To Reallocate or Not? Optimal Land Institutions under Communal Tenure: Evidence from China*

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Abstract

This paper examines rural communities' optimal institutional choice under communal tenure. I argue that frequent land reallocations with a labor-contingent rule of allocation, despite inefficiently trapping labor in agriculture, can nonetheless be welfare-improving compared to secure tenure. I rely on a legal reform in 2003 that stopped land reallocations in all Chinese villages, and adopt a difference-in-difference strategy to identify the causal effects of reallocations. On average, the elimination of land reallocations increased off-farm labor and household per capita net income by 8% and 7% respectively. However, this came at the cost of a 5% decrease in total agricultural output and a significant jump in income inequality.

Keywords: Institutions, Communal Tenure, Land Reallocations, Agriculture

JEL Classification: D02, D13, D61, O12, P26, Q15

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1 Introduction

Many economists regard the lack of well-functioning private property rights institutions as a major obstacle to economic development (North and Thomas, 1973; Acemoglu, Johnson, and Robinson, 2001; de Soto, 2000). Correspondingly, policy-makers are increasingly considering property privatization and titling as one of the most effective ways for governments to combat poverty and encourage growth (Binswanger-Mkhize, Deininger, and Feder, 1995; Baharoglu, 2002). Despite this consensus on the importance of private property rights, communal tenure, in which a group of people own land collectively but frequently redistribute use rights between members, remains commonplace in many developing countries. These include Mexico, many countries in Asia, and the majority of sub-Saharan Africa.

I study rural societies' optimal land institutional design under communal tenure, taking into consideration the various market imperfections and constraints faced by developing economies. While previous research on communal tenure often concentrates on its inefficiency consequences,[1] I conduct a much more comprehensive welfare evaluation of communal tenure. In addition to providing a coherent theory to explain why rural communities adopt practices of production-contingent access to land and periodic reallocations under communal tenure, I empirically test some of the tradeoffs faced by rural communities in choosing between possible land institutions. These tradeoffs then provide an explanation for why certain communities might prefer communal tenure over private ownership despite the efficiency costs often associated with it. Understanding these tradeoffs is essential for evaluating any property law reform in developing countries.

I analyze the topic in the context of rural China, where land is collectively owned at the village level, and where elected village officials frequently redistribute use rights of land across households until the central government enacted the Rural Land Contracting Law (RLCL) in 2003 to prohibit land reallocations. An evaluation of the economic effects of RLCL provides a rare opportunity to examine the relationship between property rights, efficiency and equity, and sheds light to the rationale of communities' land institutional set-up under communal tenure. Its findings are also highly relevant to policy-making in contemporary China, where spurring agricultural productivity has once again become a pertinent issue due to the loss of agricultural self-sufficiency, and where the state increasingly views land reforms as necessary for maintaining high economic growth and curbing rural-urban inequality.

To study villages' choice of land institutions under communal tenure and to provide guidance for my empirical tests, I build a two-period model, assuming the existence of off-farm labor markets but the absence of agricultural labor and land markets. In the model, a fixed set of households,

[1] Numerous papers that I list in the literature review below, for example, focus on countries with communal tenure, and provide evidence that communal tenure tends to lower investment, and often leads to inefficient labor allocation.

whose different off-farm productivity is private information, are given land at the beginning of the first period. A social planner may choose to reallocate all landholdings between the first and second periods, while households simultaneously decide how to allocate labor between agricultural and off-farm activities in each period.

The model makes three primary predictions: First, in the absence of functioning markets, land distribution across households affects both income distribution and agricultural efficiency in the village. Conditional on a reallocation happening, the social planner has an incentive to use households' previous-period labor decisions as a signal of their off-farm productivity and allocate more land to households whose lagged agricultural labor is higher (conditional on their lagged per capita landholding). Second, villages with lower administrative costs and higher cross-household variation in demographic change reallocate more often. Finally, the labor-contingent rule of allocation leads households to oversupply labor to agriculture. Reallocations therefore have two counterbalancing effects: they improve welfare by reducing production inefficiencies due to imperfect markets and income inequality on the one hand, but create labor inefficiency on the other.

I test the model using panel data between 1986 and 2008 from China's National Fixed-Point Survey (NFS) and retrospective data from the Village Democracy Survey (Padro-i Miquel, Qian, and Yao, 2006). Compared to previous data, this data permits much more accurate observation of the timing of major village land reallocations. The panel nature of the NFS survey is also essential for my identification strategy: it helps alleviate endogeneity problems caused by unobservable household or village characteristics, which have often biased previous estimates of the effects of land reallocations using cross-sectional data.

The empirical analysis proceeds in several steps: First, I examine how villages allocate land across households during major reallocations. To do this, I employ a first-difference model on a panel of households that have undergone multiple reallocations. Consistent with the model, my estimates show that a one standard deviation increase in a household's lagged percentage of labor in agriculture increases the land allocated to the household by 0.05 standard deviations.

Second, to identify the determinants of a village's reallocation frequency, I calculate each village-year's standard deviation in households' percentage change in their number of rural residents, number of rural laborers, and number of rural male laborers respectively. I show that, during the pre-reform period, the village-specific mean of all three indicators are, indeed, positively correlated with a village's frequency of reallocations. Factors that tend to increase the administrative costs of reallocations, such as the number of households in the village, whether the village is in a mountainous area, and the plot size variation in the village, decrease the probability of reallocations in the village.

Finally, I rely on the RLCL reform, which reduced reallocation probability in all Chinese villages to zero, to test the effects of land reallocations on various market outcomes. I exploit the variation in villages' reallocation practices before the reform, and identify the causal effects of reallocations by examining how changes in outcomes differ across villages with different pre-reform reallocation tendencies. Restricting the estimates to changes due to the exogenous shock of the reform ensures that the estimated effects are not biased by reverse causality. Controlling for village fixed effects in my empirical model should also eliminate any omitted variable bias caused by time-invariant village characteristics. In addition, I conduct a large number of robustness exercises to show that my estimates are unlikely to be biased by measurement errors or confounded by the effects of other concurrent changes, such as overall provincial growth or the agricultural levies reform happening at about the same time.

On average, I find that the RLCL reform increased household labor allocation to off-farm activities by 2.7 percentage points, which accounted for about 30% of China's total off-farm labor increase between 1995 and 2003. This labor transition increased households' per capita net income by 7%. However, the elimination of land reallocations also decreased total agricultural output by about 5%, corroborating land reallocations' role in substituting for markets to encourage efficient agricultural production, and significantly increased income inequality.

The empirical evidence is, therefore, consistent with the model's predictions. These results imply that prohibiting land reallocations generates a mixed-bag of village welfare consequences: in rural China, changing village reallocation policies can create a trade-off between dynamic inefficiencies in household labor choice and static production inefficiencies due to imperfect market conditions. In addition, my evidence demonstrates that land reallocations performed an important function of wealth redistribution within the village.

For policymakers, these results imply that, to obtain the full benefits of private property rights under imperfect markets, one should pair policies that enhance private property rights with policies that reduce market imperfections. Even then, policymakers that value equity will face a choice between improving total income and improving equity.

The paper makes significant contributions to our understanding of how property institutions affect economic outcomes: Past empirical studies have provided much evidence on the effects of property rights on production investment (Besley, 1995; Banerjee, Gertler, and Ghatak, 2002; Jacoby, Li, and Rozelle, 2002; Banerjee and Iyer, 2005; Goldstein and Udry, 2008; Galiani and Schargrodsky, 2010; Leight, 2013) or credit access (Feder, Onchan, Chalamwong, and Hongladarom, 1988; Alston, Libecap, and schneider, 1996; Field and Torero, 2006). This paper adds to a relatively newer literature on the effects of property rights on households' labor decisions (Field, 2007; de la Rupelle, Quheng, Li, and Vendryes, 2009; Wang, 2011; Giles and Mu, 2012; de Brauw and Mueller, 2012; de Janvry, Emerick, Gonzalez-Navarro, and Sadoulet, 2013).

The paper contributes to this literature by not only identifying the causal effects of land tenure on household labor allocation, but also providing a theoretical explanation for why labor inefficiency exists under rural communal tenure. I argue that, when information is asymmetrical, policy designers have incentives to allocate land based on households' labor decisions, which creates distorted incentives for households to over-supply labor to agriculture. In addition, the paper goes a step further by conducting a more comprehensive welfare evaluation of communal tenure. I argue that a very good reason why policy-makers should create such institutions is because they reduce income inequality and improve overall agricultural productivity under imperfect markets. In other words, the existence of labor inefficiencies alone may not constitute sufficient reason to establish private property rights.

The remainder of the paper is organized as follows: Section 2 presents background information. Section 3 presents the conceptual framework. Section 4 describes the data. Section 5 presents the estimation results. Section 6 concludes.

2 Land Rights in China

2.1 Land Tenure System in China

China's economic reforms between 1979 and 1983 made a number of drastic changes to its rural property regime. The launch of the Household Responsibility System, which granted land use rights and residual income rights to farming households, shifted China's agricultural sector from a collective-based system to a family-based one. The decollectivization of China's rural economy has, however, only been partial. To this day, land usage rights granted to the households are not mortgageable. More importantly, formal ownership of the land still remains with the collective, which allows village officials to periodically redistribute land among households. Some scholars believe that the state purposely allows periodic land readjustments by village leaders to provide localities with flexibility in land management (Kung and Liu, 1997).

According to surveys conducted in the 1990s, by 1996, two thirds of Chinese villages had reallocated land using administrative methods, often in the middle of land contract terms (Brandt, Huang, Li, and Rozelle, 2002). My data, which covers both a greater number of villages and a longer time period, portrays a similar situation: 85% of my sample of 244 villages had reallocated land by 2002, and the average number of reallocations each village conducted between 1980 and 2002 is around 2. In these village-wide reallocations, a great deal of land changes hands simultaneously. The exact procedure by which land is redistributed varies across villages, but the most common practice is for village leaders to redivide all land in the village into bundles with equal distribution of land quality types, and distribute the bundles to households based on their population and agricultural labor force.[2] Figure D.1 in the Appendix shows the percentage of villages

[2]For more information on the various different practice of how land is redistributed in a land reallocation, see Liu,

that conducted major land reallocations for each year in my sample. In any given year, about 10 percent of all villages had reallocated land.[3] Thus, for the great majority of Chinese farmers, land reallocation is not a negligible risk.

The frequency of land reallocations varies a great deal across villages, even those within the same county area. In a survey conducted by Brandt, Huang, Li, and Rozelle (2002), 39 out of 44 surveyed counties report differences between villages in the frequency of reallocations. A separate survey by Krusekopf (2002) similarly records significant variations in land-tenure security both across and within countries. Figure 1 presents variation in the number of land reallocations from 1980 to 2002 based on my data. The figure on the left shows the mean number of land reallocations in the 31 provinces, while the figure on the right focuses on different sampled villages in one particular province. Clearly, significant variation exists in both cases.

There have been very few comprehensive and solid empirical studies on what motivates land reallocations, or why the frequency differs so much across villages. The right to reallocate land is typically vested in the village government (Brandt, Huang, Li, and Rozelle, 2002), in which the main creators of reallocation policies are the party secretary and the village head. The former is, as a rule, selected by higher-level party organizations. The latter, however, may be appointed by township government officials, elected by villagers through formal elections, or selected by a village representative assembly (O'Brien and Li, 1999; Pastor and Tan, 2000).

Preexisting studies on China's land system suggest three main motivations for why village leaders conduct land reallocations. First, periodic land reallocations help maintain a relatively egalitarian distribution of land. During the Mao years, equitable access of land by all households was advocated as a crucial benefit of communism. Even after the creation of the Household Responsibility System, such ideological arguments continue to influence the rural public's expectation of how land should be distributed, thus leading to frequent reallocations in response to demographic changes. Second, village leaders may seek to improve land-use productivity and efficiency. In the absence of perfect land-leasing and agricultural labor markets, land reallocations act as a substitute that enables optimal matching of land and labor. Third, land reallocations potentially serve a social insurance function by redistributing wealth from households with good off-farm opportunities to households with few or none.

As I shall show later, the model I build in this paper to study leaders' reallocation decisions in fact accommodates all three hypotheses. The Pareto weight that the social planner attaches to each household in the social welfare function is proportional to the number of residents in the household, perhaps reflecting the communist ideal of egalitarian land access. The concave utility function of individual households gives the social planner an incentive to care about income equality across

Carter, and Yao (1998).

[3] This estimate is very similar to previous estimates, including Brandt, Huang, Li, and Rozelle (2002).

households. Finally, the maximization of total welfare through land reallocation is consistent with the optimization of the village's total agricultural output.

In addition, my model allows other factors to influence villages' land reallocation policies. For instance, the frequency of land reallocations in a village may depend on the administrative costs when conducting reallocations, which could be affected by the village's size, typography, and land conditions.[4] The different Pareto weight that the planner can attach to each household also allows leaders to engage in rent-seeking, through, for instance, giving preferential treatment to households with high social status or political connections.

2.2 The 2003 Legal Change

The Chinese central government has long been aware of the problems caused by the separation of land ownership rights and usage rights.[5] In order to mitigate these problems, it has adopted a series of policies and laws aimed at improving tenure security. Before 2003, however, these reforms only involved increasing the contract duration of farmers' land use rights. In the early 1980s, these rights lasted three years or less. A 1984 policy purported to increase the duration to 15 years, but "was never seriously publicized or implemented" (Zhu and Prosterman, 2007). In 1993, the central government issued a policy directive that extended farmers' land-use rights to a continuous and fixed term of 30 years, but this new term duration was not embodied in formal law until 1998, when the government also initiated a massive campaign to publicize the new policy. However, because the most important tenure insecurity faced by the farmers actually came from land reallocations by village leaders, who often choose to reallocate in the middle of these fixed terms, these policies did little to improve tenure security.

This explains why the National People's Congress decided to enact the Rural Land Contracting Law (RLCL) in 2003. Compared to previous laws, the RLCL was devoted entirely to the relationship between collectives' land ownership rights and farmers' land use rights, and seemed to express a stronger desire to improve land tenure security. Two of its components are particularly relevant to this paper: First, the RLCL defines farmers' land rights, for the first time, as property rights rather than merely as contractual arrangements between two parties (Prosterman, Ping, and Zhu, 2006). This enables farmers to seek redress for violations through the courts rather than only through administrative means. Second, and more importantly, the law explicitly prohibits all land reallocations by village officials throughout farmers' 30-year term of land usage. The only exceptions are under "special circumstances such as natural disasters," in which case minor adjustments that

[4] More generally, administrative costs can also incorporate the potential loss of time and productivity created by reallocations. For instance, Jacoby, Li, and Rozelle (2002) and Leight (2013) both argue that tenure insecurity due to reallocations tends to decrease households' fertilizer use, which negatively affects agricultural output. Because these production losses are proportional to the probability of land reallocation, they can also be regarded as part of the fixed administrative cost that the village must pay for each major reallocation in my model.

[5] One problem, for instance, is that tenure insecurity tends to discourage investment by households.

involve just a few households can be implemented, but even then only if a two third-majority in the village assembly is obtained, and if higher government entities, such as the township government or the county unit responsible for agriculture, give express approval (Article 27).

The implementation of the RLCL has hardly been flawless, as many villages have continued to conduct major land reallocations illegally after 2003. My data do show, however, that the frequency of reallocations has significantly decreased. On average, only 2% of villages conducted reallocations each year between 2003 and 2006, compared to a yearly average of about 9% before the reform. Other studies on the implementation of the RLCL also believe that the legal change has significantly increased land tenure security across China (Deininger and Jin, 2009). Based on a survey conducted just 9 months after the law was in force, the dissemination of information about the law was rapid and extensive–82% of villages had been invited to participate in township-level meeting to discuss the law. Villagers in general were also positive towards the implementation of the law, with 81% of the villagers answering that the RLCL increased their tenure security (Deininger, Jin, Xian, and Rozelle (2004)).

In summary, the 2003 Rural Land Contracting Law was the first legal change that seriously tackled the problem of periodic land reallocations. Even though there were still villages that conducted reallocations after the reform, the law has significantly improved land tenure security across China. Because the law prohibits land reallocations in all villages, regardless of their prior reallocation practices, we expect villages with less secure pre-reform land tenure, i.e. with more frequent reallocations, to enjoy a higher security boost from the institutional change.

