of collectively managed forests. In contrast, collective forestry would be more prone to efficiency loss in a village with a bigger population (Richter, van Soest & Grasman, 2013). Meanwhile, higher incomes earned from household-based forestry also suggest additional benefits from de-collectivisation. Therefore, these two variables are found contributory to de-collectivisation of forest rights, as shown by their negative effects on the share of collectively managed forests.

# 4 CONCLUSIONS

This study makes one of the earliest attempts to develop a formal theoretical framework to model the reciprocal and complex interactions between PES and land tenure. We adjust the theoretical framework to the specificities of two different land-based PES programmes in China and draw theoretical predictions as to the impact of PES on land tenure for each case. We then test these hypotheses using primary data collected in the field and find that different types of PES entail more complex implications for land tenure than the literature often has assumed. Our paper, thus, contributes to the thin evidence base on the intricate relationship between PES and land tenure.

 Though our theoretical framework involves many contextual details regarding China’s PES and land tenure arrangements, it could be tailored to other PES-tenure interactions. For instance, the widespread debates over the impact of REDD on forest rights typically entail central governmental bodies and local actors (such as communities) as principal stakeholders contesting forest rights in pursuit of their own interest. The bone of contention concerns the implications of REDD for these stakeholders, in particular, which of the following two effects would play a more decisive role: new incentives (springing from PES payments) for central governmental bodies to tighten their grip on forest rights, or local actors’ opportunity to be formally recognised as ES suppliers which would strengthen their forest rights (e.g. Phelps, Webb, & Agrawal, 2010; Wunder, 2010). These particular features are distinct from the two cases studies explored in this paper, yet the main narrative holds up well, which boils down to the identification of, 1) the most influential stakeholders of land rights, 2) interactions among these stakeholders which drive the formation of land rights, and 3) connections between PES and such interactions. These theoretical insights were all touched upon by previous studies (such as Phelps et al., 2010; Resosudarmo et al., 2014; Sandbrook et al., 2010; Sunderlin et al., 2014). Our study has further developed these insights into a unified formalised game-theory model. Although it is an early attempt to use this model to explore the effects of PES on land tenure, similar bargaining models have been applied to studies concerning endogenous land tenure arrangements in other contexts (e.g. Burton, 2004; Engel et al., 2006, 2013; Engel & Palmer, 2008). These findings imply a potential of applying this analytical framework to other situations.

Our theoretical and empirical analyses find consistent evidence for the positive impact of the SLCP on land tenure. Several previous studies found that SLCP participants were more likely to take up off-farm employment opportunities, which was suggested as being attributable to enhanced land tenure security (Groom et al., 2010). This study provides supporting evidence for such conjectures. Actually such positive outcomes are not confined to the case of the SLCP. There has been evidence showing that many ES suppliers of Costa Rica’s national PES joined the programme to secure their property rights (Arriagada et al. 2015). These findings shed some new insight into the conservation efficacy and the post-contract prospect of these PES schemes. For one thing, more stable land tenure was frequently found to be able to facilitate sustainable land-use strategies, such as sufficient investment in forest restoration and less pre-mature logging (Besley, 1995; Deininger et al., 2011; Liscow, 2013; Robinson, Holland, & Naughton-Treves, 2014; Yi et al., 2014). On the other hand, for those SLCP participants who are redirected to more profitable off-farm occupations, it becomes less attractive to re-cultivate their lands enrolled in the SLCP, even after the contract expires. This could be a reason why there is little evidence of deforestation and re-cultivation on SLCP lands, even after 2007 when the SLCP halved its compensation rate and became unable to cover the loss of farming profits. These findings further imply a possibility of developing ‘self-sustainable’ PES. If a PES is designed in such a way that it can induce favourable institutional developments (such as more stable land tenure) which would in turn propel ES suppliers towards an optimised and environmentally-friendly livelihood portfolio, perpetual payments may not be necessary to secure additional ES provision (i.e. the same ES would be delivered even without any payments hereafter) (Grosjean & Kontoleon, 2009).

On the other hand, the EPBFCP is found to have an effect in favour of collective forest tenure, which somewhat stands in the way of the country’s agenda to further de-collectivise communal forests to individual households. In a sense, our finding resembles previous discussions over the effects of REDD on recentralisation of forest rights, although the effects are delivered through different avenues: EPBFCP backs collective forest tenure by reducing villagers’ motivation to de-collectivise communal forests, whereas REDD is suspected to have created new incentives for authorities to recentralise forest rights. Since household-based forest tenure is often reckoned to perform better in China (relative to collective forest tenure) in terms of promoting sustainable forestry strategies (Hyde, Belcher, & Xu, 2003), our finding translates into a caveat about the conservation efficacy of the EPBFCP. However, different forms of forest tenure (public/communal/private) were found to have heterogeneous implications for forest conservation in different regions of the world (Robinson et al., 2014). Further academic efforts are needed to accumulate direct evidence of the conservation outcomes of the EPBFCP.[[8]](#footnote-8)

