EARTHBOUND LABOR AND INCOMPLETE EXIT FROM FARMING IN CHINA:

MULTIPLE RESTRICTIONS AND NONSEPARABLE DECISIONS

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ABSTRACT

Smallholder farming remains the predominant production mode in China, despite massive outflow of rural labor. Policy restrictions on farmland and rural labor have been found to impede land consolidation by constraining land transfers and by inhibiting agricultural households from exiting completely from farming. However, complex policy effects on resource allocation are not fully understood. A large number of smallholders are observed to exit seasonally or partially from farming all the contract land to which they hold use rights. I develop a theory to explain the persistence of smallholder farms based upon the tendency of agricultural households to exit from farming incompletely. The theory highlights the interdependence of policy restrictions faced by Chinese farmers and the value of contract land as a safety net and an appreciable asset. It is the first to model the non-productive value of land to be simultaneously determined by the cultivation size and farm labor input. Using the data that I collected from 512 households in Southwest China, I estimate the effects of tenure security, land and labor endowments, land-based subsidies, and local wage rates on exits and resource decisions of smallholders. I also provide evidence of a wedge between the on-farm marginal productivity and the market nonfarm wage rate of part-time farm labor.

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I. INTRODUCTION

The persistence of smallholder farming has been an intensively discussed feature of China's transforming agricultural sector. Millions of agricultural households cultivate small and fragmented fields to which they hold use-rights contracts. Smallholder farming has been shown to be associated with insufficient land-attached investment (Jacoby, Li, and Rozelle, 2002) and inefficient use of land and labor (Hare, 1999; Jin and Deininger, 2009). To mitigate the efficiency loss, the Chinese government has launched a series of policy reforms since 2003, strengthening tenure security and supporting rural households to resettle in urban areas, with the goal of consolidating farmland.

Nevertheless, limited evidence has been found for systematic land consolidation in most Chinese provinces. From 1986 to 2013, the percentage of Chinese population living in rural areas quickly went down from 75% to 46%, while the average farm size increased only from 0.61 to 0.62 ha (Tan, Heerink, and Qu, 2006; Ji et al., 2016). By 2015, over 85% of farms were of sizes less than 0.67 ha (Development Research Center of the State Council, 2016).

To consolidate farmland in China, contract land needs to be released from numerous agricultural households and reallocated to a relatively small number of commercial farms. Households can release land either by exiting completely from farming (i.e., returning land to village collectives) or by transferring land out. Unfortunately, both options have been impeded by restrictive policies. First, exit from farming is difficult and costly mainly due to China's dualistic residential restrictions (Ji et al., 2010; Wen, 2014). Rarely do agricultural households end their land contracts and permanently leave the villages. Second, transferring out land is risky and costly largely because of imperfect land tenure (Kimura et al., 2011; Deininger et al., 2015). Agricultural households are relatively inactive in land markets, limiting the reallocation of farmland.

However, to date understanding of the effects of policy restricitons is incomplete. Prior research predominantly studies whether agricultural households participate in land markets and how large is the physical area transferred year by year (Jin and Deininger, 2009). Whereas the physical area of fields is rather inflexible over time, the cultivated area varies frequently (Cheung, 1969). Overlooking land fragmentation and cropping seasonality, researchers have not fully accounted for partial and seasonal arrangements, including abandonment, of farmland. Focusing on the binary choice of exiting permanently from or staying in farming (Yang, 1997; Tao and Xu, 2007), researchers have largely ignored various forms of incomplete farm exit. In fact, temporary and partial exit has been widely observed in China for as long as rural labor has flowed between farm and nonfarm sectors (Ran and Yang, 1985; Zhang, Li, and Song, 2014).

This paper explains how the consolidation of farmland in China has been impeded by interdependent policy restrictions, through the lens of incomplete farm exit. I address three questions in sequence: 1) how smallholders exit from farming in incomplete ways, 2) why incomplete exit tends to be optimal for agricultural households, and 3) what the efficiency effects of policy restrictions are.

I collected data from 512 households in Southwest China. The survey data reveal that a large number of households reduce cultivation sizes seasonally and partially from the entire arable areas under their land contracts. A complex continuum of incomplete exit exists between no exit and complete exit. In the sample, 68% of households rearrange their contract land by transferring or abandoning some phots. Less than 6% of households completely exit from farming in a year, but more than 46% exit in various incomplete ways.

I develop a theory to explain the inclination of agricultural households to exit incompletely from farming, highlighting the interdependence of policy restrictions faced by Chinese farmers.

Under multiple risks and restrictions, the value of contract land as a safety net and an appreciable asset is a function of the simultaneously determined cultivation size and farm labor input. The non-productive value of land is use-based, which is the crux as to why incomplete exit from farming is likely to be optimal for the households.

Additional flexibility in resource use helps households maximize income, but not eliminate inefficiency caused by policy restrictions. Inefficient resource allocation is evidenced by unequal marginal productivities of farmland and of farm labor across households and by wedges between marginal productivities and market prices of the two factors. Tenure security, land and labor endowments, land-based subsidies, and local wages are found to be central determinants of exit decisions. Effects of the determinants are estimated using the survey data. The relationship between land and labor decisions is studied using a constructed instrumental variable.

This paper contributes to the literature in three ways. First, it provides the first rigorous examination of complex land use and farm exit in today's China. Second, it develops a theory of incomplete exit from farming to characterize the distorted resource allocation under interdependent policy restrictions and multiple risks. I improve upon prior models by allowing a simultaneous allocation of land and labor to determine the non-productive value of contract land. Third, it finds systematic empirical evidence of resource-allocation effects of policy restrictions on smallholder farms in China.

Beyond the context of China, the research links to the active literature on imperfect property rights and economic development (Besley and Ghatak, 2010). Particularly, my investigation of used-based land rights speaks to studies on adjusting resource allocation to protect insecure property rights (Basu, 1986; Barzel, 1989; Field, 2007; de Janvry et al., 2015). I have brought new modeling techniques and empirical evidence to the discussion.

The next section reviews prior research on the inefficient allocation of resources by agricultural households in China. Limitations of existing models are highlighted. I derive the theory of incomplete exit from farming in the third section. Empirical evidence is provided in the fourth section, before I close the paper with a brief discussion on the general relevance and external validity of the findings.

II. Factor Decisions of Agricultural Households in China

The predominance of smallholder farming in China has been considered as a signal of inefficient allocation of land and labor at the household level. To explain the inefficiency, policy restrictions on farmland and rural labor have been emphasized.

Chinese agricultural households hold use-rights contracts of farmland which are thirty-year long. Selling contract land is forbidden, though renting is allowed. Reallocation of land was a major threat to tenure security in early years (Liu, Carter and Yao, 1998; Kung, 2002; Kung and Bai, 2011), while expropriation has become a top concern recently (Kimura et al., 2011). The Household Registration or *hukou* System segregates urban and rural residents in their rights to welfare benefits. The *hukou* restrictions impose substantial costs on rural laborers who work and live in cities (Chan and Zhang, 1999). Migrant-workers have limited access to unemployment insurance, retirement pensions, health benefits, and housing resources in urban areas (Xiong, 2015).

Extensive discussion has been made on the relationships between policy restrictions and the use of land and labor by agricultural households. Researchers agree that the allocation of land and labor is distorted, but employ different analytical approaches to study the efficiency effects of multiple restrictions on multiple factors.

Most research studies how restrictions imposed on land or labor affect the use of either factor. For example, some researchers conclude that insecure tenure increases costs of land transfers and decreases the efficiency of land or labor allocation (Liu, Carter and Yao, 1998; Carter and Yao, 2002; Deininger and Jin, 2005; Deininger and Jin, 2009; Kimura et al., 2011). Some others argue that insecure land tenure (Rozelle et al., 1999; Mullan, Grosjean, and Kontoleon, 2011), or the *hukou* system (Chan, 2010), inhibits sectoral reallocation of labor, especially in the form of migration. A researcher can also link restrictions on one factor with the use of both, or link restrictions on both factors with the use of one. One strand of literature finds that insecure land tenure deters migration and also leaves land rental markets inactive (Deininger et al., 2015). Hare (1999) and Yang and Zhou (1999) show that restrictions on land and labor jointly cause temporary migration and wide wedges between on-farm and off-farm productivities of labor.

The most comprehensive, yet least-taken, approach considers restrictions on and the use of both factors, emphasizing the interdependence of elements (Tao and Xu, 2007; Wen, 2014). Policy restrictions not only add transaction costs to resource allocation, but also create considerable non-productive value in contract land. Limited social insurance that farmer-workers enjoy in case of layoff and retirement create substantial value of farmland as a safety net. Compensation after land expropriation, which partly depends on the recent farm production values (Ding, 2007), makes farmland an appreciable asset.

Most prior studies provide empirical evidence and conceptual models. Among a few papers with rigorous modeling, restrictions on land transfers and insecurity of tenure are treated as part of transaction costs in land markets (Jin and Deininger, 2009). Households allocate land and labor faced with varying transaction costs over time and space. The variation in transaction costs due to heterogeneous implementation of land policies is used to estimate effects of land restrictions.[1] Such models do not incorporate the non-productive value of contract farmland.

[1] This econometric approach finds its root in studies by Besley (1995) and Banerjee, Gertler, and Ghatak (2002).

Yang (1997) models the non-productive value as potential rentals or sales generated by transferring land rights, when an agricultural household permanently exits from farming (i.e. migrates). However, the household could either hold the contract or return the land to the village collective before 2003. The non-productive value would thus be forgone upon an exit. Yang argues that the loss of non-productive value adds a one-time cost to permanent exit and discourages long-term migration. In his model, the cultivation size either equals zero or the entire contract size, and the non-productive value is independent from current farming activities.

In the context of urban Peru, Field (2007) provides a classic model of endogenous non-productive value of a property. A household allocates labor to protect its living space from the government's eviction. The risk of eviction is set as a function of guard labor. Field only has to worry about using household labor to protect the property, because the living space is not a production input for an urban household. Being a production input complicates the non-productive value of farmland for an agricultural household.