3 Theoretical Framework

The 2003 Rural Land Contract Law exogenously exerted a village-specific shock to villages' land tenure security. To better understand the source of variation in this village-specific shock (which results from village leaders' difference in reallocation policy choice during the pre-2003 period), and to provide guidance on the paper's empirical tests to identify the causal effects of land tenure insecurity, I build a model to study villages' land reallocation decisions, with endogenous labor responses by households. Section 3.1 presents the model's basic set-up and discusses the main assumptions. Section 3.2 characterizes the baseline model with complete information. Section 3.3 assumes instead that a household's off-farm earning ability is its private information, and that the social planner can credibly commit to her policies. I use the model to characterize three main theoretical results: the optimal frequency of reallocations; the optimal land distribution schedule across households if a reallocation happens; and the effect of the reallocation policy choice on households' labor allocation and various other market outcomes.

3.1 Framework Set-up and Assumptions

Consider a two-period economy in a village that has I agricultural households and a social planner. At the beginning of period 1, each household i is endowed with a population (labor force) of $p^i > 0$ and per capita landholding of $n_1^i > 0$, i=1,2...,I. The social planner, whose objective is to maximize total welfare in the village, has the option of reallocating land across households in between period 1 and period 2.[6] The total amount of land in the village, N, remains constant in all periods. Assume also that there is no land market and no agricultural labor market within the village (empirical support for this assumption will be presented in Table 1 and Appendix A). A market for off-farm employments, however, is available. Households are price-takers and receive a different wage w^i in off-farm employments.[7]

Households face the same agricultural function, $f(l,n)$, which is concave, strictly increasing and has strictly diminishing marginal returns.[8] I also assume that the cross partial derivative of the production function is positive, i.e. $f_{nl} = f_{ln}$>0 and $f(l,n)$ has constant returns to scale. One agricultural production function that satisfies all these assumptions, for instance, is the Cobb-Douglas function $f(l,n) = Al^{\alpha}n^{1-\alpha}$ with $A > 0$ and $0 < \alpha < 1$. Assume also that households' utility in each period, u, is a strictly increasing and concave function of household's per capita consumption, C_t^i, with $u_{cc}(C) < 0$ for all $C > 0$.

There are several reasons for why I assume that households do not differ in their agricultural production function, or total factor agricultural productivity: First, with only 1.4 mu (or 0.23 acre) per capita landholding, the land-labor ratio is extraordinarily low in rural China. Under such circumstances, agricultural production is dominated by smallholders who differ very little in their agricultural assets investment and in the technologies they adopt. Second, the actual amount of labor required to farm the average household landholding is very low. According to China's 1994 cost survey, the average labor input requirement per mu is only 13.6 days. Given that an average household owns only 6 mu, a single member of reasonably good health can easily manage all household landholdings to their full potential. Household demographic structures are therefore unlikely to be a constraining factor that causes agricultural production function to differ across households. Third, in section 5.1, I will provide direct empirical evidence to show that households do not differ in agricultural total factor productivity, at least not to the extent that the social planner

[6]The welfare-maximizing assumption does not require the social planner to be altruistic in designing her policies: the social planner can well pursue her self-interests by attaching much greater Pareto weights to her own household or households with political connections in the social welfare function.

[7]In China, these off-farm employments can exist in the urban areas. The different off-farm wage reflects the different demographic structures and education levels of different households, which significantly affects their members' chances of obtaining off-farm employment. In fact, many of the main off-farm employers of rural workers, such as factories or construction sites in urban areas, often enforce explicit requirements on the age, gender and education level of their potential employees.

[8]These assumptions imply that $f_l > 0$, $f_n > 0$, $f_{11} < 0$, $f_{nn} < 0$ and $f_{11}f_{nn} - f_{nl}f_{ln} \leq 0$

takes it into consideration in her land reallocation policies.

The sequence of events is as follows: At the beginning of period 1, the households simultaneously decide the percentage of labor they want to allocate to agricultural production, l_1^i, so that the percentage of labor i allocates to off-farm jobs is $1 - l_1^i$. After all production outcomes in period 1 have been realized, the social planner may choose $r = \{0, 1\}$, a decision of whether a land reallocation should happen at the end of period 1. If a reallocation does not happen, households' landholdings stay the same, i.e. $n_2^i = n_1^i$. If a reallocation happens, the social planner can change household i's per capita landholding in period 2, n_2^i, to n^i, a land amount of her choice, but needs to pay a fixed administrative cost of A. In period 2, the households again chooses l_2^i, the percentage of labor allocated to agricultural production in period 2, based on their land endowment n_2^i.

In the next two sub-sections, I will discuss the implications of the model under two different sets of assumptions. However, in both scenarios, a household's period-2 problem stays the same: $u(C_2^i(w^i, n_2^i)) = \max_{l_2^i} u(w^i \cdot (1 - l_2^i) + f(l_2^i, n_2^i))\, \forall i$. Assuming for simplicity that all households' labor decisions in the second period have interior solutions, I can derive the following comparative statics regarding households' optimal choice of l_2^i:

$$\frac{dl_2^i}{dw^i} = -\frac{1}{-f_{ll}} < 0, \tag{1}$$

$$\frac{dl_2^i}{dn_2^i} = -\frac{f_{ln}}{f_{ll}} > 0. \tag{2}$$

Equation (1) indicates that, conditional on the amount of per capita land, a household allocates less per capita labor to agriculture when the off-farm wage is higher, which implies a lower average agricultural land productivity (agricultural output per acre). However, because higher w^i ensures a higher average labor productivity, conditional on the same per capita landholding, the household still enjoys a higher period-2 per capita income when its off-farm wage is higher.

3.2 Baseline Model with Complete Information

Assume first that all household characteristics, including w^i, are observable to the social planner. As seen from the household problem in period 2, the period-2 utility of household i depends only on w^i and n_2^i. Therefore, when w^i is observable, the social planner should base her reallocation policies purely on households' characteristics, but not on their period-1 production decisions. Such a strategy ensures that the social planner can maximize welfare in period 2 without creating distortion in households' labor decisions in period 1.

Because the social planner chooses an allocation that is independent of households' period-1 decisions, the period-1 welfare of the village will be unaffected by the social planner's reallocation policies. Therefore, the social planner's objective will be simply to maximize period-2 welfare. Her problem consists of two separate steps. First the social planner needs to decide on an optimal land allocation across households based on their characteristics, assuming that a reallocation will happen:

$$SWF_{r=1} = \max_{\{n^i\}_{i=1}^{I}} \sum_{i=1}^{I} \rho^i p^i u(C_2^i(w^i, n^i)) - A, \tag{3}$$

$$subject\,to \qquad \sum_{i=1}^{I} p^i n^i \leq N. \tag{4}$$

Then, based on this optimal land allocation, she decides whether to reallocate or not:

$$SWF = \max\{SWF_{r=1}, \ \sum_{i=1}^{I} \rho^i p^i u(C_2^i(w^i, n_1^i)\}. \tag{5}$$

I assume that the Pareto weight that the social planner attaches to household i , $\rho^i p^i$, is directly proportional to the population in household i. ρ^i is an indicator of i's social status in the village. It reflects characteristics, such as i's political connections or demographic structure, which may influence how much weight the social planner attaches to i's utility. Solving the first step of the social planner's problem, I derive the following proposition:

Proposition 1: If a reallocation happens, the social planner will reallocate so as equalize the weighted marginal utility generated from a marginal unit of land across all households. The optimal per capita land allocated to each household decreases with the household's off-farm wage (i.e. $\frac{dn^i}{dw^i} < 0 \forall i$) and other households' social status, but increases with the household's social status and other households' off-farm wage. The total land allocated to a household increases with its population size ($\frac{d(n^i p^i)}{dp^i} > 0 \forall i$).

Proof: See Appendix E.1.

Proposition 1 gives us some intuition on the social planner's incentives and strategies. The ultimate objective of the social planner is to maximize total welfare in the village, which gives her an incentive both to increase total agricultural output in the village and to equalize per capita income across households of different wages. I have derived from the households' period-2 problem that, conditional on having the same per capita landholding, a household generates lower agricultural output when its off-farm wage is higher, but enjoys higher overall per capita income. Therefore, both the incentive to increase agricultural output and the incentive to equalize income across households will lead the social planner to decrease a household's per capita land allocation as its off-farm wage increases. Given that the total amount of land in a village is fixed, this implies that the per capita land allocated to a household actually increases with other households' off-farm wage.

After the social planner works out the optimal $\{n^i\}_{i=1}^{I}$ conditional on r=1, the social planner's choice of r will be such that

$$\begin{cases} r=1 & if\ \sum_{i=1}^{I} p^i\rho^i u(C_2^i(w^i,n^i)) - \sum_{i=1}^{I} p^i\rho^i u(C_2^i(w^i,n_1^i)) > A, \\ r=0 & if\ \sum_{i=1}^{I} p^i\rho^i u(C_2^i(w^i,n^i)) - \sum_{i=1}^{I} p^i\rho^i u(C_2^i(w^i,n_1^i)) \leq A. \end{cases}$$

The optimal strategy of the social planner is therefore to choose to reallocate whenever the period-2 potential welfare gain from reallocation is greater than the administrative cost.

One implication of this result is that the probability of reallocation may vary across different villages. In particular, villages with lower administrative costs and higher potential welfare gain in moving from $\{n_1^i\}_{i=1}^I$ to $\{n^i\}_{i=1}^I$ are more likely to reallocate. Given that $\{n_1^i\}_{i=1}^I$ is the optimal land allocation from a previous reallocation, the welfare gain is likely to be larger for villages whose optimal land allocation shifts away from $\{n_1^i\}_{i=1}^I$ at a faster rate. These are villages with larger wage and demographic shifts across households (i.e. the cross-household variation in shocks to off-farm wage and number of residents, respectively, is large).

Given that the social planner's strategies are independent of households' labor decisions, households will choose labor allocation decisions so as to equalize their marginal agricultural labor product and their off-farm wage in each period: $u_c \cdot (w^i - f_l(l_t^i,n_t^i)) = 0 \Longrightarrow w^i - f_l(l_t^i,n_t^i) = 0$ for *i*=1,2,...,I and t=1,2. This labor efficiency result will, however, be violated when I introduce asymmetrical information on households' off-farm productivity.

3.3 Information about w^i Is Private

Now assume that each household *i* privately observes w^i, which is drawn from an interval $[\underline{w}^i, \overline{w}^i]$ with $\underline{w}^i < \overline{w}^i$ and strictly positive density $\phi^i(\cdot) > 0$. Households' types are statistically independent. The prior distribution of the vector of types, w=(w^1,w^2, ...,w^I) $\in W^1 \times W^2 \times ... \times W^I$, therefore has a density $\phi(\cdot) = \phi^1(\cdot) \times \phi^2(\cdot) \times ... \times \phi^I(\cdot)$. Assume that $\phi(\cdot)$ is common knowledge. Households simultaneously choose their labor allocation decision at the beginning of each period in order to maximize the sum of discounted utilities across the two periods. The strategy of household *i* consists of $\{l_1^i,l_2^i(n_2^i)\}$.[9] I assume $-\frac{u_{cc}}{u_c} \leq \frac{1}{C}$ to ensure that the household's incentive to equalize consumption across two periods is not so big that they choose extreme labor decisions to lower the difference between their landholdings across the two periods.

The social planner still needs to decide whether and how to reallocate land at the end of period 1. The planner would once again like to allocate less land to those with higher off-farm wage rates. Wage rates are no longer observable, but the planner may be able to infer a household's wage, w^i,

[9] Note that $\{l_1^i,l_2^i(n_2^i)\}$ depend on w^i. I can represent household's strategy in optimal l_2^i purely as a function of n_2^i because I have derived in households' period-2 problem that, conditional on n_2^i, the optimal l_2^i is independent of what happened in period 1. Note also that l_1^i also depends on n_1^i.

from its labor choice, l_1^i. However, if the social planner allocates land according to households' period-1 labor decisions, households will have distorted incentives to deviate away from their efficient period-1 labor decision, in hopes of increasing their land allocation in the second period. Therefore, to maximize period-2 welfare while mitigating period-1 labor inefficiency, the social planner has an incentive to commit to an optimal contract before households make their period-1 labor decisions.

The sequence of events will be as follows. At the beginning of period 1, each household's off-farm wage is realized. The social planner then announces her land reallocation policies. In particular, the social planner commits to whether a reallocation will happen at the end of period 1.[10] If she commits to reallocate, she also commits to a land allocation schedule, which determines each household's period-2 land allocation as a function of all households' population, period-1 landholding and period-1 labor decisions:

$$g : \{L_1 \times N_1 \times P \times P'\} \longrightarrow \{N\},$$

where L_1, N_1, P, P' and N represent the set of possible combinations of $\{l_1^i\}_{i=1}^I$, $\{n_1^i\}_{i=1}^I$, $\{p^i\}_{i=1}^I$, $\{\rho^i\}_{i=1}^I$, and $\{n^i\}_{i=1}^I$ respectively. In other words, the g function maps the households' characteristics and labor decisions in period 1 to an I-dimensional vector, with the i-th component indicating the per capita land allocated to household i in period 2. Note that, because n_1^i, $p^i$and ρ^i for i=1,2,...,I are exogenous in the model, I omit $\{n_1^i\}_{i=1}^I$,$\{p^i\}_{i=1}^I$, and $\{\rho^i\}_{i=1}^I$ from g, and simply represent g as a function of $\{l_1^i\}_{i=1}^I$.

After the social planner announces the land reallocation contract, the households simultaneously choose l_1^i with their private information on w^i. At the end of period 1, when all the productions in period 1 have been realized, the social planner carries out the reallocation policies to which she committed. At the beginning of period 2, after the reallocation policies are implemented, the households again simultaneously decide l_2^i as a function of their period-2 landholdings.

If the social planner commits to reallocate at the end of period 1, the land allocation schedule that she commits to, $g(\cdot)$, will induce a period-1 game among the households. I assume this game of incomplete information has a pure-strategy Bayes-Nash equilibrium and assume that household behavior is characterized by such an equilibrium.[11] Hence, each household chooses a labor allo-

[10]In this model, I assume that the social planner's commitment for whether a reallocation will happen is independent of households' labor choice in period 1. This avoids situations in which each household's estimated probability of reallocation depends on their period 1 labor allocation. This assumption is consistent with how villages reallocate in reality. In the majority of the sampled villages with multiple reallocations, land reallocations take place at very regular time intervals. In Table D.1 in the appendix, I list the time intervals between consecutive reallocations for all villages with more than four reallocations. Except for a few exceptions, the great majority of villages seem to reallocate at very regular time intervals. This is consistent with the assumption that village leaders commit to a frequency of reallocation that is independent of households' labor decisions.

[11]The set of $g(\cdot)$ functions that can induce a pure Bayesian Nash equilibrium is not empty. One land allocation

cation which maximizes its expected payoff, given its beliefs about the other players' types and given the strategies played by the other households.

I assume that the g^i is increasing in l_1^i $\forall(l_1^i, l_1^{-i})$. This assumption is reasonable for two reasons: First, in practice, villages will have incentives to choose continuous and monotonic allocation functions for tractability and ease of implementation. Second, unless the social planner incentivizes the households to so severely under-supply agricultural labor in period 1 that a household of higher off-farm wage, not caring about period-2 land as much, actually prefers higher agricultural labor allocation in period 1, the social planner has no incentive to allocate less land to a household when its period-1 agricultural labor is higher. Doing so not only fails to avoid labor inefficiency in period 1, but also allocates less land to a household when its off-farm is lower, which is precisely the opposite of what the social planner wants to achieve in period 2. Given that it is unlikely that an allocation rule with severe labor inefficiency in period 1 can be optimal, it is reasonable to assume that the social planner always wants to implement an allocation rule in which the per capita land allocated to a household increases (not necessarily strictly) with its period-1 agricultural labor. For convenience of calculation, I also restrict $g(\cdot)$ to be twice differentiable.

The social planner again solves a two-step problem. In the first step, the social planner assumes that a reallocation definitely happens at the end of period 1, and her problem is to implement a mechanism $\Gamma = (g(\cdot), \{l_1^i(w^i)\}_{i=1}^I)$ such that the expected sum of discounted total welfare is maximized under a Bayesian Nash equilibrium :

$$
\begin{aligned}
SWF_{r=1} \quad = \quad & \max_{g(\cdot),\{l_1^i(w^i)\}_{i=1}^I} E_w\{\sum_{i=1}^I p^i \rho^i u(C_1^i(w^i, l_1^i(w^i), n_1^i) + \beta[\sum_{i=1}^I p^i \rho^i u(C_2^i(w^i, g(l_1^i(w^i), l_1^{-i}(w^{-i}))) - A]\}, \\
s.t. \quad & \sum_i^I p^i g^i(l_1^i, l_1^{-i}) \leq N \ \forall(l_1^i, l_1^{-i}), \\
and \quad & l_1^i(w^i) \in [0,1] \ \forall w^i, \forall i, \\
and \quad & E_{w^{-i}}[V(l_1^i(w^i), g^i(l_1^i(w^i), l_1^{-i}(w^{-i})), w^i)|_{r=1}] \geq E_{w^{-i}}[V(l, g^i(l, l_1^{-i}(w^{-i})), w^i)|_{r=1}] \\
& \forall l \neq l_1^i(w^i), \forall w^i, \forall i,
\end{aligned}
$$

where β is the discount factor and V represents a household's two-period utility as a function of its labor choice in period 1, assuming that other players' strategies are fixed and optimal: $E_{w^{-i}}[V(l, g^i(l, l_1^{-i}), w^i, n_1^i)|_{r=1}] = u[(1-l)w^i + f(l, n_1^i)] + \beta \cdot E_{w^{-i}}[u(C_2^i(w^i, g^i(l, l_1^{-i}))]$, with $u(C_2^i(w^i, n_2^i) = \max_{l_2^i} u(w^i(1-l_2^i) + f(l_2^i, n_2^i))$ $\forall i$.