 The opposite effects of the two programmes suggest that PES should be cautiously used under unclear, contested and insecure land tenure settings. Our results suggest that introducing PES under such a context could in fact afflict land tenure as was found to be the EPBFCP case. Many researchers have argued that PES can be designed in such a way that induces favourable developments in land tenure (Palmer, 2011; Sunderlin et al., 2014). Yet, the EPBFCP seems to have led to the opposite effect, even though it was introduced side by side with a forestland tenure reform. PES and land tenure reforms are not necessarily mutually reinforcing. Land tenure reform takes time to mature. In the case of the cropland tenure reform in China, it was not until 1982 that the central government gave its final nod of approval to the HRS. However, by that time, more than half of China’s villages had in effect already adopted the HRS in various guises (Rozelle & Swinnen, 2009). Subsequently, and for a good 20 years from the early 1980s, interactions among governmental authorities, village leaders and village households over cropland rights continued. Re-collectivisation and reallocation of cropland were commonly observed and documented. It was not until the early 2000’s that the frequency and scale of cropland reallocation tailed off (Deininger & Jin, 2009; Mullan et al., 2011). Had the HRS not taken root, the new incentives of the SLCP might as well have tempted local authorities and village leaders to reverse de-collectivisation of croplands. Our findings thus caution against reckless expansion of land-based PES in the presence of institutional imperfections.

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# APPENDIX A

Suppose there is a cropland plot managed by a household with a total area of *r*. The village leaders intend to reallocate part of the cropland () to an alternative household in the same village, leaving with the original household. Through cropland reallocation, the village leaders seek to obtain political and financial benefits [] by showing that they remain influential in the allocation of collective resources. Denote the production output and input of the original household respectively as and , and the counterparts of the alternative household as and . The net benefits of the village leaders and the original household can be written as:

, Eq. A1

, Eq. A2

Further we take that:

, ; , ; , .

If the two sides were able to independently make decisions on cropland reallocation, they would choose the area of reallocated cropland () which maximises their own net benefits. That is to say, the village leaders would choose the solution to the maximisation problem , which is denoted as , and the original household would choose the solution to , which is denoted as . The first order conditions are:

, Eq. A3

. Eq. A4

As long as , we have and . There is a conflict over the area of reallocated cropland between village leaders and the original household. The conflict starts when the total area of the cropland relinquished by the original household achieves , in which case the original household would prefer to retain the rest of the cropland () whilst the village leaders favour further reallocation. Engaging in the conflict would incur a cost for both the village leaders () and the original household (), mainly arising from the time and other resources spent on confrontation with each other. Since the formal and perhaps defendable rationale of cropland reallocation is to improve equity and agricultural productivity, the original household is assumed to be incapable of making a higher profit out of the disputed cropland in comparison with the alternative household []. and are assumed to be influenced by the difference [] in the cropping benefits between the two households:

. Eq. A5

Further we assume that , ; , . This suggests that if the alternative household outperforms the original household to a greater extent, it would be easier for the village leaders to defend against , whilst more difficult for the original household to reject and insist on . We assume if only one stakeholder (either the original household or village leaders) remains in the confrontation, the cropland reallocation conflict would be resolved in the best interests of this stakeholder ( for the original household or for village leaders). If both sides pull out and the conflict disappears, or neither of them withdraws which means the conflict is unresolved, the status quo () would persist and further land reallocation would not take place. Denote the probabilities of the village leaders and the original household quitting the conflict respectively as and (, ), and the discount rate of the net benefits of the two sides as and .

 If the village leaders engage themselves in the confrontation for one more period (but quit in the next period), the net benefit would be:

, Eq. A6

in which , and is the village leaders’ net present benefit of setting at forever since the next period[[9]](#footnote-9). On the other hand, if the village leaders withdraw immediately, there would not be any additional benefits or costs. The village leaders would thus remain in the conflict if Eq. A6 > 0, quit immediately if Eq. A6 < 0, and be indifferent between the two strategies if Eq. A6 = 0, or:

. Eq. A7

 Similarly, if the original household remains in the confrontation for one more period (but quits in the next period), the net benefit would be:

. Eq. A8

If the household withdraws immediately, the net benefit would be:

. Eq. A9

Equating Eq. A8 to Eq. A9 gives the threshold for the household to quit the conflict:

. Eq. A10

 Eq. A7 and Eq. A10 imply that the optimal strategies of the village leaders and the original household depend on the probability of each other quitting the conflict. In spite of that, without specifying such probabilities it is still possible to unambiguously predict the stakeholders’ optimal strategies if certain conditions hold for the other parameters (, , , , and ). This model adopts the complete information assumption, which assumes that the stakeholders are aware of each other’s parameters.