III. A THEORY OF INCOMPLETE EXIT FROM FARMING

The purpose of this model is to derive a theory of incomplete exit from farming with which to examine the nature of land and labor allocation by agricultural households under interrelated policy restrictions and specific agro-ecological conditions in China. The model improves prior analysis by characterizing the non-productive value of contract land as a function of simultaneously decided land and labor inputs. The model further considers the division of labor within a household, so that an individual's ceasing cultivation is distinguished from a household's exiting from farming.

A household maximizes the expected income over two periods. It decides how much land to cultivate and how to allocate labor endowment in farm and nonfarm sectors. Assume that decisions in one period have no persistent effects, which allows modeling household decisions as a sequence of income-maximizing problems in independent two-period windows (Carter and Yao, 2002). The two periods refer to two consecutive cropping years in this context. Each year contains two cropping seasons.

A household has contract land of a physical size equal to $\bar{s}$ and the potential arable size over two seasons is $2\bar{s}$. The amount of land cultivated during a year, s, is the summation of cultivation sizes in two seasons, s_1 and s_2, respectively. I assume away from the land market for now, so that abandoning land is the only alternative if any contract land is not cultivated by a household. I do not incorporate the market of farm labor, both because hiring farm labor is uncommon in China (Wang et al., 2016; in my dataset), and because the assumption simplifies my model without changing the core insights. In fact, allowing for hiring labor or for renting land is mathematically equivalent as long as only one market is missing (Eswaran and Kotwal, 1986). The effects of land markets are discussed latter in this section.

A minimum amount of labor input is required for generating a positive farm output. The minimum amount increases in the cultivation size, because more labor is needed as a fixed set-up cost under fixed technologies of A. I assume that the farm output function, $F(s, l^f|A)$, depends only on the input of land (s) and labor (l^f). The price of the agricultural output is normalized to one. The farm income function is expressed below.

$$\begin{cases} F(s, l^f|A) = 0, if\ l^f < l_{min}(s) \\ F(s, l^f|A\ ) > 0, if\ l^f \geq l_{min}(s) \end{cases}$$

Requiring a minimum labor input allows maximizing the income by allocating all the labor off-farm, even when $\frac{\partial F(s,l^f|A)}{\partial l^f}|_{l^f=0}$ is infinitely large. To guarantee the second-order conditions under the Kuhn-Tucker Theorem, I require $F(s, l^f|A)$ to be twice differentiable and strictly concave in s and l^f as long as $l^f \geq l_{min}(s)$. Labor and land are complements in farm production.

In my sample, over 90% of the households have at least two adult laborers. To consider intra-household division of labor, I classify labor into two types for households with multiple and heterogeneous laborers. Laborers with a comparative advantage in nonfarm sectors are the *H-type*, while the rest are the *L-type*. For each unit of farming income forgone, an H-type laborer earns relatively more off-farm. An H-type laborer earns an off-farm wage of w_H, while an L-type laborer earns w_L. In each season, a household is endowed with $\bar{l} - \overline{l_L}$ and $\overline{l_L}$ units of H-type and L-type labor, respectively.

To better characterize the tradeoffs faced by smallholder farmers, I do not set a fixed nonfarm wage rate to all laborers as classic household models do. Instead, I set the wage rate as a function of a laborer's time spent in farming. It does not mean that any individual could influence market wage rates; and it merely reflects an effect of self-selection. Farming requires discontinuous use of labor over a long period of time. If one spends less time on the farm, his/her supply of off-farm labor can be more continuous (i.e., working for more days in a row) and/or more intensive (i.e., working for more hours in a day). More continuous and intensive supply of labor allows one to enter job categories with relatively high wages, given his/her human capital. If one does not have to travel back to the field, he/she can have a larger scope of job-seeking by migrating. Migration is especially rewarding if the local nonfarm economy is underdeveloped.

Let the subscript $k \in \{H, L\}$ stand for the two types of labor. A laborer's human capital, M_k, is predetermined. I can express the wage rate as $w_k\left(l_K^f | M_k\right)$ and require that $\frac{\partial w_k\left(l_K^f | M_k\right)}{\partial l_K^f} < 0$. This specification of wage rates relates to an important efficiency effect of policy restrictions and is supported by empirical evidence presented in the next section.

Assume that a household faces three risks, namely, a risk of layoff, of land reallocation, and of land expropriation. One or more risks may be realized by the end of period one.

Consequently, different states emerge in the second period. Each state corresponds to an endowment of land and the compensation received after land expropriation. Both depend on the use of land and labor in period one.

In each period, the income consists of farm and nonfarm earnings. The expected income over two periods can be expressed as

$$\pi + D\sum_i p_i \ddot{\pi}_i,$$

where π is the first period income and $\ddot{\pi}_i$ is the second period income in state i. The parameter $p_i \in [0,1)$ refers to the probability of state i and $D \in (0,1)$ is the time discount factor.

The marginal return to cultivating the contract land in period one consists two parts: the increment of farm income and that of expected value of land as a safety net and an appreciable asset. Similarly, the marginal return to farm labor includes the gain from farming plus the increase of expected compensation under expropriation. On the margin of allocating farmland or labor, therefore, a household balances both between farm and nonfarm earnings within the first period and between production and non-productive earnings across periods.

As shown in Appendix I, solving for the optimal allocation of resources by maximizing the expected income over two periods is mathematically equivalent to maximizing the first-period income plus the expected non-productive value. The expected non-productive value of contract land is a function of first period farming activities. It is denoted by $V\left(s, l^f | \bar{l}, \bar{s}\right)$ where risk parameters, land-based subsidy rate, and D are also incorporated.[1]

A household would only leave the L-type labor on the farm if it is marginally beneficial to cultivate. The question of whether a household completely exits from farming translates to

[1] Land-based subsidies to a household refer to subsidies based on the size of contract land. The subsidies are direct cash transfers from the government to contract holding households, aiming to encourage the protection of farmland, the production of grains, and the use of high-quality agricultural inputs.

whether the L-type labor does so. This transformation makes economic sense, especially because of the small amount of contract land each household is entitled to. One or two L-type laborers can utilize the contract land to the fullest. Therefore, a household maximizes the income by allocating land and the L-type labor until the use of H-type labor is affected at corner solutions.

I can express the objective function in (1) where the H-type's earnings of $2w_H(0)(\bar{l} - \overline{l_L})$ is left out. Parameters and the subscript for a household is not written out. All the four choice variables are nonnegative. The yearly amount of farm labor is l_L^f for the L-type labor. The Lagrange multipliers are μ_j, ν_j and θ_j for the three sets of constraints, respectively. No labor is idle under the strictly increasing objective function.

$$\max_{\{s_j, l_L^{fj}\}} E(\Pi) = \sum_j w_L(l_L^{fj})(\overline{l_L} - l_L^{fj}) + \sum_j F(s_j, l_L^{fj}) + V(s, l_L^f) \quad (1)$$

Subject to,

$l_L^{fj} \leq \overline{l_L}, j \in \{1,2\};$

$s_j \leq \bar{s}, j \in \{1,2\};$

$l_L^{fj} \geq l_{min}(s_j), j \in \{1,2\}.$

III.A. Exit Decisions and Inefficient Resource Allocation

With no land market, three exit options are available in a year. A household can choose to 1) fully cultivate its contract land (i.e., no exit or $s_1 = \bar{s}, s_2 = \bar{s}$), 2) cultivate no land (i.e., complete exit or $s_1 = s_2 = 0$), or 3) cultivate part of the contract land and/or cultivate in only one season over a year (i.e., incomplete exit or $0 < s_1 < \bar{s}$ or $0 < s_2 < \bar{s}$).

The non-productive value of contract land would be zero if no risk or restriction existed, because land would not function as a safety net under layoff or as an appreciable asset under expropriation. Among households that would have exited completely if $V(s, l_L^f)$ did not exist or

$V(s, l_L^f)$ did not depend on land and labor used in farming, the positive and use-based non-productive value may incentivize some of them to farm by increasing the marginal return to self-cultivation. The non-productive value is determined on risks, subsidies, and land and labor endowments of a household. The larger $V(s, l_L^f)$ or the larger the marginal increase of $V(s, l_L^f)$ in the cultivation size, the more likely that a household draws back from exiting completely. For households that would have exited incompletely under no risk nor restriction, their cultivation sizes increase as $V(s, l_L^f)$ becomes positive and endogenous.

As long as the optimal cultivation size is positive and smaller than $2\bar{s}$, a household maximizes its income by exiting incompletely, or by abandoning some land, in exchange for off-farm earnings. Compared to no exit and complete exit, incomplete exit allows for more flexibility in the allocation of resources. Incomplete exit tends to be optimal for agricultural households, because it helps maximize the income under restrictions and risks.

At corner solutions of $l_L^{fj} = \overline{l_L}$ or $s_j = \bar{s}$, the H-type labor may return to the field. Therefore, shocks that change the non-productive value of land and consequently optimal s_j and l_L^{fj} also determine whether the H-type labor works full-time in nonfarm sectors. For example, when the risk of expropriation increases due to a new real estate project near the village, the increased $V(s, l_L^f)$ may lead to corner solutions and draw H-type migrant-workers back to the farm. As $V(s, l_L^f)$ varies, the H-type labor may migrate and return accordingly. It speaks to temporary migration which has been widely observed in China (Mullan, Grosjean, and Kontoleon, 2011).

The first-order-necessary-conditions (FOCs) of cultivated farmland and farm labor in season j are specified as follows.

$$\frac{\partial \pi}{\partial s_j} = \frac{\partial F\left(s_j, l_L^{fj}\right)}{\partial s_j} + \frac{\partial V\left(s, l_L^f\right)}{\partial s_j} - v_j = 0;$$

$$\frac{\partial \pi}{\partial l_L^{fj}} = \frac{\partial F\left(s_j, l_L^{fj}\right)}{\partial l_L^{fj}} - w_L\left(l_L^{fj}\right) + \frac{\partial w_L\left(l_L^{fj}\right)}{\partial l_L^{fj}}\left(\overline{l_L} - l_L^{fj}\right) + \frac{\partial V\left(s, l_L^{f}\right)}{\partial l_L^{fj}} - \mu_j + \theta_j = 0.$$

If the non-productive value does not exist, marginal productivities of factors are equal across households and the efficient allocation of resources is guaranteed. But if the non-productive value is endogenously determined, marginal productivities of factors become household-specific and inefficiency in resource allocation emerges.