I assume that there exists a $g^*(\cdot)$ function (not necessarily unique) that solves the above problem

rule that has this property, for instance, is a $g(\cdot)$ function which is independent of $\{l_1^i\}_{i=1}^I$. That is, the social planner chooses to allocate the same per capita land to household i no matter what l_i^i household i chooses. Such a land allocation schedule induces a Bayesian Nash equilibrium in which each household chooses their respective efficient period-1 labor allocation, given their wage types and the amount of land they have.

in maximizing total welfare. [12]

Proposition 2: If $\frac{dg^i(l_1^i,l_1^{-i})}{dl_1^i} \geq 0\,\forall(l_1^i,l_1^{-i})$, then $l_1^i(w^i)$ is decreasing in w^i, and strictly decreasing in w^i if $l_1^i(w^i) \neq 1$. In other words, an incentive-compatible contract with $\frac{dg^i(l_1^i,l_1^{-i})}{dl_1^i} \geq 0\,\forall(l_1^i,l_1^{-i})$ ensures that a higher off-farm wage type will allocate a lower percentage of period-1 labor to agriculture, and different wage types will fully separate themselves except at the corner, where the lowest types may be pooled at $l_1^i(w^i) = 1$.

Proof: See Appendix E.2.

There are two reasons why the period-1 agricultural labor decreases with the household's off-farm wage type when household land allocation increases with its period-1 agricultural labor. First, a higher off-farm wage type faces a higher opportunity cost in allocating period-1 labor to agricultural production. Second, from the household's period-2 problem, I have derived that, given the same amount of per capita landholding, the equilibrium period-2 land productivity is lower for a higher off-farm wage type, which makes period-2 land less valuable to it. Both the higher opportunity cost and the lower marginal utility from gaining more land will lead a higher off-farm wage type to be less willing to allocate agricultural labor in period 1 in exchange for more land in period-2. Therefore, when the social planner allocates more per capita land to households with higher agricultural labor allocation, high wage types will choose a lower l_1^i in equilibrium.

At the same time, given that higher period-1 per capita landholding, n_1^i, increases marginal returns from allocating labor to agricultural in period 1, I can derive that a household's equilibrium period-1 agricultural labor allocation strictly increases with n_1^i (until constrained by $l_1^i \leq 1$).[13]

Based on the households' utility maximization problem (which is subsumed in the incentive compatibility constraints of the social planner's maximization problem), given a g function, household i will choose l_1^i that satisfies:

$$u_c \cdot (f_l(n_1^i,l_1^i) - w^i) + \beta \cdot E_{w^{-i}}[u_c \cdot f_n(l_2^i, g^i(l_1^i,l_1^{-i})) \cdot \frac{dg^i}{dl_1^i}] = 0. \tag{6}$$

When $\frac{dg^i(l_1^i,l_1^{-i})}{dl_1^i} > 0$ for any $l_1^{-i}(w^{-i})$, equation (6) implies that $f_l(n_1^i,l_1^i) < w^i$. This means that household *i* deviates from its efficient labor allocation in period-1 by over-supplying labor to agricultural production. Therefore, a welfare-maximizing social planner faces a trade-off. On the one hand, she wants to make $\frac{dg^i(l_1^i,l_1^{-i})}{dl_1^i} > 0\,\forall(l_1^i,l_1^{-i})$, in order to allocate more land to households with lower off-farm wage types to maximize period-2 welfare. On the other hand, she has incentive to make $\frac{dg^i(l_1^i,l_1^{-i})}{dl_1^i}$ small to mitigate labor inefficiency in the first period. Under the optimal contract,

[12] When $g^*(\cdot)$ is not unique, I assume, without loss of generalizability, that the social planner chooses, among the solutions, the land allocation that generates least variance in per capita land-holding across households.

[13] See Appendix E.2. for proof.

the social planner will choose a $g(\cdot)$ function to ensure that the expected welfare loss from the labor inefficiency is always smaller than the expected welfare gain from an equal land distribution (conditional on all exogenous households characteristics) to the allocation implemented by g. Otherwise, the optimal strategy of the social planner should always be to implement $\frac{dg^i}{dl_1^i} = 0$ $\forall(l_1^i, l_1^{-i})$.

After finding the optimal g associated with each wage distribution, the social planner decides commit to reallocate or not. Her decision on r should be:

$$\begin{cases} r = 1 \quad if\, SWF_{r=1} - E_{\{w^i\}_{i=1}^I}[\sum_{i=1}^I p^i \rho^i \{u(C_1^i(w^i, n_1^i) + \beta \sum_{i=1}^I p^i \rho^i u(C_2^i(w^i, n_1^i))] > 0, \\ r = 0 \quad if\, SWF_{r=1} - E_{\{w^i\}_{i=1}^I}[\sum_{i=1}^I p^i \rho^i \{u(C_1^i(w^i, n_1^i) + \beta \sum_{i=1}^I p^i \rho^i u(C_2^i(w^i, n_1^i))] \leq 0. \end{cases}$$

Again, villages with lower administrative costs, larger cross-household demographic shifts, and therefore higher expected potential welfare gain in moving away from $\{n_1^i\}_{i=1}^I$ are more likely to reallocate. Given that labor inefficiency only exists when r=1, we would expect labor inefficiency to be more severe in villages that tend to reallocate more often. In other words, unless the optimal g function involves $\frac{dg^i(l_1^i, l_1^{-i})}{dl_1^i} = 0\ \forall(l_1^i, l_1^{-i})$, households' period-1 agricultural labor allocation will be higher in villages with a greater tendency to reallocate.

4 Data and Descriptive Statistics

The data used here comes from two sources. The first is the Chinese Ministry of Agriculture's National Fixed Point Survey (NFS), which is the largest panel household survey on rural China. The survey began in 1986, and tracks a nationally representative sample of about 23,000 rural households in about 300 villages, covering all the continental Chinese provinces, for every year except 1992 and 1994.[14] The NFS consists of both a village survey and a household survey. The village survey, covering the full sample, provides information on many of the main outcome variables in this paper, such as the village's total agricultural output and the percentage of its labor force that is off-farm–although the latter is only available from 1993 onwards. The household survey used in this paper, on the other hand, covers only a sub-sample: it consists of a panel of about 6800 households across 114 villages for every year between 1986 and 2008, and another 4200 households across 52 villages for the 1986-2003 period only. Measures of income inequality or demographic shifts across households come from this sample. The household survey also provides very detailed information on the landholdings of each surveyed household, which allows close examination into how land allocation across households was adjusted in any sampled village-year.

The other main source of data is the Village Democracy Survey (VDS), conducted by Gerard

[14] See "Description of the NFS", http://www.econ.yale.edu/~nq3/NANCYS_Yale_Website/Research_files/Description%20of%20the%20NFS.pdf, by Yang Yao for details on how the households are selected.

Padro-i-Miquel, Nancy Qian and Yang Yao in 2006, and specifically designed to cover the same villages as the NFS. Of the 244 villages I have data on, 225 overlap with the NFS village survey, and 166 overlap with the household-level data. The VDS provides retrospective information on political reforms, including the year each village implemented the Households Responsibility System (HRS) and every year in which a major land reallocation occurred. Because these historical data are obtained from village administrative records, they are, unlike most retrospective survey data, not subject to recall errors. They provide much more accurate measures of village land reallocation policies than those found in several previous studies, which relied primarily on household landholding data to deduce the timings of reallocations.

Table 1 displays the data set's summary statistics. The average per capita landholding is 1.72 mu (0.11 hectares), and the average village has around 425 households and 1670 residents. The mean percentage of labor allocated to off-farm activities in these villages is 38.8%, which implies that agriculture remained the main source of employment for the average village during the sampled period. Agricultural labor and land rental markets, however, were very limited. On average, hired labor only accounted for 3.36% of the total, and the mean percentage of households leasing out land was 4.66%.[15]

My primary measure of village-specific tenure security is the annual probability of major reallocations happening in a village, which is defined as the number of major reallocations in the village divided by the number of years, up to 2002, that the Household Responsibility System (HRS) had been implemented.[16] A major reallocation is defined as a reallocation that affected at least 30% of village households. Around 80% of the sampled villages have conducted major reallocations at least once, and the mean number of major reallocations is 1.84. Significant variation exists in villages' pre-reform number of reallocations, ranging from 0 to a maximum of 8. The average annual probability of reallocation happening in any village in the pre-2003 period is 0.091, which means that, an average village reallocated land about every 10 years.

The paper also constructs two different measures of the scale of each land reallocation. The first measures households' average probability of being affected by land reallocations. A household is recorded as experiencing land reallocation at year t if the household experienced a change in its contracted landholding, excluding any changes due to leasing or reforestation. I then calculate the percentage of households experiencing land change for each village-year. Because a household could have experienced land reallocation even if its total landholding area remained the same, this measure is a lower bound to the probability that a household experiences a reallocation in any

[15]The low levels of market activities support the assumption of the absence of land and agricultural labor markets in rural China.

[16]All but three villages in the sample had implemented the HRS by 1986, when my sample begins. Two of the three then implemented it in 1987, and the third in 1988. Because my household off-farm labor data only begins in 1993, the effective sample of my regressions covers only village-years in which the HRS was already in effect.

village-year.

The second measure calculates the extent that households experience land area changes during land reallocations. It is defined as the ratio between the sum of the absolute values of each household's landholding change, again excluding leasing and reforestation, divided by 2, and the total landholding of all sampled households during the same year. This ratio, the percentage of land transferred, is not a measure of tenure insecurity in the village, but rather a measure of the effect of land reallocations in substituting for markets in enabling land transactions across households.

To evaluate the accuracy of these measures, I compare the calculated scales of land reallocations in each village-year with the administrative data on major land reallocations collected by the VDS. Table 2 compares my estimates of the two measures with whether the VDS records a major reallocation in that village-year. The last column, records the correlation between the two measures and a dummy of whether the VDS records a major reallocation. Because the household survey only provides accurate data on household landholding changes from 1993 onwards, Table 2 covers all years from 1993 to 2002. As we can see, the mean percentage of affected households and land transferred are 58.8% and 11.5% in village-years when major land reallocation is administratively recorded, compared to 2.1% and 0.5% in other village-years. The correlation between these two percentages with VDS major reallocation dummy are 0.862 and 0.747, respectively, which supports the accuracy of these measures.

5 Empirical Estimations

This section empirically tests the three primary predictions of the theoretical model: First, under incomplete information, a social planner has incentives to allocate more land to households with a higher lagged percentage of agricultural labor. Second, villages with lower reallocation administrative costs and higher variance in rate of demographic changes across households reallocate more often. Third, the main benefits of the land reallocations are that they provide social insurance and ensure optimal agricultural production in the absence of functioning agricultural labor and land markets. However, the labor-contingent rule of allocation, when combined with tenure insecurity, also leads households to oversupply labor to agricultural production, and this labor inefficiency is more severe in villages that tend to reallocate more frequently.

5.1 Allocation Rule of Land Reallocations

Previous studies on China's land reallocations have generally argued that land is distributed based on how much labor households allocate to agricultural production.[17] However, these estimates are

[17] Examples include Kung and Liu (1997); Li, Rozelle, and Brandt (1998); Brandt, Huang, Li, and Rozelle (2002).

usually based on cross-sectional data, and are therefore potentially subject to endogeneity due to unobservable household characteristics that may be correlated with households' labor decisions. The panel nature of my data set allows me to mitigate this problem.

To identify the land allocation rule in major land reallocations, I use data from the NFS household survey, but include in this particular sample only those village-years in which a major reallocation occurred. I adopt a first-difference model to estimate the following equation on the sample of reallocation village-years:

$$land_{ijt} = \alpha_0 + \alpha_1 n_{ij,t-1} + \alpha_2 l_{ij,t-1} + \alpha_3 p_{ij,t-1} + \alpha_4 D_{-ij,t-1} + \mu_{jt} + \gamma_i + \varepsilon_{ijt}, \tag{7}$$

where $land_{ijt}$ represents household i's landholding at t, a year of a village-wide reallocation in village j. $n_{ij,t-1}$ $l_{ij,t-1}$and $p_{ij,t-1}$ are, respectively, household i's lagged per capita landholding, lagged percentage of labor-days allocated to agricultural production, and lagged number of rural residents. In other words, these are characteristics of household i one year before the reallocation at time t. To account for the fact that a household's land allocation also depends on the characteristics of other households in the village, I control for $D_{-ij,t-1}$, the distribution moments of other households' lagged agricultural labor, lagged per capita landholding, and lagged number of residents. μ_{jt} refers to a village-year fixed effect. γ_i represents a household fixed effect.[18]

α_1, α_2 and α_3 respectively estimate the extent to which a household's per capita landholding, labor allocation, and number of residents one year before the reallocation affects its land allocation. According to the model, α_2 and α_3 should both be positive. The model also predicts that, conditional on having the same off-farm wage, a household with higher per capita landholding allocates strictly more labor to agriculture. This implies that, conditional on having the same lagged agricultural labor allocation, a household with higher lagged per capita landholding must have a higher off-farm wage. Given that villages want to allocate less land to households with higher off-farm wage, we should expect α_1 to be negative.

Controlling for the household fixed effects helps mitigate omitted variable bias due to unobservable household characteristics. At the same time, the village-year fixed effects controls for any aggregate shocks in the village that can simultaneously affect households' land allocation and lagged labor allocation decisions.[19] However, my model predicts that the Pareto weight that the so-

[18] I control for γ_i through first-differencing across different reallocation years in the village. In other words, I regress the change in the dependent variable across two consecutive reallocations in the village against the difference in the independent variables over the same time period. When there are two reallocations in each village, the first-difference estimator is identical to the fixed-effect estimator. When there are more than two reallocations in some villages, the first-difference estimator is more efficient if the error terms are serially correlated.

Nickell bias does not arise in this dynamic model, because the differenced $n_{ij,t-1}$is not trivially correlated with the differenced ε_{ijt}: while the first difference is taken across two consecutive reallocations, $t-1$ refers to the non-reallocation year right before the current reallocation.

[19] For instance, if agricultural land was expropriated to build a new factory in a village, the total amount of land

cial planner attaches to each household, which may reflect the household's demographic structure and political connections, also affects its land allocation. One may be concerned about potential bias in α_2 if these time-changing characteristics that determine a household's Pareto weight are somehow correlated with the household's labor decisions.

To address these concerns and to increase the precision of my estimates, I attempt to control for households' Pareto weights by adding $X_{ij,t-1}$, a set of additional lagged household characteristics, into the regression. These include households' number of rural laborers, number of male rural laborers, education of the main laborer, dummies of whether the household has party members, village cadres and veterans, total labor-days worked, and a dummy of whether the household has special needs.[20] Again, to account for the fact that a household's land allocation also depends on other households' characteristics, the mean and standard deviation of these variables for other households in the same village-year are also controlled.

Table 3 shows the results of regression (7). In all columns, the standard errors are clustered at the village level. In column (1), $D_{-ij,t-1}$ includes the mean and standard deviation of the lagged agricultural labor, lagged per capita landholding, and lagged population size of other village households. Column (2) adds in, as controls, $X_{ij,t-1}$, and the mean and standard deviation of the same set of variables among other village j households in year *t-1*. Compared to column (2), column (3) adds additional distribution moments of other households' lagged agricultural labor, lagged per capita landholding, and lagged population size into $D_{-ij,t-1}$. I control for the 10th, 20th ... and 90th percentile of other households' lagged characteristics in the village-year.