As delineated by the solid lines in Figure A1, if (Regions I and III)[[10]](#footnote-10), then this implies that the confrontation cost of the village leaders in one period is greater than the net benefit of setting at forever, and the village leaders would never get involved in the conflict regardless of the behaviour of the original household. Knowing this, the household would also stay out of the conflict because can be achieved if both stakeholders withdraw, in which case the household does not even have to bear any confrontation costs which would further enhance the net benefits. Similarly, if (Regions III and IV)[[11]](#footnote-11), then this implies that the confrontation cost of the household in one period is greater than the net benefit of setting at forever, and the household would quit immediately regardless of the behaviour of the village leaders. Knowing this, if , the village leaders would remain in the conflict and set at (Region IV).

III

IV

?

I

II

Figure A1 Optimal strategies of stakeholders regarding cropland reallocation

 When the values of the parameters fall into Region II, both the village leaders and the original household could enter the conflict, in which case the stakeholder who stays longer would win. If both enter the conflict and the household withdraws at time *t*, the net present value of village leaders’ benefits would be:

. Eq. A11

Note that

. Eq. A12

Therefore, the maximum time the village leaders can afford to remain in the conflict is *TL* which makes *FL* = 0:

, Eq. A13

 Similarly, if both sides enter the conflict and the village leaders withdraw at time *t*, the net present value of the household’s benefits would be:

. Eq. A14

Note that

. Eq. A15

Therefore, the maximum time the household can afford to remain in the conflict is *TH* which makes *FH* = 0:

. Eq. A16

 Under the complete information assumption, even in Region II, the two stakeholders are able to make an immediate decision on whether to enter the conflict by comparing *TL* and *TH*. The stakeholder who cannot afford to remain as long would not enter the conflict since the success of the battle is doomed to be out of reach.

 The formal proofs of the results of the forestland tenure model are available upon request.

# APPENDIX B

Table B1 Definitions and descriptive statistics of the variables in the SLCP dataset

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Definition** | **Mean** | **SD** | **Min** | **Max** |
| *Panel 1: Land-plot level (obs. 1,310)* |
| Land reallocation | Dummy variable: 1 = A land plot was reallocated to another household during 1997-2012; 0 = Otherwise.  | 0.06 | 0.16 | 0 | 1 |
| Tenure security | Dummy variable: 1 = A household felt secure about holding a land plot after 20 years; 0 = Otherwise. | 0.75 | 0.43 | 0 | 1 |
| SLCP enrolment | Dummy variable: 1 = A land plot was enrolled in the SLCP; 0 = Otherwise. | 0.11 | 0.32 | 0 | 1 |
| Slope | Slope of a land plot (0 = < 15°; 1 = 15~25°; 2 => 25°). | 0.91 | 0.89 | 0 | 2 |
| Soil | Soil quality of a land plot (0 = Good; 1 = Medium; 2 = Poor). | 0.85 | 0.78 | 0 | 2 |
| Cropland area 1997 | Cropland area (mu) per capita in 1997. | 2.40 | 2.83 | 0 | 24.25 |
| Household size 1997 | Number of household members in 1997. | 5.12 | 1.58 | 1 | 10 |
| Ethnic minority | Dummy variable: 1 = Ethnic minority household; 0 = Otherwise.  | 0.46 | 0.50 | 0 | 1 |
| CCP membership 1997 | Dummy variable: 1 = A household had a CCP member in 1997; 0 = Otherwise.  | 0.21 | 0.41 | 0 | 1 |
| Value of durables 1997 | Monetary value (103 CNY, inflation-adjusted) of durables per capita in 1997. | 0.29 | 0.96 | 0 | 8.22 |
| Off-farm workdays 1997 | Number of off-farm workdays per capita in 1997.  | 18.57 | 37.50 | 0 | 216.67 |
| Yunnan | Dummy variable: 1 = Yunnan province; 0 = Otherwise. | 0.58 | 0.49 | 0 | 1 |
| *Panel 2: Household level (obs. 300)* |
| Land reallocation | Dummy variable: 1 = A household had at least one land plot reallocated to another household during 1997-2012; 0 = Otherwise.  | 0.10 | 0.30 | 0 | 1 |
| Tenure security | Dummy variable: 1 = A household felt secure about holding all the land plots after 20 years; 0 = Otherwise. | 0.81 | 0.39 | 0 | 1 |
| SLCP enrolment | Dummy variable: 1 = A household was enrolled in the SLCP; 0 = Otherwise. | 0.37 | 0.48 | 0 | 1 |
| Slope | Dummy variable: 1 = A household had at least one land plot steeper than 25°. | 0.58 | 0.49 | 0 | 1 |
| Soil | Dummy variable: 1 = A household had at least one land plot with poor soil.  | 0.38 | 0.49 | 0 | 1 |
| Cropland area 1997 | Cropland area (mu) per capita in 1997. | 2.18 | 2.48 | 0 | 24.25 |
| Household size 1997 | Number of household members in 1997. | 4.97 | 1.56 | 1 | 10 |
| Ethnic minority | Dummy variable: 1 = Ethnic minority household; 0 = Otherwise.  | 0.49 | 0.50 | 0 | 1 |
| CCP membership 1997 | Dummy variable: 1 = A household had a CCP member in 1997; 0 = Otherwise.  | 0.19 | 0.39 | 0 | 1 |
| Value of durables 1997 | Monetary value (103 CNY, inflation-adjusted) of durables per capita in 1997. | 0.27 | 0.82 | 0 | 8.22 |
| Off-farm workdays 1997 | Number of off-farm workdays per capita in 1997.  | 22.74 | 41.91 | 0 | 216.67 |
| Yunnan | Dummy variable: 1 = Yunnan province; 0 = Otherwise. | 0.60 | 0.49 | 0 | 1 |

Notes. 1 mu = 0.067 hectare. All monetary values were measured in 2012 CNY (CNY 1 = USD 0.16 in 2012).