According to the FOCs, a household equalizes the marginal farm income, plus the marginal non-productive value, with the market price of land. As long as $\frac{\partial V\left(s, l_L^{f}\right)}{\partial s_j}$ is positive, the marginal productivity of cultivated land would be lower than the corresponding shadow market value. For households that exit incompletely, the on-farm marginal productivity of cultivated land drops below zero, indicating a tendency of overusing farmland. The on-farm marginal productivity of farm labor is lower than its nonfarm wage rate. Standard household models find marginal productivities of full-time farmers to be lower than market wage rates (Jacoby, 1993; Skoufias, 1994), while I find a wedge also existing between the on-farm marginal productivity of part-time farm labor and the nonfarm wage rate.

Hypothesis 1*: On-farm marginal productivities of full-time and part-time farmers are lower than market nonfarm wage rates*.

Considering land transfers, a key point is that land transferred-in adds no non-productive value to the lessee-household. Specify a function of $I\left(s_j\right)$ which equals s_j if $\bar{s} \geq s_j$ and $\bar{s}$ if $\bar{s} < s_j$. Denote the unit land rental for one season by $R(q)$ where q stands for the quality of contract land (e.g., sizes and locations of the plots) or that of plots rented in. Credit constraints are not considered. The derivation of (2) is found in Appendix I.

$$\max_{\{s_j, l_L^{fj}\}} E(\Pi) = \sum_j w_L(l_L^{fj})(\overline{l_L} - l_L^{fj}) + \sum_j F(s_j, l_L^{fj}) + R(2\bar{s} - s) + V\left(\sum_j I(s_j), l_L^f\right) \quad (2)$$

Subject to,

$l_L^{fj} \leq \overline{l_L}, j \in \{1,2\};$

$l_L^{fj} \geq l_{min}(s_j), j \in \{1,2\}.$

Intuitively, land rental compensates the loss of non-productive value of land, when land is not cultivated by a household. A household would hence be more willing to reduce the cultivation size and exit completely. For households that rent in land, the wedge between the marginal productivity and the market price of land disappears. For households renting out land or staying autarky, however, the wedge remains (see proof in Appendix I). The inefficiency in land allocation cannot be eliminated even with perfect land rental markets.

Hypothesis 2: *Land markets can encourage exit from farming, reduce, but not eliminate, the inefficiency in land use.*

III.B. Comparative Statics and Further Interpretation

Under the implicit function theorem, I have derived comparative statics for land and labor use with respect to all parameters in Appendix II. Economic implications of the comparative statics are summarized below. Changes that increase the non-productive value of land, or reduce opportunity wage rates or land rentals will induce a household to cultivate a larger area, put more labor into farming, and not exit completely from farming.

To be specific, lower risks on land contracts encourage a household to reduce the cultivation size and exit completely. A larger size of contract land and higher land-based subsidy rate imply higher non-productive value of land and discourage a household from exiting completely. Similarly, a household with more laborers enjoys a higher safety net value of land and is less likely to exit completely. Higher land rentals imply higher returns to renting out land, encouraging households to withdraw from self-cultivation. Higher human capital implies higher opportunity off-farm wages and encourages working more off-farm, especially for the L-type labor.

The effect of higher local wages consists of two parts. When local wages are higher, local labor tends to work more off-farm. In the meantime, the relative wage of migrant-workers goes down, so that a laborer does not have to give up farming to obtain high wages. Instead of having all its labor work for full-time in nonfarm sectors or migrate, leaving some labor to do part-time farming may become optimal for a household.

I also argue that a household with more generations is less like to exit completely, given the number of laborers. For example, a household with three generations tends to have senior members with a clear-cut comparative advantage in farming. The clearly-defined L-type labor can do full-time farming and expand the cultivation size, while the H-type labor focuses on off-farm jobs. For a household with one generation of relatively young labor, its laborers tend to high and similar nonfarm wage rates. They are more likely to exit completely together, given a non-productive value of land.

Hypothesis 3-1: *When the contract land is larger or more fragmented, tenure security is lower, local wages or land-based subsidies are higher, or endowed with more generations and laborers, a household increases the cultivation size and does not exit from farming completely.*

Hypothesis 3-2: *Household labor, especially the L-type, tends to farm for more days if the contract land is larger or more fragmented, tenure security is lower, land-based subsidies are higher, or endowed with less human capital. When the household has more generations, the L-type labor farms and the H-type labor works off-farm for more days.*

When the cultivation size increases marginally, the L-type labor should react first to increase farming days and reduce off-farm days.

Hypothesis 3-3: *Household labor, especially the L-type, tends to farm for more days and work off-farm for fewer days if the cultivation size of the household increases.*

As the individual-level use of labor changes, the number of laborers within each working status (i.e., full-time farming, part-time farming, and full-time nonfarm working) change accordingly at the household level. Note that if the endowment of labor increases, two effects occur. The number of full-time farmers increases, because the non-productive value of land increases. The number of full-time nonfarm workers also increases, because limited labor is needed to fully utilize the contract farmland and extra labor will be allocated to nonfarm sectors. The two hypotheses below are comparable to Hypotheses 3-2 and 3-3, respectively.

Hypothesis 4-1: *When the contract land is larger or more fragmented, tenure security is lower, local wages or land-based subsidies are higher, the number of full-time farmers in a household increases and that of full-time nonfarm workers decreases. The more generations and laborers that a household is endowed with, the more full-time farmers and nonfarm workers it has.*

Hypothesis 4-2: *When the cultivation size of the household increases, the number of full-time farmers tends to increase and that of part-time farmers falls, or the number of part-time farmers increases and that of full-time nonfarm workers falls.*

III.C. Graphic Exposition

We can visualize the solution of function (1) with a few simplifications. I leave out l^f from the non-productive value of land. I scale $V(s)$ at $s = 0$ to zero and abstract away from seasonality (i.e., land endowment is $\bar{s}$ and labor endowment is $\overline{l_L}$ in each period). The endogenous wage rate for the L-type labor is expressed as $w_L(s)$ where the cultivation size is a proxy for time devoted to farming. Each locally optimal labor input is found where the farm income curve is tangent to the line of wage earnings with a slope of $w_L(s)$. If using $w_L(l^f)$, the optimal use of labor is not found at a tangent point because of a gap, $\frac{\partial w_L}{\partial l_L^f}(\overline{l_L} - l_L^f)$, between the on-farm marginal productivity of farm labor and the nonfarm wage rate. Insights drawn from the graphs are independent from the simplification.

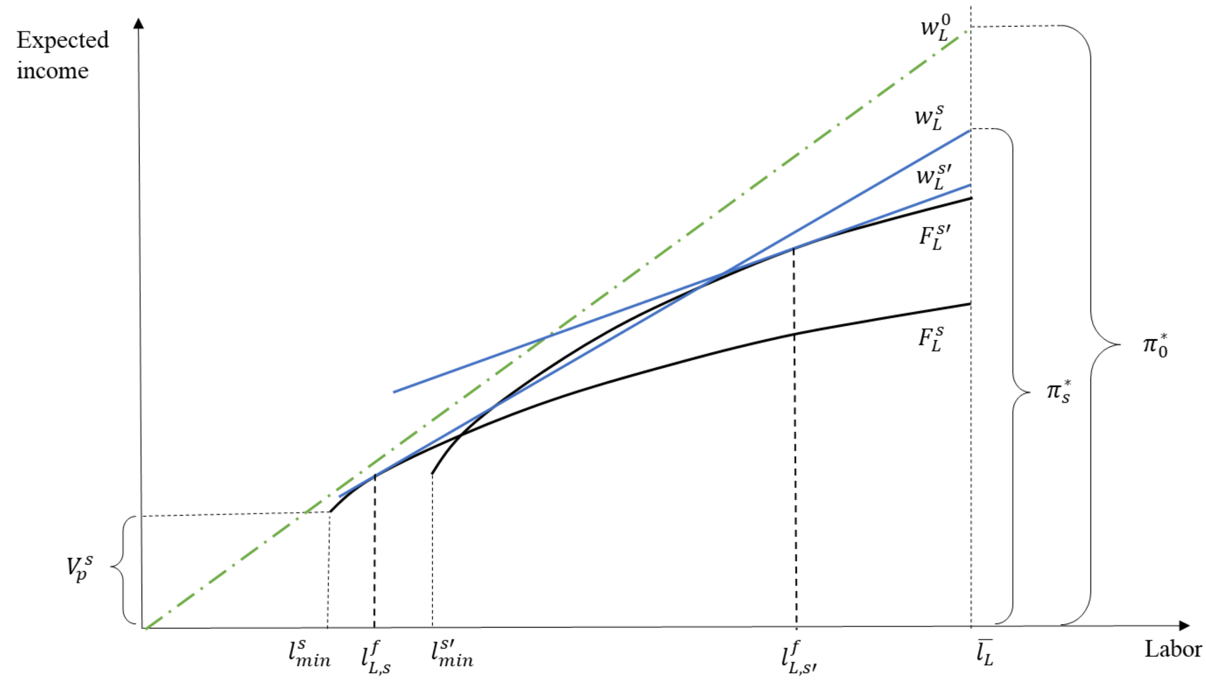

FIGURE I

The Determination of Exit of a Household

Note. The vertical axis measures the expected income earned by the L-type labor. The curves of farm income are solid in black. The curves of wage income are solid blue lines if the cultivation size is positive. The dotted green line represents wage income if a household exits completely. Set $\bar{s} \geq s' > s > 0$.

In Figure I, the vertical axis represents the expected income made by the L-type labor, while the horizontal axis represents the labor input. The L-type labor earns a full-time wage of w_L^0 and earns $w_L^s < w_L^0$ where $s > 0$. Let $s' > s > 0$. The slope of $w_L^{s'}$ line is lower than that of w_L^s. The non-productive value of land is represented by a jump at l_{min}^s on the farm income curve of F_L^s. The optimal farm labor input for s turns out to be $l_{L,s}^f$, generating a local optimum income of π_s^*. If the globally optimal cultivation size is positive but smaller than $\bar{s}$, incomplete exit is chosen instead of complete or no exit. If the optimal amount of farm labor is positive but smaller than $\overline{l_L}$, part-time farming is chosen. If the optimal l_L^f is even larger than $\overline{l_L}$, the H-type labor may switch back to farming. The globally optimal income is found by comparing π_0^* and all possible π_s^*. In Figure I, π_0^* turns out to be the largest income and the household would exit completely.