The results are quite robust. In all columns, the respective coefficient on the household's number of rural residents and lagged agricultural labor allocation is positive and significant, while the coefficient on the household's lagged per capita landholding is significantly negative. On the other hand, the lagged labor allocation and landholdings of other households have the opposite effect: the coefficient on the mean lagged agricultural labor allocation of other village households is significantly negative, and the coefficient on the mean lagged per capita landholding of these other households is positive. [21]

All these results are consistent with the model's predictions: Under incomplete information, village leaders indeed allocate land based on households' previous labor allocation decisions and

allocated to households would decrease. At the same time, households might allocate less agricultural labor in order to work at the factory.

[20]The special needs households, or the "Five Guarantees Households" (Wu Bao Hu), are households with only the childless and infirm elderly, people with disability, or young dependents that have not reached legal age for work. These households are guaranteed food, clothing, medical care, housing and burial expenses by the local government.

[21]To accommodate the possibility that households' land allocation in a reallocation could be based on their past labor decisions more than one year before the reallocation, I also repeat all regressions in Table 3 while replacing households' lagged percentage of agricultural labor with the mean percentage of labor days they allocate to farming in all years between the previous reallocation and the current one. The results, which are not included in the paper, are very similar to those in Table 3.

per capita landholding. They allocate more land to a household when the household's lagged agricultural labor allocation is higher, but allocate less when its lagged per capita landholding is higher. At the same time, with a fixed amount of land in the village, the land allocated to a household decreases with other households' lagged agricultural labor allocation and increases with their lagged per capita landholding.

Columns (4) provides empirical evidence to support the assumption that agricultural total factor productivity does not vary across households. At the very least, the results indicate that village leaders do not take agricultural productivity into consideration when setting reallocation policies. In my model, when households differ only in their off-farm wage, the social planner can fully determine households' off-farm wage from their previous labor allocation and per capita landholding. She has no incentive, therefore, to allocate land based on households' non-labor agricultural inputs, as doing so will not uncover any additional information, but will rather generate inefficiencies in non-labor inputs. If, however, households actually differ in agricultural total factor productivity, and the social planner does want to allocate land according to this difference, then she cannot determine households' agricultural total factor productivity based only on their previous labor allocation: if she tries to do that, households can disguise their agricultural total factor productivity by substituting between agricultural labor and other agricultural inputs. Therefore, if the social planner considers households' agricultural total factor productivity, we should expect her to allocate land based not only on labor allocation, but also on households' other agricultural inputs.

In column (4), I add households' lagged per capita agricultural assets into the regression, while controlling the mean and standard deviation of other households' lagged per capita agricultural assets. "Agricultural assets" include machines, draught animals, and tools, and are measured by their original market value. Based on the estimates in column (4), lagged per capita agricultural assets does not significantly affect the amount of land allocated. This contradicts the hypothesis that village leaders take households' agricultural total factor productivity into consideration.[22]

Table D.2 in the Appendix presents the same regression results as in Table 3, but with standardized coefficients. It shows that one standard deviation increase in households' lagged agricultural labor leads to a 0.045 standard deviation increase in land allocated to the household.

As a falsification test, I repeat the same regressions in Table 3 for all non-reallocation years.[23] The results of these placebo tests are presented in Table D.3 in the Appendix. The allocation

[22] I also use the same regression in column (4) to test whether households' lagged expenditure in other inputs, including fertilizers, insecticides, and so on affect households' landholdings. Again, against a model in which the social planner allocate land according to households' agricultural total factor productivity, I do not find significant effects. Due to length considerations, I do not include these results, but would be happy to provide them upon requests.

[23] In this new regression, the first difference is calculated as the difference between the households' current-year observation and the households' observation in the year immediately after the previous land reallocation.

patterns that we observe in reallocation years completely disappear in non-reallocation years. This reassures us that the estimated results in Table 3 are unlikely to have been driven by endogeneity or measurement errors unrelated to land reallocations.

5.2 Determinants of Land Reallocation Frequency

The model predicts that villages with a higher rate of cross-household demographic shifts and lower administrative costs reallocate more frequently. It is important to emphasize that the rate of cross-household demographic shifts refers not to the average value, but the cross-household variation, of population change rate in a village. If all households experience an identical percentage change in population, the optimal land allocation in the village stays the same and there is no welfare gain from reallocating land. Land reallocations only increase total welfare when heterogeneous household demographic shocks cause the optimal allocation scheme for the current labor distribution to deviate from current landholding patterns. Therefore, villages with a high frequency of reallocations are not those with high average population growth, but those with a higher degree of heterogeneity in households' rate of demographic change.

To measure cross-household variation in population change, I first calculate each household's percentage change in the number of rural residents as the logarithm of the ratio between the household's current number of rural residents and the previous year's. I then calculate $\sigma_t^j(p)$, the standard deviation of this household-specific percentage change for each village j and each year t:

$$\sigma_t^j(p) = standard\,deviation(log(\frac{p_t^{ij}}{p_{t-1}^{ij}})),$$

where p_t^{ij} refers to household i's number of rural residents in year t. Finally, the village-specific rate of variation in cross-household change, $\sigma_j(p)$, is calculated as the mean of $\sigma_t^j(p)$ for all years before 2003. I repeat the same procedure on households' number of rural laborers and number of male laborers, thereby deriving two alternative measures of demographic variation.

Table 4 presents the results of regressing villages' pre-reform average annual probability of reallocation against, respectively, σ_j in households' number of rural residents, rural laborers, and male rural laborers. All three σ_j measures are normalized to have mean zero and standard deviation one. As we can see from the table, all three measures have a positive and significant correlation with villages' pre-reform probability of reallocation.

Given that the Hukou (Household Registration) system prevents rural residents from permanently migrating to urban areas, most demographic shifts are triggered by births, deaths, young children reaching legal age to work, or marriages into or out of households. Therefore, villages with high cross-household variation in demographic shocks are likely to be those with households at more heterogeneous stages of their demographic cycles. Because it is highly implausible that reallocation frequency in a village can exert heterogeneous shocks to household demographic structures, the results in Table 4 are unlikely to be driven by households' endogenous demographic responses to the village's reallocation frequency. The results imply, therefore, that a higher rate of demographic shifts in a village indeed leads to more frequent reallocations: a one standard deviation increase in cross-household variation in population changes increases the annual probability of reallocation by about 1.2 percentage points, or 13% of the mean annual probability of reallocations in an average village.

Next, I examine how the administrative costs of reallocations affect villages' tendency to reallocate. The main administrative costs associated with land reallocations are the costs of organizing households and dividing plots into suitable parcels. The organizational costs will likely increase with the number of households in the village, while the costs of dividing land into suitable parcels will likely increase when plots are more heterogeneous in size or quality. I therefore construct three different measures of administrative costs: the number of households in the village, a dummy of whether the village is in a mountainous area, and the standard deviation in land plot size. Whether the village is in a mountainous area is included because the plots' elevation, flatness, soil quality, and ease of access to water are all more varied in mountainous terrain.

To test whether administrative costs deter frequent land reallocations, one can, of course, regress the annual probability of reallocations on each of these three measures. However, one concern with such regressions is the possibility of reverse causation: both household size and plot division may endogenously respond to how frequent reallocations are carried out in the village. To address this, I use the initial value of each measure at the beginning of the sampled period as an independent variable instead.[24] Table 5 shows the regression results. Consistent with the model, all three measures of administrative costs tend to decrease villages' frequency of reallocations. In particular, being in a mountainous area reduces annual reallocation probability by about 3 percentage points, which is 33% of the mean annual probability of reallocations in an average village.

5.3 Effects of Land Reallocations on Labor Inefficiency

5.3.1 Identification Strategy

This section examines the casual effects of land reallocations on household labor allocation. As with all empirical studies of property rights, a major obstacle here is the potential endogeneity of property rights institutions. In particular, there are significant concerns about reverse causation: villages' land reallocation policies could be direct responses to the households' labor allocation

[24]The mountainous dummy is not subject to this concern because it is constant across time and exogenous to villages' reallocation policies.

decisions. Another potential concern is that households' labor allocation decisions may be correlated with other unobserved village characteristics that influence their land reallocation policies. This paper makes use of the RLCL and the pre-reform variation in villages' reallocation policies to address these issues. I estimate the following equation over the sampled villages:

$$M_{jt} = \alpha_o + \alpha_1 Pre_t * R_j + \mu_t + \gamma_j + \varepsilon_{jt}, \tag{8}$$

where M_{jt} is the percentage of laborers working in off-farm jobs at time t in village j. Pre_t is a dummy indicating that the observation is before the 2003 RLCL reform. μ_t and γ_j represent time and village fixed effects respectively. R_j is a measure of land tenure insecurity in village j due to pre-reform administrative land reallocations. In most villages, major reallocations simply involve all households, so frequency is a good measure of reallocation risks. R_j is, therefore, the pre-reform annual probability of reallocations. Later in the paper, I will check the robustness of my results with alternative measures of reallocation risks, which take the scale of reallocations into consideration.

The main parameter of interest in this empirical model is α_1, which captures the impact of a village's pre-reform land tenure security on the village's pre-reform off-farm labor allocation relative to its post-reform labor allocation. That is, it measures the extent to which, following the 2003 reform, the change in villages' off-farm labor allocation differs across villages with different pre-reform reallocation frequencies. The theoretical model predicts that under-supply of labor to off-farm activities is more severe in villages that reallocate more frequently. Therefore, if land reallocations indeed create labor inefficiencies, α_1 should be negative.

Restricting the estimate to the change in households' labor allocation due to exogenous shocks of the RLCL ensures that the estimated effect is not biased by reverse causality. The difference-in-difference strategy also helps mitigate omitted variable bias: the village fixed-effect should eliminate any omitted variable bias caused by time-invariant village characteristics. In some specifications, I put in an additional set of controls X_{jt} to further eliminate endogeneity due to time-variant characteristics. These controls include the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP.

One concern with this identification strategy is that the estimated effects may reflect other over-time changes that are correlated with villages' pre-reform reallocation frequency. For instance, my estimates may be biased by the effects of other reforms happening around the same time, which perhaps targeted village characteristics that are correlated with its reallocation policies. To eliminate such bias, the paper controls for the interactions between year dummies and villages' pre-reform characteristics, such as the respective logarithm of the population, the number of enterprises, and the total value of collective fixed assets in the village. Similarly, the interactions between year dummies and pre-reform provincial characteristics, including whether the province has a coastline, the mean percentage of non-farm labor in other villages of the same province, and the logarithm of the provincial per capita GDP, are also controlled for.

5.3.2 Results

Figure 2 provides some summary statistics to help us visualize the effects of the 2003 reform. In Figure 2, I include only the villages whose identities remained the same throughout the sampled period[25] and separate the villages into two subgroups by their frequency (mean annual probability) of land reallocations prior to the reform. The solid line plots the average percentage of off-farm labor in villages that have a below-median frequency of pre-reform reallocations, and the dotted line plots the same variable in villages with above-median frequency of pre-reform reallocations.

The model predicts that villages with a higher pre-reform probability of reallocation will have a relatively lower percentage of labor allocated to off-farm employments before 2003. After the reform, when reallocations are banned and the two groups are brought to the same level of tenure security, the difference in labor allocation should disappear. This is exactly what the data show: Prior to the reform, higher-frequency villages (dotted line) allocated much less labor to off-farm employments. After the reform, however, the two lines merge and become indistinguishable. This latter fact indicates that the two groups of villages are likely to be comparable in other characteristics that may also influence households' labor decisions. Moreover, the figure shows that the difference in labor allocation between the two groups was very consistent throughout the pre-reform period, and disappeared once the reform was implemented, which strongly suggests that the convergence was not driven by any different time trends between the two comparison groups. The time-varying effects estimated in Section 5.3.3 will further support this argument.

Table 6 records my estimates of α_1 in equation (8). Column (1) corresponds to equation (8). Column (2) adds into the equation the interaction terms between year indicators and the respective logarithm of villages' pre-reform population, number of enterprises, and collective fixed assets. Column (3) further controls for the interactions terms between year indicators and, respectively, a dummy of whether the province has a coastline, the mean pre-reform non-farm labor allocation in other villages from the same province, and the logarithm of the provincial pre-reform per capita GDP. Columns (4) to (6) repeat the regressions in columns (1) to (3) while controlling for X_{jt}, the set of additional controls discussed above in section 5.3.1.

In all columns and across all specifications, the estimated α_1 is negative and significant, and the

[25] I dropped villages that have ever experienced village mergers during the sampled period (44 out of 244 villages). Because many of the mergers happened around the same period as the reform, dropping these merged villages ensures that the captured discontinuity in the figure is not due to changes in villages' identities. I will talk in greater detail about the village merges in section 5.4.

inclusion of additional controls does not substantially alter its magnitude. On average, an increase in the annual probability of a major reallocation from 0 to 1 decreases off-farm labor by about 30 percent. This implies that an average village (with annual probability of reallocation of about 0.091) under-supplied labor to off-farm employments by 2.7 percentage points per year. The labor influx into off-farm jobs driven by the 2003 reform, therefore, accounts for about 30% of China's total off-farm labor increase between 1995 and 2003. These results are consistent with the model, and suggest that land reallocations did indeed trap labor in the agricultural sector.

5.3.3 Time-varying Effects

In the Appendix, I also allow the effect of land reallocations to vary over time by estimating the following equation:

$$M_{jt} = \alpha_o + \sum_{t \neq 2005} \beta_t \cdot R_j + \mu_t + \gamma_j + \varepsilon_{jt}, \tag{9}$$

where β_t indicates the effect of villages' pre-reform probability of reallocation on their percentage of off-farm labor at year t. Compared to Equation (8), the flexible specification allows us to examine time variation in the impact of a village's pre-reform reallocation frequency. 2005 is chosen as the base year to make all β_ts have a negative sign.

Table D.4 presents the estimates of β_t in equation (9). Consistent with the model's predictions, the estimated β_t is significantly negative in all pre-reform years. Except for a slight drop in 2000, the magnitude of β_t is also very similar throughout the pre-reform period. The post-reform estimates of β_t, however, have much smaller magnitudes and are mostly indistinguishable from zero. Once again, the similarity of the magnitudes of β_t throughout the pre-reform period, and the sharp drop of the estimated effect only since 2003 strongly suggests that differential village time trends exerted no significant influence on my results. It also argues against the existence of omitted variable bias, unless the omitted variable somehow managed to bias the results consistently in all years before 2002, but suddenly exerted no effect from 2003 onward.

5.4 Robustness Checks

Table 7 presents the results of several robustness checks I conducted. Column (1) runs the baseline regression which corresponds to equation (8).

5.4.1 Controlling for Availability of Off-farm Employments

One potential concern is that the relative availability of off-farm employments, which conceivably affects both households' labor allocation and the village's tendency to reallocate, could bias the results. To determine whether such bias exists, the paper creates a variable $nonfarm_{p-j,t}$, which equals to the average off-farm labor allocation at year t in all other villages in the same province as village j. Given that land reallocations are determined at the village level, land reallocations in village j should have no direct effect on the labor allocation decisions of households in other villages, and therefore should only be correlated with $nonfarm_{p-j,t}$ through their common correlation with the relative availability of non-farm employments in the province.

In column (2) of Table 7, I add $Nonfarm_{p-j,t}$ and $pre * Nonfarm_{p-j,t}$ into regression (8) as a robustness check. The estimate of α_1 remains negative and significant and hardly changes at all in magnitude. In column (3) of the same table, I use the number of enterprises in the village, instead of $Nonfarm_{p-j,t}$, as an alternative indicator of the availability of non-farm employment in the village. I add the number of enterprises in a village and its interaction with the pre dummy as additional controls into the baseline equation. This in fact over-controls, as the number of enterprises and the level of economic development in the village are partially determined by its land reallocation policies. Nonetheless, the estimate of $\alpha_1$remains negative and significant, and its magnitude changes very little. These results suggest that omitting the availability of off-farm employments from my regression equation creates no significant bias.

5.4.2 Agricultural Levies Reform around 2003

Starting from the late 1990s, the Chinese central government passed a series of laws and regulations designed to reduce local ad hoc agricultural taxes, which eventually led to the complete eradication of local agricultural levies. The exact timing of the agricultural levies reform varied by village. In my sample, 25% of the villages implemented this reform before 2001, 4% after 2004, and the other 71% in 2002 or 2003. The close chronological proximity of the agricultural levies reform and the RLCL may bias my results if the agricultural levies reform exerted a differential effect on villages' off-farm labor allocation, which is somehow correlated with the village's pre-2003 reallocation frequency. This is possible, for example, if eradication of agricultural levies affects household labor decisions, while either the timing of the reform or the amount of agricultural levies collected from the village before the reform is correlated with the village's pre-2003 land reallocation frequency.