Table B2 Definitions and descriptive statistics of the variables in the EPBFCP dataset

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Definition** | **Mean** | **SD** | **Min** | **Max** |
| Share of collectively managed forests | Share of collectively managed forests in the total forest area of the village.  | 0.27 | 0.25 | 0 | 0.99 |
| EPBFCP  | Share of ecological forests in the total forest area of the village.  | 0.19 | 0.19 | 0 | 0.87 |
| Off-farm employment of village leaders | Dummy variable: 1 = The village leader had off-farm jobs; 0 = Otherwise. | 0.44 | 0.50 | 0 | 1 |
| Household forestry income | Mean forestry income (103 CNY per capita, inflation-adjusted) obtained from privately-managed forests in the village. | 0.98 | 1.83 | 0 | 13.03 |
| Punishment | Number of villagers punished due to excessive exploitation of collectively managed forests.  | 1.78 | 6.13 | 0 | 60 |
| Villagers’ conferences | Number of villagers’ conferences in that year.  | 5.55 | 5.19 | 0 | 36 |
| Village population | Number of villagers (103) living in the village. | 1.17 | 1.01 | 0.15 | 6.50 |
| Household total income | Mean income (103 CNY per capita, inflation-adjusted) of the village. | 3.88 | 2.01 | 0.39 | 14.81 |
| Share of CCP members  | Share of CCP members in in the village population. | 0.03 | 0.01 | 0.01 | 0.09 |
| Household size | Mean household size of the village. | 4.42 | 1.61 | 3.03 | 16.84 |
| Share of labour | Share of villagers aged between 16 and 60 in the village population.  | 0.53 | 0.15 | 0.17 | 0.87 |
| Forest area | Total forest area (103 mu) of the village. | 13.81 | 13.50 | 0.31 | 78.88 |
| Cropland area | Total cropland area (103 mu) of the village. | 1.03 | 0.71 | 0.21 | 4.00 |
| Education | Dummy variable: 1 = The village had schools; 0 = Otherwise.  | 0.58 | 0.50 | 0 | 1 |
| Slope | Average slope (degrees) of the village territory.  | 4.64 | 2.07 | 0.32 | 8.65 |
| Distance to urban areas | Distance (km) from the village to the nearest county centre.  | 35.54 | 25.45 | 0 | 96 |

Notes. 1 mu = 0.067 hectare. All monetary values were measured in 2010 CNY (CNY 1 = USD 0.15 in 2010).

Table B3 Robustness check: Impact of the SLCP on land tenure

|  |  |  |
| --- | --- | --- |
| **Dependent variable:**  Tenure security (binary)**Explanatory variable:** | **Model B1**  | **Model B2**  |
| **Land-plot level** | **Household level** |
| SLCP enrolment | 1.48 | \*\*\* | 0.97 | \*\*\* |
|  | (0.56) |  | (0.36) |  |
| Slope | -0.23 | \* | -0.21 |  |
|  | (0.14) |  | (0.31) |  |
| Soil | -0.03 |  | 0.01 |  |
|  | (0.13) |  | (0.28) |  |
| Cropland area 2012 | -3.91×10-3 |  | 0.14 | \* |
|  | (0.04) |  | (0.07) |  |
| Household size 2012 | 0.05 |  | 0.10 |  |
|  | (0.10) |  | (0.08) |  |
| Ethnic minority | 0.02 |  | -0.06 |  |
|  | (0.26) |  | (0.27) |  |
| CCP membership 2012 | -0.16 |  | -0.28 |  |
|  | (0.44) |  | (0.36) |  |
| Value of durables 2012 | 0.01 |  | 0.06 |  |
|  | (0.05) |  | (0.11) |  |
| Off-farm workdays 2012 | -1.17×10-3 |  | -4.32×10-4 |  |
|  | (2.31×10-3) |  | (2.35×10-3) |  |
| Yunnan | 0.33 |  | 0.90 | \*\*\* |
|  | (0.28) |  | (0.29) |  |
| Constant | 0.88 |  | 0.13 |  |
|  | (0.68) |  | (0.71) |  |
| Clustered standard errors at  the village level | Yes |  | Yes |  |
| Model significance (*p*-value) | 0.00 |  | 0.00 |  |
| Pseudo R2 | 0.03 |  | 0.07 |  |
| Observations | 1,310 |  | 300 |  |

Notes. \* *p*-value < 0.10, \*\* *p*-value < 0.05, \*\*\* *p*-value < 0.01. Standard errors are in brackets.