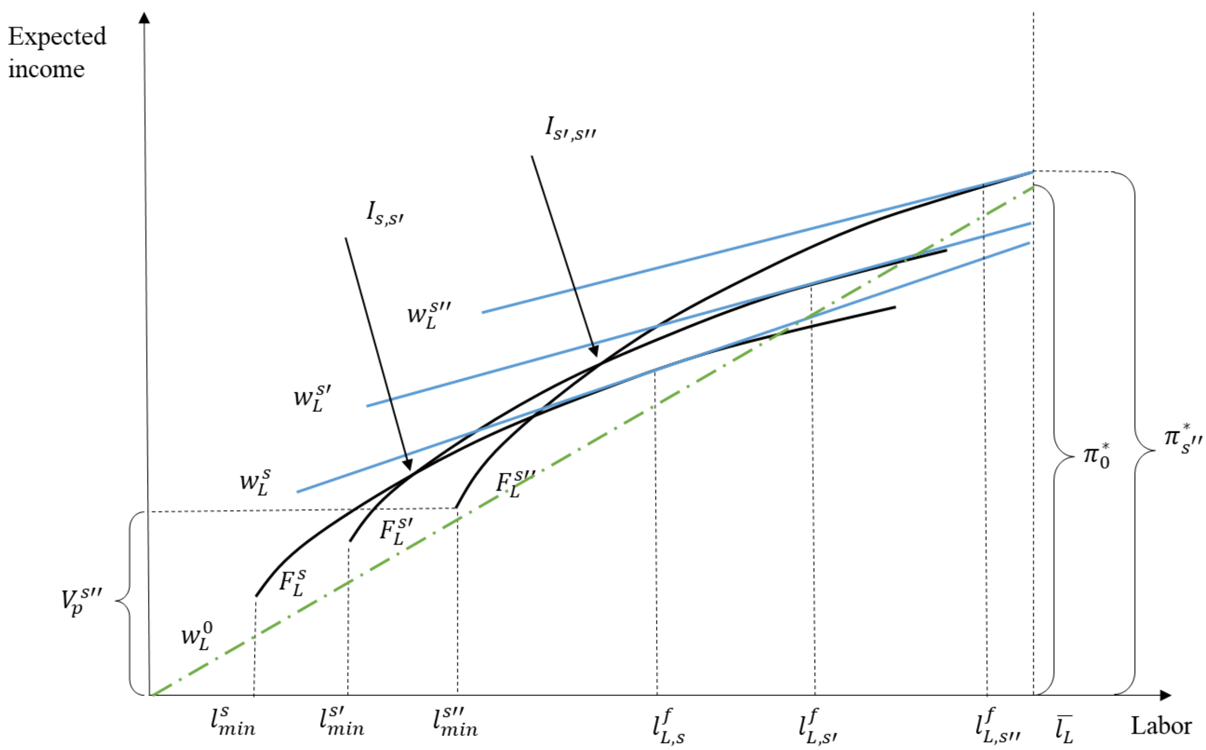

FIGURE II

The Occurrence of a Property Trap

Note. Notation follows Figure I. $I_{s,s'}$ and $I_{s',s''}$ are intersection points of two pairs of farm income curves. Set $\bar{s} \geq s'' > s' > s > 0$.

Let $s'' > s' > s$. Figure II describes an interesting effect, when the optimal farm labor input at s is to the right of the intersection point of two farm income curves (i.e., $I_{s,s'}$). Because $F_L^{s'}$ lies on the top of F_L^s at $l_{L,s}^f$, the household may increase the income by cultivating s' as long as the drop of wage rate is small. After switching to s', the new optimal farm labor becomes $l_{L,s'}^f$.

At $l^{f}_{L,s'}$, the household can be better-off by cultivating even more land as $F^{s''}_{L}$ lies on the top of $F^{s'}_{L}$. So on and so forth, it ends up cultivating $\bar{s}$ and pushes the productivity of farm labor to the lowest, while earning the largest expected income partly due to the large non-productive value of land.

Call the reinforcing process the *property trap* effect. It is effectively a chain effect that drags down the productivity of farm labor and pushes up that of land because of the use-based non-productive value of land. The effect is strengthened by an endogenous wage rate and the fragmentation of land. The more fragmented land is, the closer intersection points are, and more likely that the effect occurs.

Hypothesis 5: *Land fragmentation pushes a household closer to a property trap, implying relatively high intensity of farm labor and low on-farm marginal productivity of farm labor.*

I close this section by highlighting the interdependence among different efficiency effects of policy restrictions revealed by the theory. First, the effects are household-specific. Zero or multiple effects can strike a household. For example, a household that allocates labor inefficiently may use land efficiently if it rents land in. Second, efficiency effects are transformable among each other, so that mitigating one can aggravate another. For example, a reduction in subsidies on machinery might push households to exit completely (because the minimum farm labor input increases), but also slows down mechanization and increases land abandonment if land markets are not highly active. Such a dilemma suggests potential conflicts of agricultural policies in China.

IV. EMPIRICAL EVIDENCE

To test the hypotheses derived from the theory, I need information of seasonal and partial arrangements of farmland. In this section, I first explain how I can obtain the information using a unique survey design. Based on the survey data, I estimate the causal effects of tenure security, land and labor endowments, land-based subsidies and local nonfarm wages on farmland and labor decisions. Evidence of the inefficient use of labor is provided. In particular, I find empirical evidence of a wedge between the on-farm marginal productivity and the nonfarm wage rate of part-time farmers.

IV.A. Design of the Survey

Information of household cropping practice season by season is central to testing the theory of incomplete exit from farming. Previous household surveys conducted in China typically asked the interviewees how land was used over a year. Information collected from direct questions does not tend to capture informal or seasonal arrangements of land, both because of the ambiguity of questions and the unwillingness to report politically sensitive activities (e.g., abandonment of contract land is officially forbidden).

An indirect way of collecting information of land use centers upon crops grown in each season. Based on the knowledge of agricultural production in the sampled villages, I grouped crops into 11 categories. The categories include rice, wheat, barley, rapeseed, corn, soybeans and/or sweet potatoes, summer vegetables (e.g., cucumbers and eggplants), winter vegetables (e.g., garlic and radishes), annual herbs and fruits, perennial herbs and fruits, and, finally, trees and horticulture. Rice, corn, soybeans, sweet potatoes, and summer vegetables are grown during May to October. Wheat, barley, rapeseed, and winter vegetables are grown roughly from November to April. Other crops occupy the land all the year round. Interviewees reported how much land was used for each crop category and if there was intercropping. The information allows me to infer accurate cultivation size season by season.

For illustration, think of a household entitled to 10 *mu* of contract land or 20 *mu* of arable are in two seasons.[1] Suppose that the household grows 8 *mu* of rice, 1 *mu* of corn, 6 *mu* of wheat,

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[1] Six *mu* equals one acre and fifteen *mu* is one hector.

1 *mu* cabbage, and 1 *mu* of sunflowers. Sunflowers occupy the field for the whole year. I hence know that the household utilizes $8 + 1 + 1 = 10$ *mu* in summer, but $6 + 1 + 1 = 8$ *mu* in winter. The household does full cultivation in summer but not in winter. If the household does not report any seasonal land transfer nor growing any cover crop, which is explicitly asked in an interview, the household must be abandoning 2 *mu* of arable area in winter.

IV.B. Overview of the Sample Data

The province of Sichuan in Southwest China has a population of 83 million, out of which 42 million live in rural areas, and covers a territory of 486 thousand square kilometers, out of which 67 thousand square kilometers is arable. Its Gross Domestic Production (GDP) was 503 billion USD in 2016 out of which 12% came from the agricultural sector (Sichuan Province Bureau of Statistics, 2016). The province is endowed with various land forms and has been a major agricultural producer in China, especially of staples, oil-bearing crops, and vegetables (National Bureau of Statistics, 2015). Sichuan Province was included in many nation-wide surveys on agricultural issues in China (Jin and Deininger, 2009; Deininger et al., 2014; Ji et al., 2016).

During the summer of 2016, I led a team of fourteen enumerators to collect data in East Sichuan Province. In total, 512 households from 14 villages were surveyed. One member from each household, with 69.3% of interviewees being the household heads, answered the questions. The sample contains information about more than 1850 individuals. The four most recent cropping seasons were covered to obtain a sufficient amount of information, while limiting inaccurate reporting due to fading memory. The seasons include the two from May 2014 to April 2015, forming the 2015 cropping year, and the two from May 2015 to April 2016, belonging to the 2016 cropping year. In addition to cropping practice, the survey collects information about demographic features, factor endowments, and nonfarm economic activities of households.

The sample includes households from different types of county-level economies around the economic center of Sichuan, the capital city of Chengdu. Chengdu is the fifth most populous Chinese metropolitan area and houses over 14 million residents. It provides millions of jobs to local and migrant workers.

Three types of county-level economies were selected. County 1 and County 2 are located near the downtown of Chengdu and lie almost entirely within the Chengdu Plain. They are endowed with fertile and well-irrigated farmland. Their urbanization rates are over 60% and agriculture contributes less than 5% to GDP. County 3 is located 96 kilometers away from Chengdu and has 15% of its GDP from the agricultural sector. Half of its area is flatland and the other half hilly. The farmland is of medium quality. The fourth county lies 142 kilometers away from Chengdu. A large share of its labor migrates to work, while over 30% of its GDP comes from agricultural production. Most of the farmland is hilly, largely rain-fed, and not fertile.

Within each county, the selection of households was randomized. Based on the size of agricultural population in a county, different numbers of households were randomly picked from the name lists provided by village leaders. [1] Other information of the sampling process and the four counties can be found in Table AI.

On average, each household is entitled to 4.1 *mu*, or 0.7 acre, of contract land. The contract land is divided into seven plots, so that the average plot size is only 0.1 acre. In the 2016 cropping year, 68% of the households rearranged the contract land. Over 72% of the rearrangements were partial and 49% were seasonal. Nearly 29% of households abandoned some contract land,

[1] Households whose *hukou* registrations remained in the village but had moved to urban areas could not be interviewed. Such households exited completely from farming for the long-term. By 2016, about 12% of registered households had left the village. The percentage was particularly high in the fourth county.

forgoing 12% of the arable area over the year on average. Only 6% of the households exited completely, while 47% exited in a variety of incomplete ways (see Table I).