To address this concern, the paper runs two more regressions. In column (4) of Table 7, I add a dummy of whether the agricultural levies reform had been implemented in the village as a control. In column (5), I control for the amount of agricultural levies collected in the village-year.[26] In both columns, my estimates of α_1 remain negative and significant, and their magnitude hardly changes at all. Neither the implementation of the agricultural levies nor the amount of agricultural levies

[26]The amount is usually zero if the agricultural levies reform has been implemented in the village.

seem to cause any significant omitted variable bias to my estimates. It is therefore implausible that the agricultural levies reform poses any serious threat to the accuracy of my estimates.

In results not shown in the paper, I also rerun the regressions in Table 7 with all the additional controls that were added in Table 6. The magnitude of the estimates remain largely similar.

5.4.3 Measuring Reallocation Risks

In most villages, because major reallocations affect everyone, their annual probability is a good measure of the reallocation risks faced by individual households. There will be measurement errors in my estimates, however, if some major reallocations fail to affect all households.

Another potential concern is that, by equating the risk of reallocation with the annual probability of major reallocations, I ignore risks faced by households due to minor or partial reallocations. In Appendix B, I discuss in great detail how I address these two concerns, and show that these measurement issues are unlikely to markedly bias my results.

5.4.4 Village Mergers

The "Big Village" reform in China, which was launched first in some provinces and later propagated nationally in the late 1990s, may also pose some challenges to my analysis. Under this reform, multiple villages may be merged to form a bigger administrative village. The merged bigger village often carries the same administrative code in the NFS data set as one of the villages before the merger, which could introduce errors into my estimates. In my sample, 44 villages (18% of the entire sample) have experienced a merger at least once, and 22 of them (8.6% of the sample) experienced the merger after 2002. To eliminate any resulting error, the paper reruns the main regression, but with all villages that experienced mergers dropped from the sample. The results of these regressions are presented in Table D.5, and are very similar to the baseline estimates in Table 6.

5.4.5 Effects of Demographic Shifts on Household Labor Allocation

As an additional test of the model's predictions, and to further show that the estimated effects of reallocations on household labor allocation are unlikely to be driven by omitted variable bias, I test the reduced-form effects of demographic shifts on household labor allocation. As discussed in Appendix C, I show that higher cross-household variation in demographic shocks systematically decreases households' off-farm labor allocation in a village during the pre-reform period. This is consistent with my model in which demographic shifts increases likelihood of reallocations whereas higher reallocation risks decrease households' labor allocation to agriculture.

Any plausible alternative channel for the observed pattern would require that an unobservable shock be correlated with how demographic shocks differ across households, but also systematically increase agricultural labor allocation for all households. The fact that households who experience both positive and negative demographic shocks (relative to other households) nonetheless increase their agricultural labor allocation is inconsistent with most conceivable sources of omitted variable bias.

5.5 Other Outcomes

5.5.1 Agricultural Output

Before I present the effects of the reform on households' income and confirm that households' labor allocation decisions were indeed inefficient before the reform, I would like to first test the benefits of reallocations.

The theoretical model predicts that the main benefits of land reallocations are, first, to ensure optimal agricultural production in the absence of functional agricultural land and labor markets; and, second, to equalize wealth across households. Unlike households' labor decisions, what affects total agricultural output and income inequality is not the probability of land reallocations, but rather the extent to which land changed hands during reallocations (which measures the extent to which labor and land mismatch were corrected during reallocations). Therefore, to identify these potential benefits of land reallocations, I rerun equation (8), but replace M_{jt} with the appropriate outcome variable, and R_j with the pre-reform average annual percentage of land transferred through reallocations in village j.[27]

Table 8 presents the effects of land reallocations on agricultural output. Ideally, I should measure total agricultural output by the total agricultural net income of all village households, but that data is unavailable. To compensate, I use three different variables to measure total agricultural output. The first is the sum of sampled households' agricultural net income in each village-year, scaled by the total amount of arable land they held in that year. Essentially, this measures the village's average land productivity. The second measure is the total weight of all agricultural crops produced by the village each year. The third measure is simply the total weight of the village's main crop.

The estimates of α_1 using the logarithm of each of the three measures as the dependent variable are presented in columns (1) to (3), columns (4) to (6), and columns (7) to (9) respectively. In all columns, standard errors are clustered at the village level, and the set of additional controls is indicated by "yes". As seen in the table, α_1 is significantly positive regardless of which measure of agricultural output I use, and its estimates are highly robust to additional controls. This suggests

[27] How the percentage of land transferred in each major reallocation is calculated is discussed in Section 4.

that land reallocations boosted villages' overall agricultural productivity, which further implies that agricultural land and labor markets were indeed imperfect in rural China, and that land reallocations helped mitigate the resulting inefficiencies. Given that the mean annual percentage of land transferred by reallocations is about 1% before 2003, my estimates imply that the RLCL decreased average agricultural output by an average of about 5%.

One may worry that the positive effect of land reallocations on agricultural output may not necessarily reflect their ability to improve production efficiency under imperfect markets. Rather, it is possible that reallocations simply increase agricultural output because they increase labor supply to agriculture, which would actually be inefficient. If, however, that is the case, we should expect villages with higher pre-reform frequencies of reallocation, and therefore higher over-supply of agricultural labor, to experience more drastic post-reform changes in agricultural output. In Table D.6 in the Appendix, I repeat the regressions in Table 8, but replace R_j with the annual probability of reallocation. The results show that land reallocation probability has no significant effect on village agricultural output. The positive effects estimated in Table 8 were therefore mainly the result of efficient transfer of land across households.

5.5.2 Income Inequality

Next, I test the effects of land reallocations on cross-household income inequality. To do this, I rerun regression (8) with income inequality as the dependent variable and the pre-reform annual percentage of land transferred through reallocations as R_j.

Table 9 presents the results of these calculations. Three standard measures of per capita income inequality–the coefficient of variation [columns (1) to (3)], the Gini coefficient [columns (4) to (6)], and the general entropy measure GE(1) [columns (7) to (9)]–are employed. The controls added to each column are the same controls added in the corresponding column in Table 8. In all columns, the estimated coefficient of the interaction term between the pre-reform dummy and village land transfers is negative and significant, implying a negative effect of land reallocations on income inequality across households.

5.5.3 Per Capita Net Income

Last but not least, I will estimate the effects of land reallocations on households' per capita income. Based on the model, land reallocations affect households' income in two separate ways. On the one hand, reallocations lead to labor allocation inefficiency, which negatively affect households' per capita income. On the other hand, by enabling efficient transfers of land in the absence of functional markets and improving overall agricultural production efficiency, land reallocations also have a separate positive effect on the village's average income. Whereas households' labor decisions are only affected by the probability of reallocations, the magnitude of the positive income effect is determined by the extent to which land changed hands during reallocations. Therefore, I can decompose the two effects using the following regression:

$$y_{jt} = \alpha_o + \alpha_1 Pre_t * R1_j + \alpha_2 Pre_t * R2_j + \mu_t + \gamma_j + \varepsilon_{jt}, \tag{10}$$

where y_{jt} is the logarithm of households' average per capita net income in village j at year t, and $R1_j$ and $R2_j$ are respectively the pre-reform annual probability of reallocations and average annual percentage of land transferred during reallocations in village j.

Table 10 presents my estimates of α_1 and α_2 for this regression.[28] In all columns, α_1, the effect of reallocation probability on village per capita net income, is negative and significant, verifying the inefficiency of the effect of land reallocations on households' labor decisions. On average, an increase in reallocation probability from 0 to 1 decreases per capita net income by about 110%. Also consistent with the model, my estimated α_2 is positive: an increase in percentage of land transferred from 0 to 100% increases per capital net income by about 320% . Given that the average annual probability of reallocation is about 0.091 and the average annual percentage of land reallocated is about 0.94% in my sample, the overall effect of reallocations on income is negative. The 2003 reform, which eliminates land reallocations, should have increased the per capita income of an average village by 7%.

6 Conclusion

I have demonstrated that frequent land reallocations under collective ownership may have caused Chinese rural households to sub-optimally allocate excessive labor to the agricultural sector. The finding that excessive labor may still be trapped in the Chinese agricultural sector due to land tenure insecurity has important policy implications: As China continues to industrialize and develop, the continued movement of rural labor into non-agricultural employment is a necessary step, both for sustaining China's rapid growth, and for remedying the country's massive–and still growing–rural-urban income disparity. A recent debate among scholars and policymakers focuses, for example, on whether China's huge rural labor surplus has reached a limit.[29] By showing that land tenure insecurity has deterred farmers from choosing off-farm employment, this paper suggests that China can further unleash its labor potential through property rights reforms, which may buy her some valuable time to restructure into a more high-tech, capital-intensive, and domestic consumption-based economy.

[28] Like off-farm labor allocation, data on per capita net income only becomes available starting from 1993.

[29] IMF economists Mitali Das and Papa N'Diaye forecast in a 2013 working paper that China's surplus labor will disappear between 2020 and 2025.

On the other hand, I also propose that, while previous scholarship correctly identified the efficiency loss associated with communal property, it may also have overlooked its benefits. The paper demonstrates that, in the absence of agricultural land and labor markets, frequent land reallocations under collective ownership can increase the efficiency of agricultural production. In addition, land reallocations also functioned as an important wealth-redistribution and social insurance mechanism. These potential benefits explain, at least partially, why collective or community-based ownership of land remains prevalent in many developing countries, and why progress towards decollectivization and privatization in these countries has often been slow, uneven, and even resisted by the very people they were designed to benefit.

There is, therefore, considerable ambiguity as to whether the prohibition of land reallocations has really increased individual welfare. The loss of agricultural productivity associated with the reform can be particularly costly for China, as the country has recently lost its agricultural self-sufficiency, which has long been regarded as having key national strategic value. The paper suggests that, in order to mitigate the welfare costs associated with the elimination of reallocations, the reform should be accompanied by efforts to develop markets and establish alternative social insurance mechanisms. Recent land reforms by the Chinese government indeed seem headed in this direction: In 2008, the central government enacted a policy change that allowed farmers to subcontract, lease land use-rights, and join cooperatives. In 2013, the central government's Number One Document listed allowing voluntary transferal of land and encouraging the formation of large family farms as two of its top priorities.[30] Whether these recent developments can fully compensate for the welfare losses caused by the elimination of land reallocations deserves further research and analysis.

[30]The Number One Document refers to the first document published by the Chinese central government every year. It usually provides guidance and emphasizes the main tasks the government wants to achieve in the year. The 2013 Number One Document was published on Jan. 31st of 2013. In this document, the central government brought up the concept of "large family farms" for the first time.

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Figures and Tables

Figure 1: Variation in Number of Reallocations

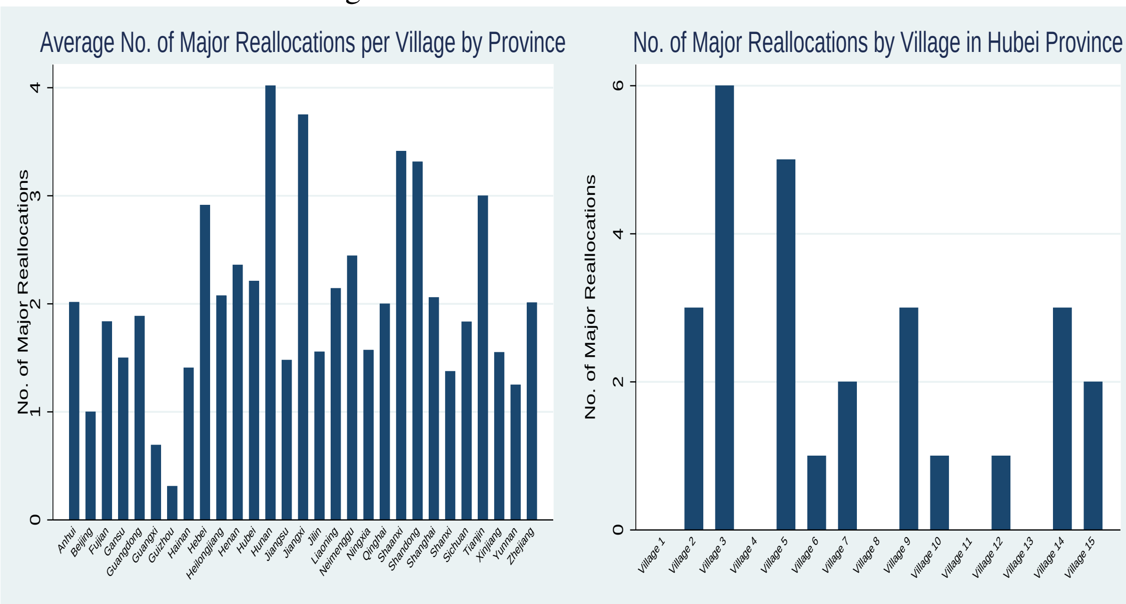

Figure 2: Different Trends of Off-Farm Labor by Pre-Reform Frequency of Reallocations

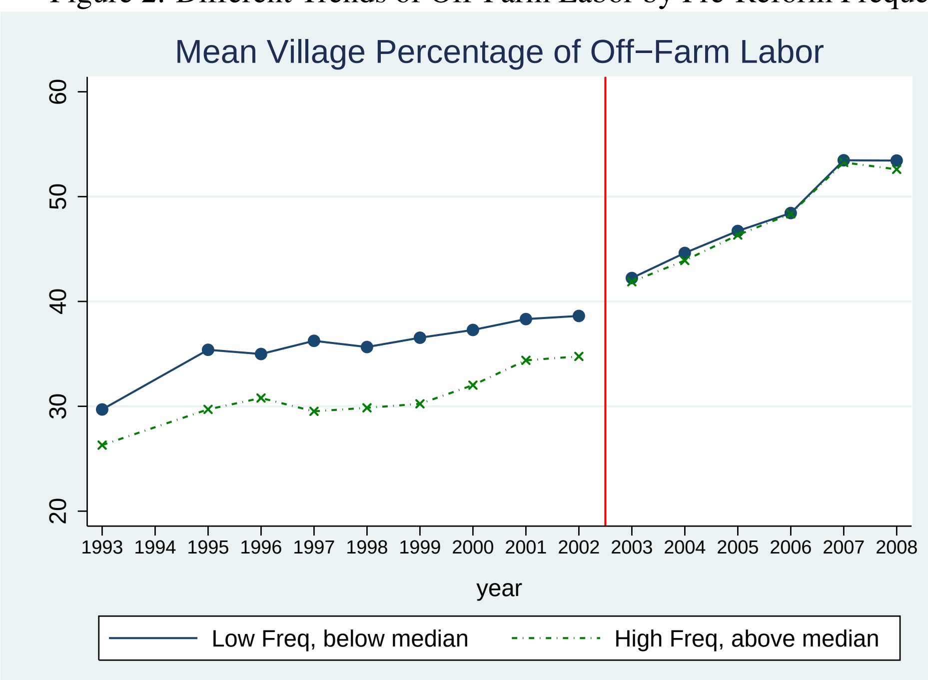

Table 1: Descriptive Statistics

Village Characteristics	Obs.	Mean	Std. Dev.
Number of households	5485	425.44	287.81
Number of permanent residents	5485	1666.58	1095.75
Total arable land (mu)	5485	2422.27	2677.89
Per capita land	5485	1.72	2.01
Number of enterprises	3571	10.1	28.5
Annual per capita net income (yuan)	3571	2635.51	2576.6
Percentage of nonfarm labor (%)	3571	38.84	23.61
Percentage of households renting out land (%)	3571	4.66	9.75
Percentage of hired labordays in family businesses (%)	1391	3.36	33.4
Number of major reallocations	244	1.84	1.56
Annual probability of reallocation before 2002	244	0.091	0.076

Notes: An observation is a village for the last two rows and a village-year for all other rows. The sample covers 1986-2008 for the first 4 rows, 1993 -2008 for the next 4 rows. Percentage of hired labordays in family businesses is calculated based on data from the household survey and is available only for years before 1992 and after 2002.

Table 2: Consistency between Measures of Land Reallocations

		Obs.	Mean	Std. Dev.	Corr. with reallocation dummy
% hh experiencing land change	No reallocation	1329	0.0208	0.0444	0.862
	Reallocation	141	0.588	0.288	
% land transferred	No reallocation	1329	0.0047	0.0129	0.747
	Reallocation	141	0.115	0.0849	

Notes: An observation is a village-year. The sample covers years between 1993 and 2002.