**Table B4 Covariate balance before and after matching a**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Unmatched** | **NN 1-1** | **NN 1-5** | **Radius** | **Kernel** |
|  | **D** | **B** | **T** | **D** | **B** | **T** | **D** | **B** | **T** | **D** | **B** | **T** | **D** | **B** | **T** |
| *Panel 1 Land-plot level* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Slope | 0.70 | 87.2 | 0.00 | -0.01 | -0.80 | 0.94 | -0.01 | -0.8 | 0.94 | -0.00 | -0.1 | 1.00 | 0.04 | 5.4 | 0.62 |
| Soil | -0.02 | -2.8 | 0.75 | -0.02 | -2.6 | 0.82 | -0.04 | -5.5 | 0.62 | -0.06 | -7.5 | 0.50 | -0.03 | -4.2 | 0.71 |
| Cropland area 1997 | 0.81 | 26.4 | 0.00 | -0.90 | -29.5 | 0.09 | -0.32 | -10.5 | 0.45 | -0.20 | -6.4 | 0.64 | -0.04 | -1.4 | 0.92 |
| Household size 1997 | 0.04 | 2.6 | 0.76 | 0.00 | 0.0 | 1.00 | 0.10 | 6.1 | 0.59 | 0.07 | 4.3 | 0.70 | 0.04 | 2.4 | 0.83 |
| Ethnic minority | 0.13 | 25.2 | 0.00 | -0.04 | -8.1 | 0.48 | -0.06 | -12.1 | 0.29 | -0.04 | -7.2 | 0.53 | -0.01 | -1.7 | 0.89 |
| CCP membership 1997 | 0.19 | 42.4 | 0.00 | 0.04 | 9.0 | 0.47 | -0.00 | -0.6 | 0.96 | 0.01 | 3.0 | 0.81 | 0.02 | 3.7 | 0.77 |
| Value of durables 1997 | 0.41 | 30.0 | 0.00 | 0.13 | 9.6 | 0.49 | 0.14 | 10.0 | 0.48 | 0.08 | 6.0 | 0.68 | 0.02 | 1.2 | 0.94 |
| Off-farm workdays 1997 | 1.74 | 4.6 | 0.59 | -0.99 | -2.6 | 0.82 | -3.55 | -9.4 | 0.44 | -2.17 | -5.7 | 0.63 | -0.14 | -0.4 | 0.98 |
| Yunnan | 0.12 | 25.6 | 0.00 | -0.01 | -2.8 | 0.80 | 0.00 | 0.0 | 1.00 | -0.00 | -1.0 | 0.93 | 0.01 | 2.6 | 0.82 |
| Mean standardised percentage difference b | 27.4 |  | 7.2 |  | 6.1 |  | 4.6 |  | 2.5 |  |
| Median standardised percentage difference | 25.6 |  | 2.8 |  | 6.1 |  | 5.7 |  | 2.4 |  |
| Rubin’s B c | 109.3 |  | 25.9 |  | 22.2 |  | 14.5 |  | 9.0 |  |
| Rubin’s R c | 0.93 |  | 0.43 |  | 0.92 |  | 1.06 |  | 1.3 |  |
| *Panel 2 Household level* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Slope | 0.21 | 43.6 | 0.00 | 0.09 | 19.5 | 0.15 | 0.01 | 2.0 | 0.88 | 0.02 | 3.9 | 0.77 | 0.02 | 4.2 | 0.75 |
| Soil | 0.01 | 2.4 | 0.84 | -0.01 | -1.9 | 0.89 | -0.01 | -1.2 | 0.93 | -0.02 | -4.9 | 0.72 | -0.01 | -2.1 | 0.88 |
| Cropland area 1997 | 0.80 | 30.3 | 0.01 | 0.08 | 3.1 | 0.80 | -0.09 | -3.6 | 0.78 | -0.09 | -3.4 | 0.79 | -0.07 | -2.8 | 0.83 |
| Household size 1997 | 0.34 | 21.7 | 0.07 | 0.09 | 6.0 | 0.66 | 0.13 | 8.0 | 0.55 | 0.05 | 3.3 | 0.81 | 0.04 | 2.7 | 0.84 |
| Ethnic minority | 0.29 | 59.4 | 0.00 | 0.10 | 21.4 | 0.12 | 0.00 | 0.4 | 0.98 | -0.02 | -3.5 | 0.80 | -0.01 | -2.8 | 0.84 |
| CCP membership 1997 | 0.09 | 22.2 | 0.06 | 0.01 | 2.3 | 0.87 | 0.01 | 1.9 | 0.90 | -0.00 | -0.6 | 0.97 | -0.02 | -3.9 | 0.79 |
| Value of durables 1997 | 0.16 | 17.0 | 0.12 | -0.04 | -4.7 | 0.57 | -0.06 | -6.8 | 0.41 | -0.03 | -3.1 | 0.70 | -0.03 | -3.4 | 0.66 |
| Off-farm workdays 1997 | -2.62 | -6.7 | 0.59 | -3.16 | -8.1 | 0.56 | -0.90 | -2.3 | 0.86 | -0.29 | -0.7 | 0.96 | -0.73 | -1.9 | 0.88 |
| Yunnan | -0.06 | -12.2 | 0.31 | -0.02 | -3.8 | 0.78 | -0.03 | -5.7 | 0.68 | -0.05 | -9.8 | 0.48 | -0.06 | -12.0 | 0.38 |
| Mean standardised percentage difference | 24.0 |  | 7.9 |  | 3.5 |  | 3.7 |  | 4.0 |  |
| Median standardised percentage difference | 21.7 |  | 4.7 |  | 2.3 |  | 3.4 |  | 2.8 |  |
| Rubin’s B | 89.9 |  | 33.2 |  | 14.2 |  | 13.9 |  | 15.0 |  |
| Rubin’s R | 1.27 |  | 1.21 |  | 1.77 |  | 1.05 |  | 1.17 |  |