TABLE I

ENDOWMENT AND ARRANGEMENTS OF CONTRACT LAND

	(1)	(2)	(3)	(4)	(5)
Contract land, *mu*	4.4	4.1	3.7	5.1	4.1
	(1.6)	(2.7)	(2.0)	(3.0)	(2.4)
Number contract plots	6.1	6.8	5.5	11.4	7.1
	(2.8)	(4.5)	(2.4)	(7.7)	(5.1)
Land arrangements					
Seasonal (%)	5.6	0.0	3.3	9.1	5.1
Yearly-partial (%)	24.1	47.2	22.9	7.4	20.9
Seasonal-partial (%)	11.1	16.7	14.3	75.2	27.7
Yearly (%)	13.0	13.9	15.6	8.3	13.9
No transfer (%)	46.3	22.2	43.9	0.0	32.4
Abandonment (%)	16.7	47.2	15.0	62.8	28.7

Note. Standard deviations are in parentheses. Columns (1) to (4) refer County 1 to County 4, respectively. Information is from the 2016 cropping year. The lower six rows report percentages of households that conduct particular land arrangements. Seasonal arrangements refer to land transfers lasting for one season. Yearly-partial arrangements refer to transfer-outs for the whole year but involving only part of the contract land. Seasonal-partial arrangements refer to seasonal transfer-ins or transfer-outs involving only part of the contract land. Yearly arrangements are year-round transfer-ins or transfer-outs of the entire contract land. No-transfer households cultivate fully and only the contract land. Column (5) reports the average statistics of the sample.

In the 2015 cropping year, five households in the sample cultivated more than 30 *mu* or five acres of land in at least one cropping season. This number grew to seven in the 2016 cropping year. Assumptions in the theoretical model apply to smallholders but not large farms. For instance, the assumptions of not hiring labor and not using mechanical power are inappropriate for large farms. Thus, I exclude the twelve observations of large farms in the following analysis.

IV.C. Tests on Household Exit Decisions

Recall Hypothesis 3-1, exit decisions depend on three groups of determinants. First, a household tends to exit completely if the safety net and asset value of contract land decreases. I use land and labor endowments to proxy the non-productive value of land. If a household is endowed with more contract land, the value of land as a safety net and as an appreciable asset tends to increase. If a household has more laborers, the potential safety-net value of land is expected to go up. Land-based subsidies, which increase in the size of contract land, add to the asset value of contract land. The non-productive value also increases in the risks over a household's land contract. I use a dummy variable, *land certificate*, as a proxy for the security of a land contract. Holding a certificate enhances tenure security and brings down the non-productive value. Recent experience of land reallocation or expropriation is a proxy for a household's expected risks concerning its land rights.

Second, when the opportunity costs of self-cultivation increase, a household is more likely to exit. Land fragmentation, measured by the average size of contract plots, is a proxy for net land rentals. A larger average plot size implies that higher land rentals tends to be forgone if self-cultivating the contract land. Higher local wages are expected to lower the opportunity costs of part-time farming relative to migration.

Third, if the division of labor types is clearer, a household is less likely to exit completely. I use the number of generations as the proxy for the division of labor types. The more generations in a household, clearer the division between labor types is. All the right-hand-side variables are measured at the household level, except for the local wage rate measured at the village level.

The exit decision of a household is represented by a categorical variable Ex_{jit}. The subscripts $j, i,$ and t indicate villages, households, and years. It equals zero if a household does not exit, one if it exits incompletely, and two if completely. Because most variation in explanatory variables is inter-household, fixed-effect or first-difference models are not employed. Otherwise, the estimation would be largely driven by a few households that experienced major changes within two consecutive years and would not characterize economic patterns of the majority.

I use a pooled multinomial logit model with $Ex_{jit} = 0$ as the baseline. I employ a set of household variables to control for potential household characteristics that simultaneously affect the explanatory variables of interest and the dependent variable. The control variables include the numbers of dependents, high school graduates, middle school graduates, young males and females in a household, the percentage of paddy field out of the contract land, and the size of housing land that a household owns.[1] Household-level explanatory variables and control variables are denoted as H_{jit} in equation (3). The vector V_{jt} includes the local wage rate and a few village-level control variables. Summary statistics of all dependent and explanatory variables are found in the appendix Table AII. Year fixed effects of T_t and village fixed effects, v_j, are included. Error terms, μ_{jit}, are clustered at the natural village level to account for potential covariance among households in the same natural village and serial correlation in errors within households.[2]

$$f(Ex_{jit}) = \beta_0 + \sigma_1 H_{jit} + \sigma_2 V_{jt} + \gamma_1 T_t + \gamma_2 v_j + \mu_{jit} \quad (3)$$

The left-hand-side of (3) represents the probability of a household choosing to exit incompletely (i.e., $Ex_{jit} = 1$) or to exit completely ((i.e.,$Ex_{jit} = 2$) instead of not exiting from farming ((i.e.,$Ex_{jit} = 0$). Instead of calculating marginal effects on the relative probabilities for the explanatory variables, I examine the signs of estimates to see if the revealed patterns support my hypotheses. In column (1) of Table II, a positive sign suggests that by increasing an explanatory variable, the probability of choosing $Ex_{jit} = 1$ relative to choosing $Ex_{jit} = 0$ increases. A similar interpretation applies to column (2).

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[1] The size of housing land is of particular important as a control variable. One could argue that the value of house in the village is the major reason as to why an agricultural household does not completely exit from farming to resettle in cities. The size of housing land is the proxy for the value of a house.

[2] The number of natural villages is 45 which is appropriate for the number of clusters (Cameron and Miller, 2015).

TABLE II

EXIT, LAND, AND LABOR DECISIONS OF HOUSEHOLDS

	Multinomial logit			OLS			Tobit			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. Var.	$Ex = 1$	$Ex = 2$	CulS	#FTF	#PTF	#FTW	CultS	#FTF	#PTF	#FTW
Land	0.58	1.04	-0.51	0.05	-0.14	0.21	-0.46	0.09	-0.12	0.20*
certificate	(0.55)	(1.15)	(0.51)	(0.19)	(0.14)	(0.18)	(0.49)	(0.19)	(0.19)	(0.11)
Land	-1.84**	-16.71***	0.26	0.01	-0.04	-0.04	0.50	0.06	-0.11	0.06
reallocated	(0.80)	(1.13)	(0.89)	(0.23)	(0.23)	(0.22)	(0.86)	(0.29)	(0.25)	(0.26)
Land	-0.54	0.63	0.25	0.06	-0.05	0.04	0.21	0.05	-0.07	0.07
expropriated	(0.48)	(0.64)	(0.59)	(0.13)	(0.15)	(0.12)	(0.55)	(0.13)	(0.13)	(0.12)
Size	0.18***	-0.06	0.39***	0.01*	0.01	-0.02*	0.37***	0.02**	0.01	-0.02*
contract land	(0.03)	(0.08)	(0.05)	(0.01)	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.01)
Number	-0.63***	-1.23***	0.75***	0.52***	-0.07	0.27***	0.80***	0.54***	-0.08	0.21***
laborers	(0.21)	(0.45)	(0.24)	(0.05)	(0.05)	(0.05)	(0.22)	(0.06)	(0.06)	(0.05)
Land-based	-0.29	-5.38***	1.49***	0.11	0.02	-0.03	1.49***	0.10	0.02	-0.02
subsidies	(0.26)	(1.77)	(0.36)	(0.08)	(0.10)	(0.07)	(0.33)	(0.09)	(0.08)	(0.07)
Avg. size	-0.88**	3.14***	-0.74*	-0.03	-0.34***	0.37***	-0.97**	-0.08	-0.46***	0.32***
contract plot	(0.45)	(0.95)	(0.40)	(0.09)	(0.08)	(0.10)	(0.44)	(0.10)	(0.12)	(0.07)
Local	-2.27*	-11.49*	2.87	-0.18	0.14	0.18	2.86	-0.13	0.40	0.27
skilled wage	(1.19)	(6.51)	(2.15)	(0.24)	(0.23)	(0.14)	(2.02)	(0.25)	(0.31)	(0.20)
Number	0.38	-1.26	0.61*	0.06	-0.002	0.35***	0.66**	0.10	0.02	0.50***
generations	(0.29)	(1.01)	(0.33)	(0.09)	(0.09)	(0.09)	(0.33)	(0.09)	(0.11)	(0.07)
% zero obs.			5.7%	16.7%	59.8%	51.3%	5.7%	16.7%	59.8%	51.3%
No. Obs.	1,006	1,006	1,006	1,006	1,006	1,006	1,006	1,006	1,006	1,006
R^2/Pseudo R^2	N/A	N/A	0.47	0.33	0.23	0.49	0.11	0.15	0.10	0.27

Note. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. Multinomial logit models are used for columns (1) and (2), OLS for columns (3) to (6), and Tobit for columns (7) to (10). *Ex* equals 1 means incomplete exit and 2 means complete exit. *CulS* stands for the cultivation size, *#FTF* for the number of full-time farmers, *#PTF* for part-time farmers, and *#FTW* for full-time nonfarm workers. The unit of subsidies is 1000 RMB, while that of local wage rates is 100 RMB. Marginal effects at mean/zero are reported for Tobit models. All control variables listed in Table AII are included in the regressions. All regressions include year fixed effects and village fixed effects. Standard errors are clustered the natural village level.

Reading from columns (1) and (2), holding a land certificate has positive, though not statistically significant, impacts on exiting. Having experienced recent land reallocation is likely to have increased the expected risk over land contracts and draws a household back to farming. Having a larger size of contract land makes a household more likely to exit incompletely. A household with more labor endowment tends not to exit at all. Higher land-based subsidies particularly discourages complete exit.

When the average plot size is larger, a household is more likely to exit completely or not to exit at all. It tends to exit completely, because the opportunity land rentals increase. Yet when contract plots are sufficiently large, a household may find it optimal to stay in farming and expand into a large farm. Higher local wages draw a household back from exiting completely. Finally, more generations in a household discourage complete exit.