Table 3: Land Allocation Rule: Reallocation Years

	Dependent Variable: land $_t$			
	(1)	(2)	(3)	(4)
Percentage of labor in agriculture $_{t-1}$	0.233*	0.458**	0.461**	0.439**
	(0.125)	(0.180)	(0.183)	(0.179)
Per capita land $_{t-1}$	-0.240***	-0.248***	-0.242***	-0.244***
	(0.0810)	(0.0829)	(0.0832)	(0.0832)
No. of residents $_{t-1}$	0.344***	0.314***	0.297**	0.300**
	(0.0781)	(0.0717)	(0.149)	(0.149)
Other hh mean % farm labor $_{t-1}$	-1.739**	-1.489*	-1.187	-1.159
	(0.733)	(0.750)	(0.793)	(0.800)
Other hh mean pc land $_{t-1}$	1.353	1.425	1.546	1.592
	(1.395)	(1.451)	(1.680)	(1.678)
Per capita agricultural assets $_{t-1}$				0.172
				(0.148)
Controls:				
Village-year FE	yes	yes	yes	yes
Household FE	yes	yes	yes	yes
Sd. in other hh's % farm labor $_{t-1}$	yes	yes	yes	yes
Sd. in other hh's pc land $_{t-1}$	yes	yes	yes	yes
Mean and Sd. in other hh's population size $_{t-1}$	yes	yes	yes	yes
$X_{ij,t-1}$		yes	yes	yes
Mean and sd. in $X_{-ij,t-1}$		yes	yes	yes
Deciles in other hh's % farm labor $_{t-1}$			yes	yes
Deciles in other hh's pc land $_{t-1}$			yes	yes
Deciles in other hh's population size $_{t-1}$			yes	yes
Mean and sd. in other hh's pc agricultural assets $_{t-1}$				yes
Observations	7763	7763	7763	7763
Adjusted R^2	0.247	0.250	0.251	0.251

Notes: An observation is a household and a year. The sample is limited to village-years in which a real- -location happens. t-1 refers to the period one year before the current year of observation. The controls included are indicated in the table by "yes." X includes households' no. of rural laborers, no. of male rural laborers, total labordays worked, education of the main laborer, dummies of whether the household has party members, village cadres and veterans, and a dummy of whether the household is in special needs. Coefficients are reported with standard errors clustered at the village level in parentheses. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table 4: Demographic Shifts and Reallocation Frequency

	Dep. Var.: Annual Probability of Reallocation		
	(1)	(2)	(3)
Pre-reform mean σ in no. of rural residents	0.0119**		
	(0.00582)		
Pre-reform mean σ in no. of rural laborers		0.0141**	
		(0.00579)	
Pre-reform mean σ in no. of male rural laborers			0.0172***
			(0.00573)
Observations	166	166	166
R^2	0.025	0.035	0.052

Notes: An observation is a village. σ refers to each village's standard deviation in households' annual percentage change in number of rural residents, number of rural laborers, and number of rural male laborers respectively. Each of the three demographic shift measures is normalized to have mean zero and standard deviation 1. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table 5: Administrative Costs of Reallocations

	Dep. Var.: Annual Probability of Reallocation			
	(1)	(2)	(3)	(4)
Initial no. of households	-0.00683			-0.00894*
	(0.00512)			(0.00507)
Mountainous area		-0.0262*		-0.0303**
		(0.0133)		(0.0133)
Initial size variation in plots			-0.00372	-0.00865
			(0.00576)	(0.00576)
Pre-reform mean σ in no. of rural residents				0.0141**
				(0.00576)
Observations	158	158	158	158
R^2	0.011	0.024	0.003	0.085

Notes: An observation is a village. σ refers to each village's standard deviation in households' annual percentage change in number of rural residents. Each of the independent variables, ex- -cept the dummy of whether the village is in a mountainous area, is normalized to have mean zero and standard deviation one. Standard errors in parentheses. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table 6: Effects of Reallocation Probability on Off-Farm Labor

	Dep. Var.: Percentage of Off-Farm Labor					
	(1)	(2)	(3)	(4)	(5)	(6)
Pre*prob. of reallocation	-30.75***	-30.56**	-27.97**	-28.58**	-29.60**	-27.11**
	(11.82)	(12.04)	(12.25)	(11.91)	(12.12)	(12.34)
Controls:						
Year FE*log(population)$_j$		yes	yes		yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes		yes	yes
Year FE*log(fixed asset)$_j$		yes	yes		yes	yes
Year FE*log(provincial GDP)$_j$			yes			yes
Year FE*coast$_j$			yes			yes
Year FE*log(prov. nonfarm labor)$_j$			yes			yes
X_{jt}				yes	yes	yes
Observations	3217	3217	3217	3217	3217	3217
Adjusted R^2	0.825	0.835	0.835	0.827	0.836	0.836

Notes: An observation is a village and a year. The sample includes the 225 villages covered by both the NFS and the VDS for the years 1993 and 1995-2008. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table 7: Robustness Checks: Control for Availability of Off-Farm Opportunities and Agricultural Levies

	Dep. Var.: Percentage of Off-Farm Labor				
	(1)	(2)	(3)	(4)	(5)
	base	control for other village off-farm labor	control for no. of enterprises	control for levies reform	control for levies
Pre*prob. of reallocations	-28.56**	-28.63**	-27.86**	-27.36**	-28.54**
	(12.07)	(12.21)	(12.33)	(12.14)	(12.07)
Observations	3151	3151	3151	3151	3151
Adjusted R^2	0.831	0.832	0.834	0.845	0.844

Notes: An observation is a village and a year. The sample includes the 225 villages covered by both the NFS and the VDS for the years 1993, and 1995-2008. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects.* , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table 8: Effects of Land Reallocations on Agricultural Output

	log(average land product)			log(weight of all crops)			log(main-crop weight)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pre*% land transferred	3.099*	3.131**	3.863**	3.469**	3.269*	2.154	8.595**	8.202*	6.838*
	(1.606)	(1.518)	(1.583)	(1.623)	(1.685)	(1.585)	(4.003)	(4.277)	(3.944)
Controls:									
Year FE*log(population)$_j$		yes	yes		yes	yes		yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes		yes	yes		yes	yes
Year FE*log(fixed asset)$_j$		yes	yes		yes	yes		yes	yes
X_{jt}			yes			yes			yes
Observations	1860	1860	1860	2382	2382	2382	2394	2394	2394
Adjusted R^2	0.805	0.806	0.806	0.902	0.903	0.917	0.848	0.848	0.857

Notes: An observation is a village and a year. The sample in columns (1)-(3) includes the 114 villages covered by both the NFS household survey and the VDS for years 1986-2008. The sample in columns (4) - (9) includes the years 1993 and 1995-2008 and the 166 villages covered by the VDS, the NFS village survey, and the NFS household survey in the pre-reform period. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table 9: Effects of Land Reallocations on Income Inequality

	Cross-household Inequality in Per Capita Net Income								
	log (Coefficient of Var.)			log (Gini)			log(GE(1))		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pre*% land transferred	-1.665**	-1.670**	-1.982**	-1.328*	-1.318*	-1.584**	-2.438*	-2.442*	-3.028**
	(0.787)	(0.790)	(0.767)	(0.702)	(0.768)	(0.733)	(1.264)	(1.379)	(1.322)
Controls:									
Year FE*log(population)$_j$		yes	yes		yes	yes		yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes		yes	yes		yes	yes
Year FE*log(fixed asset)$_j$		yes	yes		yes	yes		yes	yes
X_{jt}			yes			yes			yes
Observations	2616	2616	2616	2616	2616	2616	2616	2616	2616
Adjusted R^2	0.496	0.498	0.501	0.546	0.553	0.556	0.531	0.537	0.540

Notes: An observation is a village and a year. The sample includes the 114 villages covered by both the NFS household survey and the VDS for years 1986-2008. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table 10: Effects of Reallocation Probability on Per Capita Net Income

	Dep. Var.: log(Per Capita Net Income)					
	(1)	(2)	(3)	(4)	(5)	(6)
Pre*prob. of reallocation	-1.325***	-1.058***	-1.082**	-1.293***	-1.042**	-1.040**
	(0.427)	(0.404)	(0.420)	(0.426)	(0.403)	(0.417)
Pre*% land transferred	4.683	3.189	3.276	4.496	2.966	2.890
	(3.781)	(3.797)	(3.879)	(3.707)	(3.738)	(3.786)
Controls:						
Year FE*log(population)$_j$		yes	yes		yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes		yes	yes
Year FE*log(fixed asset)$_j$		yes	yes		yes	yes
Year FE*log(provincial GDP)$_j$			yes			yes
Year FE*coast$_j$			yes			yes
Year FE*log(prov. nonfarm labor)$_j$			yes			yes
X_{jt}				yes	yes	yes
Observations	2334	2334	2334	2334	2334	2334
Adjusted R^2	0.875	0.882	0.882	0.876	0.883	0.884

Notes: An observation is a village and a year. The sample includes the years 1993 and 1995-2008 and the 166 villages covered by the VDS, the NFS village survey, and the NFS household survey in the pre-reform period. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households,the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

APPENDIX

Appendix A Imperfect Agricultural Labor and Land Markets Assumption

Summary statistics in Table 1 show that both the percentage of hired labor and the percentage of households that leased out land are very low in the sampled villages, which is consistent with the paper's assumption that agricultural land and labor markets are imperfect in rural China. However, one concern is that these market activities may be low not due to imperfect markets, but because the land reallocations under communal tenure makes it unnecessary for households to conduct land or labor transactions through market means. To provide further evidence for the assumption of imperfect agricultural land and labor markets, I test how households' land-leasing and labor-hiring activities respond to demographic shifts across households in a village.

If agricultural labor and land markets are perfectly functional in rural China, and land reallocations indeed lower households' demand for market participation, we should expect land-leasing and labor-hiring activities to rise as households experience heterogeneous demographic shocks in between reallocations. In other words, demographic shifts, which lead to mismatch of labor and land distribution across households, should increase market activities in a village, at least until the next land reallocation eliminates any mismatch again. To measure demographic shifts in a village, I again use the measure that I constructed in section 5.2, but use the year of previous land reallocation in the village as the base year. Specifically, I calculate each household's percentage change in the number of rural residents as the logarithm of the ratio between the household's current number of rural residents and that in the year of the previous reallocation. I then calculate demographic shift, $\sigma_t^j(p)$, as the standard deviation of this household-specific percentage change for each village j and each year t:

$$\sigma_t^j(p) = standard\,deviation(log(\frac{p_t^{ij}}{p_{r_t}^{ij}})),$$

where p_t^{ij} refers to household i's number of rural residents in year t and $p_{r_t}^{ij}$ refers to household i's number of rural residents in the year of the last land reallocation in village j before year t. I repeat the same procedure on households' number of rural laborers and number of male laborers, thereby deriving two alternative measures of variation in demographic shocks.

I test how land-leasing and labor hiring activities respond to demographic shifts by running the following regression:

$$M_{jt} = \alpha_o + \alpha_1 \cdot \sigma_t^j(p) + \mu_t + \gamma_j + \varepsilon_{jt}. \quad (11)$$

In this regression, I only include village-years in which a reallocation does not happen. M_{jt} is the outcome variable: I use the percentage of households renting in and renting out land respectively to measure land-leasing activities and the percentage of hired labor in family businesses to measure labor-hiring activities in the village. μ_t and γ_j represent time and village fixed effects. α_1 estimates how the amount of land-leasing and labor-hiring activities respond to the degree of demographic shifts across households. If agricultural land and labor markets are perfectly functional, we should expect α_1 to be positive.

Table A.1 presents my estimates of α_1 in equation (11). In columns (1) to (3), the dependent variable is the percentage of households renting out land in the village, and the main independent variable is $\sigma_t^j(p)$ in, respectively, households' number of rural residents, number of rural laborers, and number of male rural laborers. Columns (4) to (6) repeat the regressions in columns (1) to (3), but with the percentage of households leasing in land as the dependent variable. Columns (7) to (9) again repeat the three regressions with the percentage of hired labor in family businesses as the dependent variable. In none of these regressions is the estimate of α_1 significantly different from zero. This implies that land-leasing and labor-hiring activities do not seem to respond to shifts in land-labor match in the village, which argues against perfectly functional agricultural land and labor markets.

Table A.1: Effects of Demographic Shifts on Land-Leasing and Labor-Hiring Activities

	% of hh renting out land			% of hh renting in land			% of hired labor in family businesses		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
σ_t in no. of rural residents	-0.0759			-0.0746			-0.00273		
	(0.421)			(0.270)			(0.00557)		
σ_t in no. of rural laborers		-0.254			-0.121			-0.00669	
		(0.372)			(0.257)			(0.00674)	
σ_t in no. of male rural laborers			-0.0660			-0.0975			0.0134
			(0.227)			(0.191)			(0.0144)
Observations	1963	1963	1963	1963	1963	1963	1253	1253	1253
Adjusted R^2	0.546	0.547	0.546	0.572	0.572	0.572	0.081	0.081	0.082

Notes: An observation is a village and a year. The sample includes village-years in which a reallocation does not happen. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. Land-leasing data is available for all years after 1993. Hired labor data is available for years before 1992 and after 2002.

Appendix B Measuring Reallocation Risks

In most villages, because major reallocations affect everyone, their annual probability is a good measure of the reallocation risks faced by individual households. There will be measurement errors in my estimates, however, if some major reallocations fail to affect all households. To address this issue, I calculate the annual percentage of reallocated households in major reallocations as an alternative measure of R_j in equation (8). I record a household as affected by a major reallocation if it experiences landholding changes not due to leasing or reforestation in a major reallocation year. I then divide the total percentage of affected households by the number of sampled years to calculate the annual percentage.[31]

Another potential concern is that, by equating the risk of reallocation with the annual probability of major reallocations, I ignore risks faced by households due to minor or partial reallocations. I choose not to take minor reallocations into consideration because they are inherently of a different nature from major reallocations: First, they only involve households with demographic changes (Kung and Bai, 2011). Other households know for sure that they will not be affected. This implies that, for most households, minor reallocations do not change their perception of reallocation risks at all. Second, even for those households that are affected by minor reallocations, there is a limit to how much land can be adjusted–negatively affected households were usually obligated to surrender only one plot (Kung and Bai, 2011). Unlike how they conduct major reallocations, policy makers do not construct a reallocation rule that fully accounts for households' demographic information and labor allocation. Consequently, the effect of minor reallocations on households' labor decisions is probably much smaller.

Nonetheless, as an additional robustness check, I construct two alternative measures of reallocation risk that take minor reallocations into consideration. The first calculates the annual percentage of households experiencing land change not due to leasing or reforestation in any year, regardless of whether a major reallocation occurred. The second calculates the same thing, but also adds the assumption that all major allocations affect all households.

Table B.1 presents my estimates of equation (8), using alternative measures of R_j (villages' pre-reform tenure insecurity). Panel A repeats the regressions in columns (1) to (6) of Table 6, where I use village's pre-reform annual major reallocation probability as R_j.[32] Panel B records the same estimates, but uses the mean annual percentage of households affected by major reallocations as R_j. In panels C and D, the two measures of reallocation risk that account for minor reallocations assume, respectively, the role of R_j. As we can see from Table B.1, α_1 is negative and significant

[31] As mentioned before, because it is possible for a household to experience land swaps even when the area of land allocated to the household did not change, this measure is, in fact, a lower bound to the annual probability that a household will be affected by a major land reallocation.

[32] I use the same sample for all four panels. Because household data is available only for a sub-sample of villages, the regressions in Table B.1 cover a smaller sample compared to Table 6.

in almost all 18 regressions. In fact, the estimated effects of reallocation risks on household labor allocation are lowest in Panel A. The alternative measures seem to imply even larger effects.