Notes.
a Column D: Mean difference (treated group – control group); Column B: Standardised percentage difference; Column T: statistical significance of mean difference (*p*-value).

b For continuous variables, the standardised percentage difference is defined as: , in which and respectively denote the sample mean of this covariate in the treated and control groups whilst and denote the sample variance. The counterpart for dichotomous variables is , wherein and respectively denote the sample mean of the dichotomous variable in the treated and control groups. The advantage of this measure in comparison with t-statistics is that it is not influenced by sample sizes. A standardised percentage difference greater than 10 is often regarded as evidence of significant difference between contrasted groups (Austin, 2009).

c Let and respectively represent the mean and variance of the linear predictions of the latent dependent variable in the treatment model for those treated observations that are matched to untreated ones. The counterparts for the untreated observations are denoted as and . The Rubin’s B statistic can be expressed as: . The Rubin’s R statistic is defined as: . Significant overall unbalance would be detected if the Rubin’s B statistic is greater than 25 or if the Rubin’s R statistic does not lie in the interval between 0.5 and 2 (Rubin, 2001).

Table B5 Model specification of SLCP enrolment

|  |  |  |
| --- | --- | --- |
| **Dependent variable:**  SLCP enrolment**Explanatory variable:** | **Model B3**  | **Model B4**  |
| **Land-plot level** | **Household level** |
| Slope | 1.00 | \*\*\* | 0.75 | \*\* |
|  | (0.12) |  | (0.30) |  |
| Soil | -0.12 |  | -0.11 |  |
|  | (0.13) |  | (0.28) |  |
| Cropland area 1997 | 0.03 |  | 0.16 | \*\*\* |
|  | (0.03) |  | (0.06) |  |
| Household size 1997 | 0.02 |  | 0.26 | \*\*\* |
|  | (0.07) |  | (0.08) |  |
| Ethnic minority | 0.43 | \*\* | 1.23 | \*\*\* |
|  | (0.19) |  | (0.27) |  |
| CCP membership 1997 | 0.80 | \*\*\* | 0.24 |  |
|  | (0.21) |  | (0.34) |  |
| Value of durables 1997 | 0.23 | \*\*\* | 0.45 | \*\* |
|  | (0.07) |  | (0.18) |  |
| Off-farm workdays 1997 | -2.55 × 10-3 |  | -4.43 × 10-3 |  |
|  | (3.01 × 10-3) |  | (3.30 × 10-3) |  |
| Yunnan | 0.72 | \*\*\* | -0.43 |  |
|  | (0.21) |  | (0.28) |  |
| Constant | -4.29 | \*\*\* | -3.09 | \*\*\* |
|  | (0.46) |  | (0.59) |  |
| Model significance (*p*-value) | 0.00 |  | 0.00 |  |
| Pseudo R2 | 0.15 |  | 0.14 |  |
| Observations | 1,310 |  | 300 |  |

Notes. \* *p*-value < 0.10, \*\* *p*-value < 0.05, \*\*\* *p*-value < 0.01. Standard errors are in brackets.