IV.D. Tests on Land and Labor Decisions

The survey data provide information of cultivation sizes and days spent by each laborer on-farm and off-farm in a year. The information allows me to quantify the implications of changing exit decisions as changes in land and labor allocation. The explanatory variables are in the same as the ones in (3). At the household level, I consider four dependent variables: the cultivation size and the numbers of full-time farmers, part-time farmers, and full-time nonfarm workers. The econometric specification is written below.

$$y_{jit} = \sigma_0 + \sigma_1 H_{jit} + \sigma_2 V_{jt} + \gamma_1 T_t + \gamma_2 v_j + \mu_{jit} \qquad (4)$$

Some dependent variables contain nontrivial numbers of zero observations (see Table II). Tobit models can be used to generate unbiased estimation of average marginal effects of the explanatory variables on observed depended variables. However, a marginal effect must be computed at a specific value, typically at the mean, of an explanatory variable. Therefore, Tobit outcomes have limited interpretation which applies to a particular type of household. Estimates of average effects under ordinary-least-squares (OLS) models are biased towards zero, but have straightforward interpretation that applies to all households.

To take advantages of both models, I report OLS estimates in columns (3) to (6) of Table II and display the marginal effects of explanatory variables under Tobit models in columns (7) to (10). Throughout this section, the marginal effect of a variable is computed at zero if it is a dummy variable and at the mean otherwise. The two sets of estimates show consistent patterns and support the theory.

The interpretation centers upon OLS estimates. A household with a land certificate reduces the cultivation size by 0.5 *mu*. Simultaneously, it decreases the number of part-time farmers in exchange for more full-time nonfarm workers. Though statistically insignificant, every five households who have obtained land certificates can allow one more part-time farmer to work in nonfarm sectors for full-time. The coefficient of land certificates on the number of full-time nonfarm workers becomes significant at the 10% level under a Tobit model (see column (10)).

As shown in column (3), a household only cultivates another 0.4 *mu* for every additional *mu* of contract land, exactly pointing to a positive impact of land endowment on incomplete exit found in column (1). An endowment of one more laborer pushes the household to farm another 0.8 *mu*. In the meantime, the numbers of full-time farmers and full-time nonfarm workers increase.

When subsidies increase by 10,000 RMB for a given contract size, the household cultivates an increment of 15 *mu* of farmland and uses one more full-time farmer both according to OLS and Tobit estimations.[1] When the average plot size increases by one *mu*, a household reduces the

[1] During the period of 2015 to 2016, one USD equals 6.2 to 6.9 RMB (https://finance.google.com).

cultivation size by 0.7 *mu* or a 12%-reduction from the average cultivation size, which echoes the increased probability of exiting completely found in column (2). Increasing the average plot size also allows part-time farmers to focus on nonfarm employment.

Finally, with one more generation in the household, the number of full-time nonfarm workers increases by 0.4 and the cultivation size also increases by 0.6 *mu* under the OLS model. Under the Tobit model, an additional generation allows every two households currently having two generations to add one full-time nonfarm worker. The simultaneous increases of the cultivation size and the number of full-time workers again support the hypothesis of more generations increasing the division of labor within a household.

To classify labor into two types, I use a *Probit* model to predict a laborer's probability of working full-time in nonfarm sectors. The dependent dummy variable equals one if a laborer actually works full-time off the farm. Individual characteristics, inducing gender, age, and education, are included in the *Probit* model (i.e., P_{jipt} is the vector of individual characteristics defined in Table AII). The subscript *p* refers to individuals. Whoever in a household has the highest predicted probability of working full-time off the farm is the H-type labor, while the others are the L-type. At most two laborers within a household are the H-type if they have an equal and highest predicted probability. A household with only one laborer does not have H-type labor.

It turns out that a household has 2.1 L-type laborers and 0.9 H-type laborer on average. Only 17% of the H-type labor works full-time on the farm, while 56% of the other type does so. Simple *t-tests* show that H-type laborers are significantly more likely to be male, younger, and more educated.

The dependent variables are on-farm and off-farm working days for each laborer during a year. Again, both OLS and Tobit models are applied to the equation (5). Again, marginal effects on observed dependent variables are computed at zero for dummy variables and at means for other variables. The interpretation focuses on OLS estimates.

$$z_{jipt} = \sigma_0 + \sigma_1 P_{jipt} + \sigma_2 H_{jit} + \sigma_3 V_{jt} + \gamma_1 T_t + \gamma_2 v_j + \mu_{jipt} \quad (5)$$

In addition to similar patterns displayed at the household level, Hypothesis 3-2 suggests that higher human capital would encourage working off-farm. The education level is used as a proxy for human capital of a laborer. Intuitively, more educated labor would spend more time in off-farm sectors where their skills are rewarded. Reading from Table III, more educated L-type labor works significantly longer off-farm by reducing the number of days spent in farming. Holding a land certificate, an H-type laborer reduces on-farm time by 27 days using Tobit estimation. Having experienced land expropriation may imply more nonfarm jobs available near the village and hence encourages the H-type labor to work more off-farm and reduces on-farm working days of the L-type labor.

The H-type labor reduces on-farm working days in the average plot size. For households with an average plot size of 0.7 *mu* (i.e., the mean value of average plot size), its H-type labor reduces on-farm working days by 16 if the average plot size increases by one *mu* (see column (5)). The effect of increasing the average plot size on the L-type labor is insignificant. This echoes the earlier finding in column (5) of Table II that less fragmented land encourages part-time farmers to focus on nonfarm jobs. H-type laborers are expected to react more significantly, because they are more likely to be part-time farmers and have a comparative advantage in nonfarm jobs.

When the size of contract land increases by one *mu*, no significant increase is found in the on-farm days worked by either type of labor. Recall that a household only farms an additional 0.4 *mu* as the land endowment increases by one *mu*. The small increase of cultivation size may not be sufficient to trigger an increase in farming days.

TABLE III

LABOR DECISIONS OF INDIVIDUALS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	H-type labor (days)		L-type labor(days)		H-type labor (days)		L-type labor(days)	
Dep. Var.	On-farm	Off-farm	On-farm	Off-farm	On-farm	Off-farm	On-farm	Off-farm
Education	-6.20	-4.26	-4.55	13.55***	-5.15	-6.51	-8.12**	11.70**
	(4.19)	(6.68)	(5.11)	(4.93)	(3.14)	(7.32)	(3.99)	(5.00)
Land	-15.31	27.78	19.27	30.06	-26.91*	20.68	9.59	26.21
certificate	(12.19)	(32.26)	(20.05)	(25.64)	(14.52)	(33.27)	(14.26)	(23.92)
Land	27.67	-72.08	4.06	59.56	10.12	-98.64	6.18	34.63
reallocated	(19.65)	(60.24)	(52.08)	(45.04)	(9.78)	(76.36)	(35.54)	(31.79)
Land	-6.81	23.77	-23.91***	-14.68	-0.83	26.95	-18.51***	-15.55
expropriated	(7.69)	(17.84)	(8.04)	(12.62)	(5.82)	(18.31)	(5.85)	(13.85)
Size	-1.63***	-0.46	0.57	0.80	-0.54	-0.58	0.39	0.53
contract land	(0.60)	(1.79)	(1.00)	(0.92)	(0.58)	(1.76)	(0.74)	(0.88)
Number	-3.39	-12.21	-14.62**	2.89	-9.89**	-17.84*	-23.31***	-0.94
laborers	(3.69)	(9.98)	(6.55)	(7.56)	(3.92)	(9.42)	(6.24)	(7.03)
Land-based	14.32**	0.97	1.75	-10.82	10.30**	0.19	2.67	-11.94
subsidies	(5.67)	(17.29)	(10.12)	(11.02)	(4.59)	(15.88)	(7.51)	(10.40)
Avg. size	-12.02	-6.78	5.85	-5.18	-16.38**	-9.82	-7.01	-3.89
contract plot	(9.23)	(15.84)	(9.61)	(9.41)	(6.53)	(18.63)	(6.92)	(8.82)
Local	0.34	46.73*	-19.42	2.10	13.66	54.68**	-5.95	10.42
skilled wage	(32.23)	(24.94)	(23.58)	(24.11)	(18.96)	(24.26)	(21.54)	(29.02)
Number	6.25	53.75***	16.59**	15.09	0.78	51.48***	17.39**	19.59*
generations	(7.82)	(16.64)	(8.02)	(10.38)	(6.73)	(16.21)	(7.54)	(10.14)
% zero obs.	65.9%	32.7%	28.7%	61.2%	65.9%	32.7%	28.7%	61.2%
R^2/Pseudo R^2	0.34	0.38	0.26	0.28	0.11	0.06	0.05	0.06

Note. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. OLS models are used in the left four columns and Tobit for the rest. The numbers of observations are 883, 875, 2156, and 2156 from column (1) to (4). Same numbers apply to columns (5) to (8). The unit of subsidies is 1000 RMB, while that of local wage rates is 100 RMB. Marginal effects at mean/zero are reported for Tobit models. All control variables listed in Table AII are included in the regressions. All regressions include year fixed effects and village fixed effects. Standard errors are clustered the natural village level.

Instead, the intensity of farming might have gone up. Information of hours worked per farming day, unfortunately, is not available in the dataset. The limited increase in on-farm days as the cultivation size increases repeats in Table IV.

When land-based subsidies increase by 1,000 RMB, an H-type laborer farms for 15 more days or half a month. Increasing local wages induces the H-type labor to significantly increase off-farm working days, but not at a cost of decreasing on-farm days. It speaks to an increased probability of choosing part-time farming as local wages increase found in Table II.

The effect of labor division is clear. For each additional generation in the household, an H-type laborer works for another 54 days off-farm to take his/her comparative advantage, while an L-type laborer farms for 17 more days under OLS models.

IV.E. Tests on Relationships between Land and Labor Decisions

To see how labor decisions change as the household increases its cultivation size marginally, an instrumental variable (IV) is needed for identification. There are at least two sources of bias if not using an IV. First, the causal relationship may be reversed for the nonseparable decisions. Second, there can be omitted variables that affect both decisions. For instance, unobserved heterogeneity in farming capacity of a household or an individual may affect land and labor decisions simultaneously. The former bias leads to an overestimation of the coefficient, while the latter can bias the estimates in either direction.