Table B.1: Different Measures of Tenure Insecurity: Percentage of Off-Farm Labor

	Dep. Var.: Percentage of Off-Farm Labor					
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A					
Pre* prob. of reallocation	-42.10***	-37.32***	-36.79***	-38.40***	-34.93**	-34.96**
	(13.61)	(13.47)	(13.74)	(13.66)	(13.57)	(13.83)
Adjusted R^2	0.834	0.846	0.846	0.837	0.848	0.847
	Panel B					
Pre* % hh reallocated (major only)	-62.96***	-52.54***	-52.82***	-57.26***	-49.54***	-50.10***
	(17.10)	(17.65)	(18.36)	(17.63)	(17.92)	(18.66)
Adjusted R^2	0.835	0.847	0.846	0.838	0.848	0.847
	Panel C					
Pre* % hh reallocated (major+minor)	-56.33***	-49.25***	-51.05***	-51.49***	-47.10***	-48.81***
	(16.64)	(17.28)	(18.10)	(16.78)	(17.30)	(18.26)
Adjusted R^2	0.835	0.847	0.846	0.837	0.848	0.848
	Panel D					
Pre* % hh reallocated (minor + major	-39.75***	-36.69***	-36.85**	-36.50***	-34.78**	-35.31**
assumed to be 100%)	(14.13)	(14.16)	(14.41)	(13.80)	(13.93)	(14.19)
Adjusted R^2	0.834	0.846	0.846	0.837	0.848	0.847
Controls (for all panels):						
Year FE*log(population)$_j$		yes	yes		yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes		yes	yes
Year FE*log(fixed asset)$_j$		yes	yes		yes	yes
Year FE*log(provincial GDP)$_j$			yes			yes
Year FE*coast$_j$			yes			yes
Year FE*log(prov. nonfarm labor)$_j$			yes			yes
X_{jt}				yes	yes	yes
Observations	2238	2238	2238	2238	2238	2238

Notes: An observation is a village and a year. The sample includes the years 1993 and 1995-2008 and the 166 villages covered by the VDS, the NFS village survey, and the NFS household survey in the pre-reform period. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Appendix C Effects of Demographic Shifts on Household Labor Allocation

As an additional test of the model's predictions, and to further show that the estimated effects of reallocations on household labor allocation are unlikely to be driven by omitted variable bias, I also test the reduced-form effects of demographic shifts on household labor allocation. The specification is the following:

$$M_{jt} = \alpha_o + \alpha_1 Pre_t * \sigma_j + \mu_t + \gamma_j + \varepsilon_{jt}, \tag{12}$$

where M_{jt} still denotes the percentage of off-farm labor at time t in village j, Pre_t is a dummy equaling to 1 when t $\leq$2002, and σ_j refers to village j's pre-reform mean rate of cross-household demographic variation that I constructed in section 5.2. Based on the model, higher cross-household variation in demographic shocks, by increasing the likelihood of reallocations, should decrease households' pre-reform off-farm labor allocation. This systematic relationship should, however, disappear after the reform, once households were able to allocate labor efficiently. Therefore, α_1, which estimates how change in labor allocation due to the reform differs across villages with different σ_j, identifies the effect of demographic shifts on household pre-reform labor allocation.

Table C.1 presents my estimates of equation (12). In panel A and B, σ_j measures the cross-household demographic variation in, respectively, the number of rural residents and the number of male laborers. The set of controls that I add in each column corresponds to the same controls I add in Table D.4. In all specifications, the estimated α_1 is negative and significant. The results are, therefore, consistent with the model's predictions: before the reform, cross-household variation in demographic shocks indeed caused households to over-supply labor to agriculture.

Table C.1: Effects of Demographic Shifts on Off-Farm Labor

	Dep. Var.: Percentage of Off-Farm Labor			
	(1)	(2)	(3)	(4)
	Panel A			
Pre* σ_j in no. of rural residents	-1.923*	-2.102**	-2.109**	-2.037**
	(1.004)	(0.884)	(0.921)	(0.913)
Adjusted R^2	0.845	0.856	0.855	0.857
	Panel B			
Pre* σ_j in no. of male laborers	-2.471***	-2.666***	-2.671***	-2.595***
	(0.940)	(0.834)	(0.882)	(0.877)
Adjusted R^2	0.846	0.857	0.856	0.858
Controls (for all panels):				
Year FE*log(population)$_j$		yes	yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes	yes
Year FE*log(fixed asset)$_j$		yes	yes	yes
Year FE*log(provincial GDP)$_j$			yes	yes
Year FE*coast$_j$			yes	yes
Year FE*log(prov. nonfarm labor)$_j$			yes	yes
X_{jt}				yes
Observations	2238	2238	2238	2238

Notes: An observation is a village and a year. The sample includes the years 1993 and 1995-2008 and the 166 villages covered by the VDS, the NFS village survey, and the NFS household survey in the pre-reform period.σ is normalized to have mean zero and standard deviation of one. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Appendix D Additional Figures and Tables

Figure D.1: % Villages with Major Land Reallocations by Year

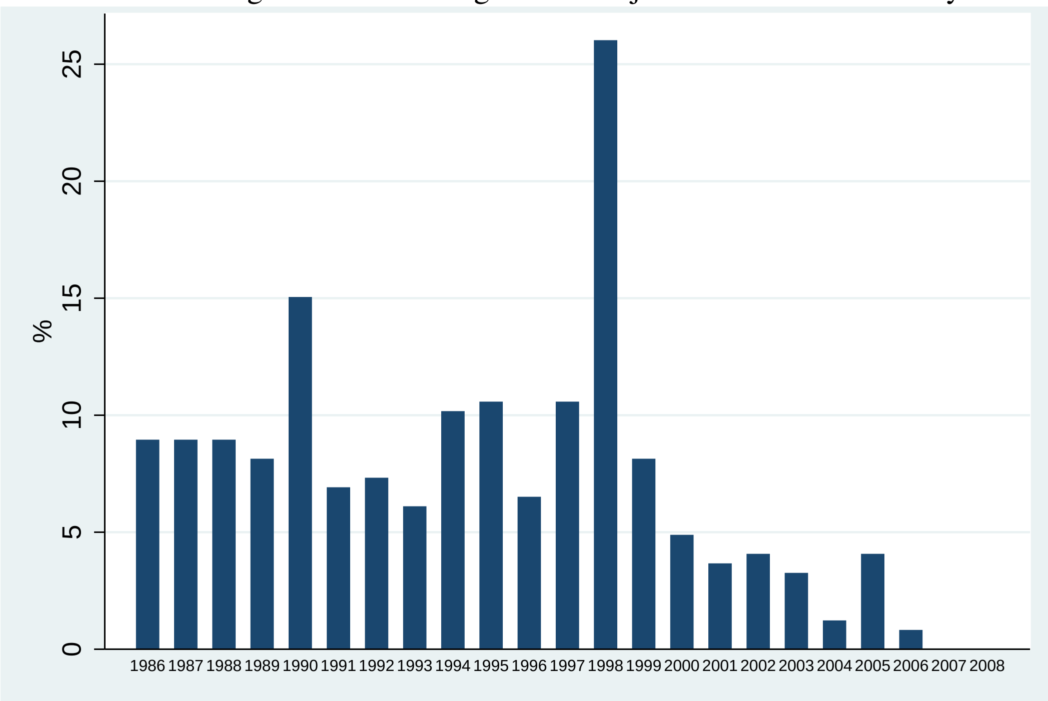

Table D.1: Reallocations Happen at Regular Time Intervals

village ID	Years since Last Reallocation						
	1	2	3	4	5	6	7
2101		1	4	1			
3601		5	3				
3602		1	1	1	1		1
3605			1		4		
3716		1		5			
4112			2	1	1		
4204			2	3	1		
4206				2	3		
4305			4		1		
4316			7				
5109			1	2	1		
6101		1	4				
6103			5				
6110			2		2		
6114			5				
6115			5				
6405			4		2		

Notes: Each observation is a village and a reallocation. The table includes all villages that reallocated more than 4 times. The number in the cell records the number of times a reallocation happened exac- -tly after that many years (the corresponding number indicated in the column title) from the previous reallocation. With the exception of village 3602, villages seem to reallocate at very regular intervals.

Table D.2: Land Allocation Rule (Standardized Coefficients): Reallocation Years

	Dependent Variable: $land_t$			
	(1)	(2)	(3)	(4)
Percentage of labor in agriculture $_{t-1}$	0.023*	0.045**	0.045**	0.043**
Per capita land $_{t-1}$	-0.084***	-0.087***	-0.085***	-0.085**
No. of residents $_{t-1}$	0.185***	0.169***	0.160**	0.161**
Other hh mean % farm labor $_{t-1}$	-0.063**	-0.054*	-0.043	-0.042
Other hh mean pc land $_{t-1}$	0.153	0.162	0.175	0.180
Per capita agricultural assets $_{t-1}$				0.017
Controls:				
Village-year FE	yes	yes	yes	yes
Household FE	yes	yes	yes	yes
Sd. in other hh's % farm labor $_{t-1}$	yes	yes	yes	yes
Sd. in other hh's pc land $_{t-1}$	yes	yes	yes	yes
Mean and Sd. in other hh's population size $_{t-1}$	yes	yes	yes	yes
$X_{ij,t-1}$		yes	yes	yes
Mean and sd. in $X_{-ij,t-1}$		yes	yes	yes
Deciles in other hh's % farm labor $_{t-1}$			yes	yes
Deciles in other hh's pc land $_{t-1}$			yes	yes
Deciles in other hh's population size $_{t-1}$			yes	yes
Mean and sd. in other hh's pc agricultural assets $_{t-1}$				yes
Observations	7763	7763	7763	7763
Adjusted R^2	0.247	0.250	0.251	0.251

Notes: An observation is a household and a year. The sample is limited to village-years in which a real--location happens. t-1 refers to the period one year before the current year of observation. The controls included are indicated in the table by "yes." X includes households' no. of rural laborers, no. of male rural laborers, total labordays worked, education of the main laborer, dummies of whether the household has party members, village cadres and veterans, and a dummy of whether the household is in special needs. Coefficients are reported with standard errors clustered at the village level in parentheses. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table D.3: Placebo Test: Non-Reallocation Years

	Dependent Variable: land $_t$			
	(1)	(2)	(3)	(4)
Percentage of labor in agriculture $_{t-1}$	0.0600	0.0737	0.0702	0.0787
	(0.0513)	(0.0664)	(0.0677)	(0.0675)
Per capita land $_{t-1}$	0.305***	0.304***	0.289***	0.287***
	(0.0519)	(0.0522)	(0.0575)	(0.0589)
No. of residents $_{t-1}$	0.171***	0.162***	0.152***	0.151***
	(0.0293)	(0.0245)	(0.0239)	(0.0240)
Other hh mean % farm labor $_{t-1}$	0.485	0.622*	0.508	0.494
	(0.311)	(0.357)	(0.378)	(0.382)
Other hh mean pc land $_{t-1}$	-1.740***	-1.770***	-4.910***	-4.882***
	(0.422)	(0.409)	(1.317)	(1.298)
Per capita agricultural assets $_{t-1}$				-0.0359
				(0.0329)
Controls:				
Village-year FE	yes	yes	yes	yes
Household FE	yes	yes	yes	yes
Sd. in other hh's % farm labor $_{t-1}$	yes	yes	yes	yes
Sd. in other hh's pc land $_{t-1}$	yes	yes	yes	yes
Mean and Sd. in other hh's population size $_{t-1}$	yes	yes	yes	yes
$X_{ij,t-1}$		yes	yes	yes
Mean and sd. in $X_{-ij,t-1}$		yes	yes	yes
Deciles in other hh's % farm labor $_{t-1}$			yes	yes
Deciles in other hh's pc land $_{t-1}$			yes	yes
Deciles in other hh's population size $_{t-1}$			yes	yes
Mean and sd. in other hh's pc agricultural assets $_{t-1}$				yes
Observations	87550	87550	87550	87548
Adjusted R^2	0.129	0.131	0.137	0.138

Notes: An observation is a household and a year. The sample is limited to village-years in which a real--location does not happen. t-1 refers to the period one year before the current year of observation. The controls included are indicated in the table by "yes." X includes households' no. of rural laborers, no. of male rural laborers, total labordays worked, education of the main laborer, dummies of whether the household has party members, village cadres and veterans, and a dummy of whether the household is in special needs. Coefficients are reported with standard errors clustered at the village level in parentheses. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table D.4: Time-Varying Effects of Reallocation Probability on Off-Farm Labor

	Dep. Var.:Percentage of Off-Farm Labor			
	(1)	(2)	(3)	(4)
Year 1993*pre-reform prob. of reallocation	-38.32**	-43.71**	-42.68**	-41.33**
	(17.70)	(18.84)	(18.46)	(19.04)
Year 1995*pre-reform prob. of reallocation	-42.55***	-43.99***	-42.77***	-42.20**
	(15.57)	(16.18)	(16.02)	(16.58)
Year 1996*pre-reform prob. of reallocation	-30.88*	-32.33**	-31.72*	-30.72*
	(15.84)	(16.22)	(16.17)	(16.76)
Year 1997*pre-reform prob. of reallocation	-41.94***	-42.28***	-42.00***	-41.22***
	(13.93)	(14.66)	(14.66)	(15.33)
Year 1998*pre-reform prob. of reallocation	-38.23***	-39.13**	-38.50**	-37.08**
	(14.45)	(15.31)	(15.30)	(15.80)
Year 1999*pre-reform prob. of reallocation	-41.43***	-41.81***	-40.66***	-38.36**
	(14.21)	(15.16)	(15.14)	(15.65)
Year 2000*pre-reform prob. of reallocation	-28.08*	-30.31**	-28.69*	-27.69*
	(14.72)	(15.25)	(15.09)	(15.64)
Year 2001*pre-reform prob. of reallocation	-21.39	-21.52	-20.30	-18.27
	(13.25)	(13.72)	(13.82)	(14.35)
Year 2002*pre-reform prob. of reallocation	-28.89**	-30.92**	-30.21**	-29.96**
	(12.71)	(13.31)	(13.33)	(13.58)
Year 2003*pre-reform prob. of reallocation	-4.011	-6.647	-6.762	-7.081
	(9.313)	(9.722)	(9.568)	(9.740)
Year 2004*pre-reform prob. of reallocation	-4.852	-6.375	-6.289	-6.390
	(5.816)	(6.697)	(6.481)	(6.620)
Year 2006*pre-reform prob. of reallocation	-8.749*	-10.27**	-10.21**	-11.01**
	(5.006)	(5.016)	(4.917)	(5.045)
Year 2007*pre-reform prob. of reallocation	-2.970	-5.372	-7.450	-9.022
	(10.92)	(11.14)	(11.27)	(11.32)
Year 2008*pre-reform prob. of reallocation	-3.866	-6.549	-8.425	-10.12
	(10.94)	(11.14)	(11.26)	(11.30)
Controls:				
Year FE*log(population)$_j$		yes	yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes	yes
Year FE*log(fixed asset)$_j$		yes	yes	yes
Year FE*log(provincial GDP)$_j$			yes	yes
Year FE*coast$_j$			yes	yes
Year FE*log(prov. nonfarm labor)$_j$			yes	yes
X_{jt}				yes
Observations	3217	3217	3217	3217
Adjusted R^2	0.825	0.835	0.835	0.836

Notes: An observation is a village and a year. The sample includes the 225 villages covered by both the NFS and the VDS for the years 1993, and 1995-2008. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table D.5: Robustness Checks: Drop Merged Villages

	Dep. Var.: Percentage of Off-Farm Labor					
	(1)	(2)	(3)	(4)	(5)	(6)
Pre*prob. of reallocation	-29.97**	-29.18**	-25.89**	-26.41**	-26.84**	-24.25*
	(12.33)	(12.62)	(12.69)	(12.70)	(12.94)	(12.93)
Controls:						
Year FE*log(population)$_j$		yes	yes		yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes		yes	yes
Year FE*log(fixed asset)$_j$		yes	yes		yes	yes
Year FE*log(provincial GDP)$_j$			yes			yes
Year FE*coast$_j$			yes			yes
Year FE*log(prov. nonfarm labor)$_j$			yes			yes
X_{jt}				yes	yes	yes
Observations	2608	2608	2608	2608	2608	2608
Adjusted R^2	0.830	0.838	0.839	0.831	0.839	0.840

Notes: An observation is a village and a year. The sample includes the 185 villages, which experienced no village mergers and are covered by both the NFS and the VDS for the years 1993, and 1995-2008. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Table D.6: Effects of Reallocation Probability on Agricultural Output

	log(average land product)			log(weight of all crops)			log(main-crop weight)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pre*prob. of reallocation	0.128	0.163	0.235	0.375	0.465	0.321	0.544	0.628	0.383
	(0.331)	(0.329)	(0.326)	(0.444)	(0.434)	(0.406)	(0.955)	(0.956)	(0.905)
Controls:									
Year FE*log(population)$_j$		yes	yes		yes	yes		yes	yes
Year FE*log(no. of enterprises)$_j$		yes	yes		yes	yes		yes	yes
Year FE*log(fixed asset)$_j$		yes	yes		yes	yes		yes	yes
X_{jt}			yes			yes			yes
Observations	1860	1860	1860	2382	2382	2382	2394	2394	2394
Adjusted R^2	0.804	0.805	0.805	0.902	0.903	0.917	0.847	0.846	0.856

Notes: An observation is a village and a year. The sample in columns (1)-(3) includes the 114 villages covered by both the NFS household survey and the VDS for years 1986-2008. The sample in columns (4) - (9) includes the years 1993 and 1995-2008 and the 166 villages covered by the VDS, the NFS village survey, and the NFS household survey in the pre-reform period. Coefficients are reported with standard errors clustered at the village level in parentheses. All regressions control for village and year fixed effects. X_{jt} includes the number of households, the number of residents, the total amount of arable land, the percentage of laborers with higher than high school education, and the provincial per capita GDP. * , **, *** respectively denotes significance at 10%, 5% and 1% level.