Table B6 Robustness check: Impact of the EPBFCP on the share of collectively managed forestland

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Dependent variable:** Share of collectively managed forests | **Model B5** | **Model B6** | **Model B7** | **Model B8** | **Model B9** | **Model B10** |
| **Explanatory variable:** | **Pooled OLS** | **Pooled Tobit (dy/dx)** | **FE Linear** | **FE Linear** | **RE Linear** | **RE Tobit (dy/dx)** |
| EPBFCP  | 0.48 | \*\*\* | 0.43 | \*\*\* | 0.33 | \* | 0.42 | \*\* | 0.48 | \*\*\* | 0.43 | \*\*\* |
|  | (0.14) |  | (0.11) |  | (0.19) |  | (0.17) |  | (0.14) |  | (0.08) |  |
| Off-farm employment of village leaders | 1.22×10-3 |  | 0.01 |  | 0.04 |  | 9.78×10-4 |  | 1.22×10-3 |  | 0.01 |  |
| (0.04) |  | (0.03) |  | (0.05) |  | (0.06) |  | (0.04) |  | (0.04) |  |
| Household forestry income | -0.01 |  | -0.01 | \* | -0.02 |  | -0.01 |  | -0.01 |  | -0.01 | \* |
| (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  | (0.01) |  |
| Punishment | 0.01 |  | 0.01 |  | 1.62×10-3 |  | -0.01 |  | 0.01 | \* | 0.01 |  |
|  | (0.01) |  | (4.72×10-3) |  | (0.01) |  | (0.01) |  | (4.18×10-3) |  | (0.01) |  |
| Villagers’ conferences | 1.92×10-3 |  | 2.38×10-3 |  | -1.75×10-3 |  | -2.53×10-3 |  | 1.92×10-3 |  | 2.38×10-3 |  |
|  | (3.46×10-3) |  | (3.70×10-3) |  | (4.62×10-3) |  | (3.60×10-3) |  | (3.58×10-3) |  | (3.04×10-3) |  |
| Village population | -7.96×10-4 |  | -1.36×10-3 |  | -0.22 | \*\*\* | -0.17 | \*\* | -7.96×10-4 |  | -1.36×10-3 |  |
|  | (0.03) |  | (0.03) |  | (0.05) |  | (0.07) |  | (0.04) |  | (0.03) |  |
| Household total income | 0.02 |  | 0.01 |  | 0.01 |  | 0.03 |  | 0.02 |  | 0.01 | \* |
| (0.01) |  | (0.01) |  | (0.02) |  | (0.02) |  | (0.01) |  | (0.01) |  |
| Share of CCP members  | -1.50 |  | -1.21 |  | -3.33 |  | -2.93 |  | -1.50 |  | -1.21 |  |
|  | (1.41) |  | 1.19 |  | (2.22) |  | (2.45) |  | (1.33) |  | (1.25) |  |
| Household size | 0.05 | \*\*\* | 0.04 | \*\*\* | 0.09 | \*\*\* | 0.08 | \*\*\* | 0.05 | \*\*\* | 0.04 | \*\*\* |
|  | (0.01) |  | (0.01) |  | (0.02) |  | (0.02) |  | (0.02) |  | (0.01) |  |
| Share of labour | 0.14 |  | 0.12 |  | 0.02 |  | 0.06 |  | 0.14 |  | 0.12 |  |
|  | (0.13) |  | (0.11) |  | (0.20) |  | (0.19) |  | (0.16) |  | (0.12) |  |
| Forest area | 2.69×10-3 |  | 2.41×10-3 |  | 0.02 |  | 0.02 |  | 2.69×10-3 | \* | 2.41×10-3 | \* |
|  | (1.69×10-3) |  | (1.33×10-3) |  | (0.01) |  | (0.01) |  | (1.63×10-3) |  | (1.42×10-3) |  |
| Cropland area | 4.99×10-4 |  | -9.50×10-4 |  | -0.01 |  | -0.01 |  | 4.99×10-4 |  | -9.50×10-4 |  |
|  | (0.03) |  | (0.03) |  | (0.03) |  | (0.04) |  | (0.03) |  | (0.03) |  |
| Education | -0.10 | \* | -0.08 | \*\* | 0.07 |  | 0.06 |  | -0.10 | \*\* | -0.08 | \*\* |
|  | (0.05) |  | (0.04) |  | (0.10) |  | (0.14) |  | (0.04) |  | (0.04) |  |
| Slope | 0.01 |  | 0.01 | \* |  |  |  |  | 0.01 |  | 0.01 |  |
|  | (0.01) |  | (0.01) |  |  |  |  |  | (0.01) |  | (0.01) |  |
| Distance to urban areas | -3.42×10-4 |  | -1.70×10-4 |  |  |  |  |  | -3.42×10-4 |  | -1.70×10-4 |  |
| (1.11×10-3) |  | 9.18×10-4 |  |  |  |  |  | (1.07×10-3) |  | (8.39×10-4) |  |
| Constant | -0.23 | \* |  |  | -0.20 |  | -0.27 |  | -0.23 |  |  |  |
|  | (0.14) |  |  |  | (0.28) |  | (0.26) |  | (0.16) |  |  |  |
| Village fixed effects | No |  | No |  | Yes |  | Yes |  | No |  | No |  |
| Year fixed effects | No |  | No |  | No |  | Yes |  | No |  | No |  |
| Model significance (*p*-value) | 0.00 |  | 0.00 |  | 0.00 |  | 0.00 |  | 0.00 |  | 0.00 |  |
| R2  | 0.46 |  |  |  | 0.41 |  | 0.48 |  | 0.46 |  |  |  |
| Observations | 96 |  | 96 |  | 96 |  | 96 |  | 96 |  | 96 |  |