I use the cultivation size of all the peer households in the village, including large farms, as the IV. For household i^*, the IV is for its cultivation size, $CulS_{ji^*t}$, computed as

$$CulS\_P_{ji^*t} = \frac{\sum_{-i^*} CulS_{jit}}{n_{jt}-1},$$

where $CulS_P_{ji^*t}$is the cultivation size of household i^* in a year and n_{jt} is the number of sample households in village j as of year t.

The IV is household- and year-specific and ranges from 1.9 to 17.4 mu. The variation of the IV largely depends on large farms, which can be seen as exogenous to any smallholder household. Identification using this IV relies on the following assumption: the IV has an impact on cultivation sizes of a household only through local land markets and does not affect labor decisions directly. The effect through land markets is intuitive. Given a fixed amount of land endowment in a village, the more land is cultivated by other households, the less may be cultivated by household i^*. The first-stage outcomes confirm the negative and significant impact of the IV on a household's cultivation size as shown in column (8) of Table IV. If not including the IV, the R-squared of the first-stage regression falls from 0.51 to 0.47, suggesting a fair amount of explanatory power of the instrument variable.

The econometric specifications at the household level is expressed below. It is the same as equation (4), except for an additional variable of $CulS_{jit}$. The dependent variables are the numbers of full-time farmers, part-time farmers, and full-time nonfarm workers in a household.

$$y_{jit} = \sigma_0 + \sigma_1 CulS_{jit} + \sigma_2 H_{jit} + \sigma_3 V_{jt} + \gamma_1 T_t + \gamma_2 v_j + \mu_{jit}$$

Similarly, the econometric specification at the individual level resembles (5) with $CulS_{jit}$ added. The corresponding dependent variables are on-farm and off-farm working days per year for each laborer. Both IV-2SLS and IV-Tobit models are used to generate estimates. The estimates under OLS and Tobit models are also provided for comparison.

Outcomes displayed in columns (1) to (3) of Table IV confirm Hypothesis 4-2 that a household reduces the number of full-time workers and increases that of part-time workers if increasing the cultivation size. Specifically, increasing the cultivation size by 16.7 *mu* makes a household to reduce one full-time worker and simultaneously add one part-time farmer.

TABLE IV

EFFECTS OF LAND USE ON LABOR DECISIONS OF HOUSEHOLDS AND INDIVIDUALS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Household level			Individual level				First-stage
	Numbers of laborers			H-type labor (days)		L-type labor(days)		OLS
Dep. Var.	FTF	PTF	FTW	On-farm	Off-farm	On-farm	Off-farm	CulS
Cult. size	0.01	0.04***	-0.06***	0.21	-2.69	1.86	-2.85*	-2.92***
(IV-2SLS)	(0.011)	(0.013)	(0.013)	(0.708)	(2.178)	(1.300)	(1.594)	(0.731)
Cult. size	0.01	0.08	-0.09*	3.10	-4.08	2.84	-4.52	
(IV-Tobit)	(0.031)	(0.068)	(0.048)	(5.319)	(6.262)	(2.858)	(6.099)	
Cult. size	0.02	0.03***	-0.04***	0.33	-2.62	2.24	-1.68*	
(OLS)	(0.010)	(0.008)	(0.009)	(0.727)	(1.760)	(1.349)	(0.949)	
Cult. size	0.02*	0.03***	-0.03***	0.59	-2.75	2.43**	-1.54*	
(Tobit)	(0.010)	(0.009)	(0.009)	(0.520)	(1.826)	(1.055)	(0.919)	
No. Obs.	1,006	1,006	1,006	883	875	2,156	2,156	1,006
R^2	0.33	0.24	0.51	0.34	0.38	0.26	0.28	0.51

Note. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. Eight observations are missing for off-farm working days of the H-type labor. Only R-squared of IV-2SLS regressions are reported in columns (1) to (7). Marginal effects at mean are reported for Tobit models and coefficients estimated are reported for IV-Tobit models. Column (8) displays the first-stage outcome of using the average peer cultivation size as the IV for a household's cultivation size. The estimated coefficient and corresponding standard error are reported in the first and second rows, respectively. *FTF* stands for full-time farmers, *PTF* for part-time farmers, and *FTW* for full-time nonfarm workers. All control variables listed in Table AII are included in the regressions. All regressions include year fixed effects and village fixed effects. Standard errors are clustered the natural village level, except for the IV-Tobit estimation.

At the individual level, we expect that the L-type labor increase on-farm working days more than the H-type labor does as the cultivation size increases. Shown in column (4), the H-type labor barely increases the on-farm working days. Under OLS estimation, an L-type laborer gives up 2.9 off-farm days in exchange for 1.9 on-farm days. The total working days for an L-type laborer tends to drop. This indicates a loss of efficiency, when dragging labor back to the field. Under a Tobit model, the decrease in the total working days is statistically insignificant for the L-type farm labor who cultivates 5.8 *mu* of land (i.e., the means of the cultivation size).

IV.F. Wedges between On-Farm Productivity and Nonfarm Wage Rates

Recall Hypothesis 1, a wedge exists between the on-farm productivity of a part-time farmer and his/her opportunity nonfarm wage rate. To perform the test, I need to first estimate the unobserved productivity of farm labor. I closely follow the estimation strategy introduced by Jacoby (1993) and Skoufias (1994). To ensure that the results are not driven by outliers, I exclude observations of large farms, as defined earlier, and large ranches that produce livestock worth over 100,000 RMB (i.e., 15,380 USD) per year.

A double-log specification production is employed and expressed below. Define the dependent variable HpV_{it}, the value of home production, as the summation of crop and livestock production value in a year.[1] The variable of HpD_{jit} is the summation of farming and animal-feeding days, while HpC_{jit} is the expenditure on seeds, fertilizers, chemicals, irrigation and animal feed. The vector, X_{jit}, represents a group of control variables, including the size of contract land and the average size of plots. The control variables are defined in the note under Table AIII.

$$\ln(HpV_{jit}) = b_0 + b_1 \ln(CulS_{jit}) + b_2 \ln(HpD_{jit}) + b_3 \ln(HpC_{jit}) + b_4 X_{jit} + \gamma_1 T_t + \gamma_2 v_j + u_{jit}$$

[1] In my sample, over 75% of agricultural households raise livestock. On average, the value of livestock production is 45% of the value of crops. Similar as the sample studied by Jacoby (1993), I would seriously underestimate productivity of farm labor if not accounting for the value of livestock production.

Following Jacoby (1993), I add a constant of one to all the input variables before taking the logarithm. As a comparison, I estimate the production function without transforming zero observations (see Table AIII). Based on estimation, a linear prediction of home-production value (i.e., $\widehat{HpV_{\jmath\imath t}}$) is made. By assuming an equal on-farm marginal productivity of all the farm laborers, I estimate the monthly shadow wage as the average productivity of farm labor in a month.

$$shadow\ wage_{jipt} = \left[\frac{\widehat{HpV_{\jmath\imath t}} \times \widehat{b_2}}{HpD_{jit}}\right] \times 30$$

The estimated coefficient of home-production days is $\widehat{b_2}$ and measures the average percentage contribution of home-production days, HpD_{jit}, to the predicted home-production value. The estimated monthly wage for 602 observations of part-time farmers has a mean of 561.3 and the standard deviation of 1241.6. Corresponding observed monthly nonfarm wages has a mean of 2013.7 with a standard deviation of 1315.4.

In theory, the on-farm marginal productivity is smaller than the average productivity due to diminishing returns to farm labor. If a wedge is statistically significant between the average productivity and the market wage rate, then the wedge between the on-farm marginal productivity and market wage should also be significant.

The test is on whether the average productivity changes proportionally with the off-farm wage. If the coefficient of opportunity wage rates equals one and the constant is zero, then no wedge exists. I use local wage rates for skilled labor as the instrument for a laborer's wage rate and include gender, age, education, and local wage rates for unskilled labor as controls. It turns out, as shown in column (2) of Table V, the coefficient estimated by an IV-2SLS model is positive but not even close to one. Varying transaction costs and discreteness in working time can result in similar, yet perhaps not so wide, a wedge between on-farm and off-farm productivity.

TABLE V

WEDGES BETWEEN SHADOW AND MARKET WAGE RATES

Individual level	(1)	(2)	(3)
Dep. Var.	Log of shadow wage rates		First-stage
Log of off-farm wage rates	-0.06	0.12	5.77***
	(0.035)	(0.193)	(2.080)
Constant	10.82	5.88	25.27**
	(12.682)	(15.737)	(11.205)
No. Obs.	602	602	602
R^2	0.33	0.30	0.18

Note. Large farms and large ranches are excluded. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. Control variables are gender, age, education, marriage status, membership of China Communist Party, and the village nonskilled wage rate. OLS model is used in column (1) and IV-2SLS is used in column (2). Column (3) reports the first-stage outcome using the IV, *local wages for skilled labor*, for observed nonfarm wage rates of part-time farmers.

IV.G. Evidence of Endogenous Wage Rates and the Property Trap

I first test whether working part-time (i.e., positive days on-farm) instead of full-time (i.e., zero day on-farm) imposes a negative impact on wage rates. Because unobserved individual capacity can affect both the choice of working part-time and the wage rate, an IV is preferred. In column (5) of Table II, the average plot size of contract land if found to reduce the number of part-time farmers significantly. I thus use the average plot size as the IV for the dummy variable of working part-time. The first-stage coefficient is found to be significantly negative.

The specification resembles equation (5), except for the dummy variable for part-time farmers (i.e., PT_{jipt}). The dependent variable, w_{jipt}, is the monthly wage of a laborer.

$$w_{jipt} = \sigma_0 + \sigma_1 PT_{jipt} + \sigma_2 P_{jipt} + \sigma_3 H_{jit} + \sigma_4 V_{jt} + \gamma_1 T_t + \gamma_2 v_j + \mu_{jipt}$$

In the first two columns of Table VI, both OLS and 2SLS outcomes confirm the statistically and economically significant decrease in wage rates if working part-time instead of full-time in nonfarm sectors. I also estimate the effect of the number of on-farm days on wage rates. The coefficient estimated under OLS is significantly negative. Using peer cultivation sizes as the IV, the estimated coefficient of on-farm days becomes insignificant.