Appendix E Theoretical Proofs

E.1 Proof of Proposition 1

The Lagrangian of the social planner's problem conditional on r=1 is:

$$L(\lambda,\{n^i\}_{i=1}^I)=\sum_{i=1}^I p^i\rho^i u(C_2^i(w^i,n^i))-A+\lambda(N-\sum_i^I p^i n^i).$$

The first order conditions of the social planner's problem with respect to n^i is therefore:

$$\frac{\partial L}{\partial n^i} \quad = \quad p^i\cdot\rho^i\cdot u_c(w^i,n^i)\cdot f_n(l_2^i,n^i)-p^i\lambda=0\,\forall i. \tag{13}$$

At the same time,

$$\begin{aligned}
\frac{\partial^2 L}{(\partial n^i)^2} &= \rho^i[u_{cc}\cdot(f_n)^2+u_c\cdot(f_{nn}+f_{nl}\cdot\frac{dl_2^i}{dn^i})] \\
&= \rho^i[u_{cc}\cdot(f_n)^2+u_c\cdot(f_{nn}-f_{nl}\cdot\frac{f_{ln}}{f_{ll}})]<0\,\forall i. \qquad (14)\\
\frac{\partial^2 L}{\partial n^i\partial n^j} &= 0\forall i,\forall j\neq i
\end{aligned}$$

The last equality in equation (14) follows from equation (2). The inequality in (14) follows from the assumptions that $u_{cc}<0$, $f_n>0$, $u_c>0$ and the concavity of f which implies $f_{nn}-f_{nl}\cdot\frac{f_{ln}}{f_{ll}}<0$.

Therefore, with $(-)$ indicating a negative number, the bordered Hessian matrix for the problem is

$$H=\begin{pmatrix} 0 & -p_1 & -p_2 & \cdots & -p_I \\ -p_1 & (-) & 0 & \cdots & 0 \\ -p_2 & 0 & (-) & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ -p_I & 0 & 0 & 0 & (-) \end{pmatrix},$$

which is negative definite when $p_i>0\forall i$. Therefore, the second-order conditions imply that a maximum occurs at $\frac{\partial L}{\partial n^i}=0$ for i=1,2,...,I.

Simplifying equation (13), I get:

$$\rho^i\cdot u_c(w^i,n^i)\cdot f_n(l_2^i,n^i)=\lambda. \tag{15}$$

At the same time, first-order conditions of the household's problem implies $f_l(l_2^i,n^i)=w^i$. $C_2^i(n^i,w^i)=\max_{l_2^i}u(w^i\cdot(1-l_2^i)+f(l_2^i,n^i))$ and the equilibrium l_2^i therefore depend only on n^i and w^i and respond to n^i and w^i as if they are exogenous. Let $F_i(n,\lambda;w,\rho,p)=\rho^i\cdot u_c(w^i,n^i)\cdot$

$f_n(l_2^i(w^i,n^i),n^i)-\lambda=0\ \forall i\in[1,I]$, and let $F_{I+1}(n,\lambda;w,\rho,p)=N-\sum_i^I p^i n^i=0$. I thus have $I+1$ equations that characterize $I+1$ endogenous variables, $n^1,n^2,...,n^I$and λ, in terms of exogenous variables $w^1,...,w^I,\rho^1,...,\rho^I$ and $p^1,...,p^I$:

$$\begin{aligned}
F_1(n,\lambda;w,\rho,p) &= \rho^1\cdot u_c(w^1,n^1)\cdot f_n(l_2^1(w^1,n^1),n^1)-\lambda=0\\
&\vdots\\
F_I(n,\lambda;w,\rho,p) &= \rho^I\cdot u_c(w^I,n^I)\cdot f_n(l_2^I(w^I,n^I),n^I)-\lambda=0\\
F_{I+1}(n,\lambda;w,\rho,p) &= N-\textstyle\sum_i^I p^i n^i=0
\end{aligned}$$

Using the implicit function theorem and the Cramer Rule, I can derive that

$$\frac{dn^i}{dw^i}=-\frac{det\begin{pmatrix}\frac{\partial F_1}{\partial n^1} & \cdots & \frac{\partial F_1}{\partial w^i} & \cdots & \frac{\partial F_1}{\partial \lambda}\\ \vdots & & \ddots & & \vdots\\ \frac{\partial F_{I+1}}{\partial n^1} & \dots & \frac{\partial F_{I+1}}{\partial w^i} & \dots & \frac{\partial F_{I+1}}{\partial \lambda}\end{pmatrix}}{det\begin{pmatrix}\frac{\partial F_1}{\partial n^1} & \cdots & \frac{\partial F_1}{\partial n^i} & \cdots & \frac{\partial F_1}{\partial \lambda}\\ \vdots & & \ddots & & \vdots\\ \frac{\partial F_{I+1}}{\partial n^1} & \dots & \frac{\partial F_{I+1}}{\partial n^i} & \dots & \frac{\partial F_{I+1}}{\partial \lambda}\end{pmatrix}}$$

At the same time,

$$\begin{aligned}
\frac{\partial F_i}{\partial n^i} &= \rho^i[u_{cc}\cdot(f_n)\cdot\frac{dC_2^i}{dn^i}+u_c\cdot(f_{nn}+f_{nl}\cdot\frac{dl_2^i}{dn^i})]\\
by Envelope Theorem &= \rho^i[u_{cc}\cdot(f_n)^2+u_c\cdot(f_{nn}+f_{nl}\cdot\frac{dl_2^i}{dn^i})]\\
by(2) &= \rho^i[u_{cc}\cdot(f_n)^2+u_c\cdot(f_{nn}-f_{nl}\cdot\frac{f_{ln}}{f_{ll}})]<0 \qquad (16)
\end{aligned}$$

The inequality follows from the assumption that $u_c>0$, $u_{cc}<0$, $f_n>0$, and the concavity of f , which implies $f_{nn}-f_{nl}\cdot\frac{f_{ln}}{f_{ll}}\leq 0$.

$$\begin{aligned}
\frac{\partial F_i}{\partial w^i} &= \rho^i[u_{cc}(1-l_2^i)+u_c\cdot f_{nl}\cdot\frac{dl_2^i}{dw^i}]]\\
by(1) &= \rho^i[u_{cc}(1-l_2^i)+u_c\cdot f_{nl}\cdot\frac{1}{f_{ll}}]<0 \qquad (17)
\end{aligned}$$

This inequality follows from the assumption that $u_c>0$, $u_{cc}<0$, $f_{nl}>0$, and $f_{ll}<0$.

$$\frac{\partial F_i}{\partial \rho^i} = u_c(w^i,n^i)\cdot f_n(l_2^i,n^i)>0. \qquad (18)$$

Therefore, with $(-)$ indicating a negative number and (+) indicating a positive number, I derive that

$$\frac{dn^i}{dw^i} = -\frac{det\begin{pmatrix} (-) & 0 & ... & 0 & ... & 0 & -1 \\ 0 & (-) & ... & 0 & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & ... & (-) & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & (-) & -1 \\ -p^1 & -p^2 & \dots & 0 & \dots & -p^I & 0 \end{pmatrix}}{det\begin{pmatrix} (-) & 0 & ... & 0 & ... & 0 & -1 \\ 0 & (-) & ... & 0 & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & ... & (-) & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & (-) & -1 \\ -p^1 & -p^2 & \dots & -p^i & \dots & -p^I & 0 \end{pmatrix}} < 0 \forall i \tag{19}$$

for any I$\geq$ 2. Similarly, I can derive that for any I$\geq$ 2

$$\frac{dn^i}{d\rho^i} = -\frac{det\begin{pmatrix} (-) & 0 & ... & 0 & ... & 0 & -1 \\ 0 & (-) & ... & 0 & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & ... & (+) & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & (-) & -1 \\ -p^1 & -p^2 & \dots & 0 & \dots & -p^I & 0 \end{pmatrix}}{det\begin{pmatrix} (-) & 0 & ... & 0 & ... & 0 & -1 \\ 0 & (-) & ... & 0 & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & ... & (-) & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & (-) & -1 \\ -p^1 & -p^2 & \dots & -p^i & \dots & -p^I & 0 \end{pmatrix}} > 0 \forall i. \tag{20}$$

I also use the same method to derive that $\frac{dn^i}{dw^j} > 0 \ \forall i \neq j$, and $\frac{dn^i}{d\rho^j} > 0 \forall i \neq j$, and

$$
\begin{aligned}
\frac{d(n^i p^i)}{dp^i} &= n^i + p^i \cdot \frac{dn^i}{dp^i} \\
&= n^i - p^i \cdot \frac{det\begin{pmatrix} \frac{\partial F_1}{\partial n^1} & 0 & ... & 0 & ... & 0 & -1 \\ 0 & \frac{\partial F_2}{\partial n^2} & ... & 0 & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & ... & 0 & ... & \frac{\partial F_I}{\partial n^I} & ... -1 \\ -p^1 & -p^2 & \dots & n^i & \dots & -p^I & 0 \end{pmatrix}}{det\begin{pmatrix} \frac{\partial F_1}{\partial n^1} & 0 & ... & 0 & ... & 0 & -1 \\ 0 & \frac{\partial F_2}{\partial n^2} & ... & 0 & ... & 0 & -1 \\ \vdots & \vdots & & \ddots & & \vdots & \vdots \\ 0 & 0 & ... & 0 & ... & \frac{\partial F_I}{\partial n^I} & ... -1 \\ -p^1 & -p^2 & \dots & -p^i & \dots & -p^I & 0 \end{pmatrix}} \\
&= n^i - \frac{p^i n^i}{(p^1 \cdot \frac{\frac{\partial F_i}{\partial n^i}}{\frac{\partial F_1}{\partial n^1}} + p^2 \cdot \frac{\frac{\partial F_i}{\partial n^i}}{\frac{\partial F_2}{\partial n^2}} + \dots + p^i + \dots + p^I \cdot \frac{\frac{\partial F_i}{\partial n^i}}{\frac{\partial F_I}{\partial n^I}})} > 0 \ \forall i.
\end{aligned}
$$

In summary, $\forall i = 1, 2, \dots, I$,

$$
\begin{aligned}
\frac{dn^i}{dw^i} &< 0, && (21) \\
\frac{dn^i}{d\rho^i} &> 0, && (22) \\
\frac{dn^i}{dw^j} &> 0 \ \forall j \neq i, && (23) \\
\frac{dn^i}{d\rho^j} &< 0 \ \forall j \neq i, && (24) \\
\frac{d(n^i p^i)}{dp^i} &= n^i + p^i \cdot \frac{dn^i}{dp^i} > 0. && (25)
\end{aligned}
$$

E.2 Proof of Proposition 2

Household i solves the following problem:

$$\max_l V^i = u[(1-l)w^i + f(l, n_1^i)] + \beta \cdot E_{w^{-i}}[u(C_2^i(w^i, g^i(l, l_1^{-i}))],$$

$$
\begin{aligned}
\frac{\partial V^i}{\partial l} &= u_c(C_1^i)\cdot(-w^i+f_l(l,n_1^i))+\beta\cdot E_{w^{-i}}[u_c(C_2^i)\cdot f_n\cdot\frac{dg^i(l,l_1^{-i})}{dl}] \\
\frac{\partial^2 V^i}{\partial l^2} &= u_{cc}(C_1^i)\cdot(-w^i+f_l(l,n_1^i))^2+u_c(C_1^i)\cdot f_{ll}(l,n_1^i)+ \\
&\quad \beta\cdot E_{w^{-i}}[(u_{cc}(C_2^i)\cdot(f_n)^2+u_c(C_2^i)\cdot f_{nn})\cdot\frac{dg^i}{dl_1^i}+u_c(C_2^i)\cdot f_n\cdot\frac{d^2g^i}{(dl)^2}]
\end{aligned}
$$

To ensure that the households are incentive compatible, the social planner needs to set $g(\cdot)$ and $l_1^i(w^i)$ such that $\frac{\partial V^i}{\partial l}=0$ and $\frac{\partial^2 V^i}{\partial l^2}<0$ at $l_1^i(w^i)$ for all possible w^i when $l_1^i(w^i)\neq 1$. Therefore, I have

$$
\begin{aligned}
F(l_1^i(w^i);w^i) &= u_c(C_1^i)\cdot(-w^i+f_l(l_1^i(w^i),n_1^i))+\beta\cdot E_{w^{-i}}[u_c(C_2^i)\cdot f_n\cdot\frac{dg^i(l_1^i(w^i),l_1^{-i})}{dl_1^i}]=0 \qquad (26)\\
\partial F/\partial l_1^i(w^i) &= u_{cc}(C_1^i)\cdot(-w^i+f_l(l_1^i(w^i),n_1^i))^2+u_c(C_1^i)\cdot f_{ll}(l_1^i(w^i),n_1^i)+ \\
&\quad \beta\cdot E_{w^{-i}}[(u_{cc}(C_2^i)\cdot(f_n)^2+u_c(C_2^i)\cdot f_{nn})\cdot\frac{dg^i}{dl_1^i}\,|_{l_1^i(w^i)}+u_c(C_2^i)\cdot f_n\cdot\frac{d^2g^i}{(dl_1^i)^2}\,|_{l_1^i(w^i)}] \\
&< 0 \qquad (27)
\end{aligned}
$$

Using the implicit function theorem, I derive that

$$
\begin{aligned}
\frac{dl_1^i(w^i)}{dw^i} &= -\frac{\partial F/\partial w^i}{\partial F/\partial l_1^i} \\
&= -\frac{-u_c+u_{cc}(-w^i+f_l)(1-l_1^i)+\beta\cdot E_{w^{-i}}[(u_{cc}\cdot(1-l_2^i)\cdot f_n+u_c\cdot f_{nl}\cdot\frac{dl_2^i}{dw^i})\cdot\frac{dg^i}{dl_1^i}]}{\partial F/\partial l_1^i} \\
by(1) &= -\frac{u_{cc}\cdot f_l\cdot(1-l_1^i)-[u_c+u_{cc}\cdot w^i\cdot(1-l_1^i)]+\beta\cdot E_{w^{-i}}[(u_{cc}\cdot(1-l_2^i)\cdot f_n+u_c\cdot\frac{f_{nl}}{f_{ll}})\cdot\frac{dg^i}{dl_1^i}]}{\partial F/\partial l_1^i} \\
&\leq -\frac{u_{cc}\cdot f_l\cdot(1-l_1^i)+\beta\cdot E_{w^{-i}}[(u_{cc}\cdot(1-l_2^i)\cdot f_n+u_c\cdot\frac{f_{nl}}{f_{ll}})\cdot\frac{dg^i}{dl_1^i}]}{\partial F/\partial l_1^i}<0.
\end{aligned}
$$

The second last inequality follows from the assumption that $-\frac{u_{cc}}{u_c}\leq\frac{1}{C}$. The last inequality follows from inequality (27), $\frac{dg^i(l_1^i,l_1^{-i})}{dl_1^i}\geq 0$ and the assumptions that $u_c>0$, $u_{cc}<0$, $f_l>0$, $f_n>0$, $f_{nl}>0$, $f_{ll}<0$, and $l_1^i\neq 1$. Therefore, when $\frac{dg^i(l_1^i,l_1^{-i})}{dl_1^i}\geq 0$, if it is incentive compatible for i to choose l_1^i when i is of type w^i for some $l_1^i\neq 1$, then a higher wage type must always prefer a lower $l_1^i$and a lower wage type must always prefer a higher l_1^i. Therefore, if in equilibrium it is optimal for some wage types to choose $l_1^i = 1$, these must be types that have lower off-farm wage than any type whose optimal labor allocation is lower than 1. Thus, l_1^i monotonically decreases with w^i. $\frac{dl_1^i(w^i)}{dw^i} < 0$ when $l_1^i \neq 1$ implies that $l_1^i(w^i)$ strictly decreases with w^i when $l_1^i \neq 1$.

Similarly, I can derive from the implicit function theorem that, when $l_1^i \neq 1$,

$$\begin{aligned}\frac{dl_1^i}{dn_1^i} &= -\frac{\partial F/\partial n_1^i}{\partial F/\partial l_1^i} \\ &= -\frac{u_c \cdot f_{ln}(l_1^i, n_1^i) + u_{cc} \cdot f_n \cdot (-w^i + f_l(l_1^i(w^i), n_1^i))}{\partial F/\partial l_1^i} > 0.\end{aligned}$$

Here, the inequality follows because $-w^i + f_l(l_1^i(w^i), n_1^i \leq 0$ when $\frac{dg^i(l_1^i(w^i), l_1^{-i})}{dl_1^i} \geq 0$ everywhere.