Notes. \* *p*-value < 0.10, \*\* *p*-value < 0.05, \*\*\* *p*-value < 0.01. Standard errors are in brackets. In Models B7 and B8, time invariants ‘slope’ and ‘distance to urban areas’ were absorbed into village fixed effects.

|  |
| --- |
| *Panel 1: Land-plot level* |
| a |  | b |  |
| c |  | d |  |
| e |  |  |  |
|  |  |  |  |
| *Panel 2: Household level* |
| f |  | g |  |
| h |  | i |  |
| j |  |  |  |

Figure B1 Distribution of the propensity scores of SLCP enrolment

Notes. a) – e) respectively present the *plot-level* propensity scores before matching, after one-to-one nearest-neighbour matching, one-to-five nearest-neighbour matching, radius matching and kernel matching. f) – j) respectively present the *household-level* propensity scores before matching, after one-to-one nearest-neighbour matching, one-to-five nearest-neighbour matching, radius matching and kernel matching.

1. The SLCP initially aimed to enrol some 15 million hectares of cropland, but enrolment was suspended in 2007. The programme was reopened for new enrolments in 2014 with evolved provisions. Since we collected our data in 2013, all descriptions of the SLCP in this study refer to the first round of sign-up. [↑](#footnote-ref-1)
2. The in-kind compensation was replaced by cash in 2004 at a price of CNY 1.4 per kilogramme. [↑](#footnote-ref-2)
3. In an attempt to control for within-cluster correlation, we tentatively conducted conventional cluster-bootstrapping at the village level with 400 iterations for the Kernel matching estimators (Abadie & Imbens, 2008; Cameron & Miller, 2015*)*. For the estimates of the treatment effect at the plot level, the cluster-bootstrapped standard errors are larger than the original standard errors of the Kernel matching estimators. This diminishes the statistical significance of the estimated treatment effects on land reallocation at the plot level. But we can still discern a significant improvement in tenure security attributable to the SLCP. On the household level, the cluster-bootstrapped standard errors are only marginally different from the original estimates, and the findings of statistical inference are largely similar. [↑](#footnote-ref-3)
4. As a diagnosis of potential recall bias, we conducted empirical analysis using only the 2012 data, as shown in Table B3. The results once again find that the SLCP has strengthened land tenure security. This implies that potential recall bias is likely to be less harmful when evaluating the direction of the treatment effect. The study of Uchida et al. (2009) used a similar procedure to assess the influence of potential recall bias. [↑](#footnote-ref-4)
5. Recall that ‘collectively managed’ forests refer to those communal forests directly managed by a village collective (usually represented by the villagers’ committee), whereas ‘privately managed’ forests refer to those communal forests that individual households have the right to use, although both are collectively owned. [↑](#footnote-ref-5)
6. The results of the Tobit regressions reported in Table 2 are the marginal effects of the explanatory variables on the *observed dependent variable*, instead of the original coefficients which represent the effects on the *latent variable*. [↑](#footnote-ref-6)
7. As a precaution against potential recall bias, we re-estimated Models 1-6 using only the 2005 and 2010 data, since the 2000 data were collected in 2006 (whereas the 2005 and 2010 data were respectively collected in 2006 and 2011) and are thus most likely to incur recall bias. Table B6 illustrates the results, which are largely similar with the original results derived from data for all three years. [↑](#footnote-ref-7)
8. Though our findings are highly robust we should acknowledge certain important caveats. In the case of the SLCP, the validity of our matching analysis relies on the assumption that we have taken into account all factors associated with both SLCP enrolment and cropland reallocation (as shown in Table B5). Regarding the treatment effect of the EPBFCP, our fixed effects analysis has controlled for not only the observed covariates (in Model 4 in Table 2), but also village-specific unobservables that do not vary over time and year-specific unobservables that have a uniform effect on all villages. We are making the assumption that aside from those observables and unobservables, there are no other factors associated with both the stringency of the EPBFCP and de-collectivisation of forest rights. This is the reason that we wrote at length (in Sections 2.3 and 3.3) in an attempt to justify the selection of control variables. These underlying assumptions need to be taken into consideration when assessing the strength of our empirical evidence. [↑](#footnote-ref-8)
9. $\sum\_{t=1}^{+\infty }φ\_{L}^{t}∆V\_{L}=\frac{φ\_{L}∙∆V\_{L}}{1-φ\_{L}}$. [↑](#footnote-ref-9)
10. In that case, Eq. A7 < 0, since $∆V\_{L}<\left(1-φ\_{L}\right)∙C\_{L}<\frac{1-φ\_{L}}{q\_{H}}∙C\_{L}$. [↑](#footnote-ref-10)
11. In that case, Eq. A10 < 0, since $∆V\_{H}<\left(1-φ\_{H}\right)∙C\_{H}<C\_{H}<\frac{1}{1-q\_{L}}∙C\_{H}$. [↑](#footnote-ref-11)