TABLE VI

EVIDENCE OF ENDOGENOUS NONFARM WAGE RATES

Individual level	(1)	(2)	(3)	(4)
Dep. Var.	Off-farm monthly wage rates			
	OLS	IV-2SLS	OLS	IV-2SLS
If part-time working	-0.81***	-2.69**		
	(0.17)	(1.2)		
On-farm working days			-0.004***	0.006
			(0.001)	(0.030)
No. Obs.	1,331	1,331	1,331	1,331
R^2	0.24	0.07	0.23	0.16

Note. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. Individuals from large farms are excluded. OLS is used in columns (1) and (3), while an IV-2SLS model is used in columns (2) and (4). The variable, if part-time working, is a dummy which equals one if a laborer works part-time off-farm. Both first-stage coefficients of IV in columns (2) and (4) are significantly negative. All control variables listed in Table AII are included in the regressions. All regressions include year fixed effects and village fixed effects. Standard errors are clustered the natural village level.

Regarding the property trap effect, my goal is to test whether individuals from a household with more fragmented contract land have higher labor-to-land ratios (i.e., $FI_{jipt} = \frac{on-farm\ days_{jipt}}{cultivation\ size_{jit}}$). The specification of the test is similar to (5) with FI_{jipt} as the dependent variable.

TABLE VII

LAND FRAGMENTATION AND THE INTENSITY OF FARMING

Individual level	(1)	(2)	(3)	(4)
Dep. Var.	Farming days per *mu*			
	All households	Mech. costs < 150 RMB	Mech. costs < 100 RMB	Mech. costs < 80 RMB
Avg. size contract plot	-14.53	-27.28	-45.16	-48.43*
	(18.86)	(19.07)	(28.15)	(27.28)
No. Obs.	1,838	1,098	841	806
R^2	0.18	0.28	0.34	0.37

Note. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. Only farm laborers are included. Columns (2) to (4) only include households that spend less than 150 RMB, or 100 RMB, or 80 RMB per *mu* on mechanical power, respectively. All control variables listed in Table AII are included in the regressions. All regressions include year fixed effects and village fixed effects. Standard errors are clustered the natural village level.

As the theoretical model does not consider the substitution of mechanical power for farm labor, I prefer to exclude households that use mechanical power intensively. Mechanical cost per *mu* of a household varies from 4 to 398 RMB with a mean at 110 RMB.

Shown in Table VII, the coefficient of average plot size is weakly negative, even when all households are included. The coefficient has larger magnitudes and becomes more statistically significant as more mechanized households are excluded from the regression. As soon as I exclude households using more than 80 RMB of mechanical power per *mu*, the coefficient becomes significant at the 10% level.

IV.H. Robustness Tests

First, an anticipation effect could exist and change the interpretation of holding land certificates (Field, 2007; de Janvry et al., 2015). A household expecting a land certificate may use extra farm labor to double-guarantee the land rights before the certificate is received. If so, the coefficient of the dummy variable, *land certificate*, is positive on the number of nonfarm full-time workers not because tenure security is enhanced by the certificate, but merely because laborers return to nonfarm sectors after the certificate is obtained.

I generate a variable called *years certificate owned* which equals the number of years holding a land certificate. I interact the new variable with the dummy variable of interest. If the anticipation effect dominates, then the effect of land certificate fades away in the time of holding the certificate. The coefficient of the interaction term should have an opposite sign as the dummy variable does. In Table AIV, coefficients of the interaction term do not always have opposite signs, are of small magnitudes, and are rarely statistically significant. In column (8), the only significant coefficient estimated actually implies that the positive impact of holding land certificate on days worked off-farm strengthens over time for the L-type labor.

Another alternative explanation pertains to the effect of holding more contract land. I found that the cultivation size and the number of full-time farmers increase in the size of contract land. Instead of attributing the effect to an increase in the non-productive value of land, one could argue that a larger contract size implies higher land productivity and encourages farming. The two causes may co-exist. Yet if the latter dominates, one should also expect an increases in the cultivation size and in the amount of farm labor if the contract land is less fragmented. However, households tend to cultivate less land if the average plot size increases (see Table II).

A final concern is over the quality of recall data. Though recalling information is inevitable for agricultural context due to a long production process, recalling more distant data adds on worries as memory gets vague (Beegle, Carletto, and Himelein, 2012). To ensure the quality of data, I repeated all the regressions using the 2016 round of data only and obtained highly consistent results compared to Tables II to IV.[1]

V. Concluding Remarks

Consolidation of farmland has been slow in China. Restrictive policies are found to make permanent exit from farming rare and land transfers inactive. The prevailing characterization of policy effects on resource allocation, however, has been incomplete. In particular, seasonal and partial arrangements of farmland have been largely ignored.

My survey data uncovered active and complex rearrangements, either transfers or abandonment, of contract land by Chinese smallholders. Complete exit was rare, but numerous households were observed to exit in incomplete ways. I developed a theory of incomplete exit from farming to explain the persistence of smallholder farming. My model considered interrelated policies and improved upon prior models by characterizing the non-productive value of contract

[1] The estimation outcomes based on 2016 data are available upon request.

land as a function of the simultaneous decisions of farmland and labor inputs. Using the survey data, I estimated the effects of tenure security, land endowment, government subsidies, local wage rates and demographic structures on land and labor decisions. Empirical evidence was provided for the inefficient allocation of labor at the household and individual levels.

Inefficient allocation of resources by small-scale farms can be far-reaching. Relatively low productivity of farm labor and unstandardized products from numerous smallholders tend to push up costs of procurement and quality control for wholesalers and processors in China. Not having a sufficient reallocation of rural labor to industries also affects the long-term development of China's nonfarm sectors. One relevant issue is the abundance of nonfarm-worker supply. As found in this paper, a large potential supply of workers has been stored in the form of part-time farmers who farm largely because of the non-productive value of contract land.

My empirical findings, admittedly, rely upon the specific agro-ecological conditions in Sichuan Province and should be applied to other parts of China with caution. Nevertheless, the theory of incomplete exit throws light upon the flexibility and complexity of resource use in a fairly general sense. Whenever multiple cropping seasons are available or farmland is fragmented, seasonal and partial arrangements of land, transfers and abandonment, should be taken into account. The fact that exit from farming is not a binary choice should also be kept in mind.

The paper stresses that, as policy restrictions constrain one channel of resource allocation, for instance, selling land, various side channels are expected to emerge. Flexible arrangements of resources through exiting incompletely is one example from China's agricultural sector. Though the additional flexibility helps agricultural households maximize the income, it does not eliminate distortion in resource allocation caused by the restrictions.

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APPENDIX I: DERIVATION OF THE OBJECTIVE FUNCTIONS

I now demonstrate why maximizing the expected income over two periods is equivalent to maximizing the first-period income plus the expected non-productive value of contract land as specified in functions (1) and (2) in Section III. The proof focuses on a case where land markets and multiple seasons are not considered, but can be readily extended to cases where land markets and/or multiple seasons are available.

Assumptions and notation follow Section III. There are three risks that can be realized at the end of the first period. First, the probability of losing one's nonfarm job by period two is $\rho \in [0,1)$. The probability is composed by systematic and idiosyncratic shocks. The former refers to business recessions and the latter relates to demographic features of a nonfarm laborer. I ignore idiosyncratic shocks and treat ρ as a systematic shock of unemployment. Second, a risk of land reallocation, or of failing to reclaim land title, threats the uncultivated contract land. The risk is denoted as $\mu \in [0,1)$ and is exogenously determined at the village level.

Thirdly, there is a risk of land expropriation of $\eta \in [0,1)$. If any expropriation strikes a household, I assume that all its contract land shall be taken away regardless of the cultivation size. A victim household is compensated based on the size of contract land and the first-period farm outputs. The compensation function is $C(s, l^f|\bar{s})$, where l^f refers to the total amount of on-farm labor in the first period. This function is assumed to be concave in both input variables. The marginal values of s and l^f increase in the endowment of land. I assume that the compensation received is $C(s, l^f|\bar{s})$ whether reallocation of uncultivated land is intended.

If a farmer-worker is laid-off, he/she has no access to unemployment insurance provided by the government. I assume that the laborer can only do farming to generate income in the consecutive period. An on-farm laborer is able to work off-farm in period two if land is expropriated and no business recession happens. After all, a laborer is free to work in nonfarm sectors in any period. He/she did not work off-farm not because no job was available, but because he/she could maximize the expected income by farming. In addition, local governments usually assist landless farmers in job-hunting after the expropriation. If layoff and expropriation take place simultaneously, however, the household has to rely on compensation for a living in period two.

The six possible states in period two and the corresponding probabilities (i.e., p_1 to p_6) are listed below.

State 1: no layoff and no change of land, $p_1 = (1-\rho)(1-\eta)(1-\mu)$;

State 2: no layoff but uncultivated land reallocated, $p_2 = (1-\rho)(1-\eta)\mu$;

State 3: no layoff but all contract land expropriated, $p_3 = (1-\rho)\eta$;

State 4: laid-off but no change of land, $p_4 = \rho(1-\eta)(1-\mu)$;

State 5: laid-off and uncultivated land reallocated, $p_5 = \rho(1-\eta)\mu$;

State 6: laid-off and all contract land expropriated, $p_6 = \rho\eta$.

I do not write out the parameters and drop the household subscript in following expressions. If there is no risk, the optimal allocation of resources can be solved from the function below. The parameter D is the time discount factor in $(0,1)$. The amount of land-based subsidies equals the unit subsidy, B, multiplied by the size of contract land and is assumed to be independent from farming activities.

$$\left[w_H\left(l_H^f\right)\left(\bar{l} - \overline{l_L} - l_H^f\right) + w_L\left(l_L^f\right)\left(\overline{l_L} - l_L^f\right) + F(s, l^f) + B\bar{s}\,\right](1+D) \tag{A1}$$

The optimal cultivation size is referred to as s^*, while the optimal labor use are l_H^{f*} and l_L^{f*}. The maximized income in a period is denoted as π^*.

The non-productive value to land under risks complicates the problem. The new objective function can be expressed in (A2). The three variables with double dots on the top are the second-period choices of cultivation size and labor. The letter π refers to period one income and $\ddot{\pi}_i$ is the income in State i in the second period.

$$\max_{s, l_H^f, l_L^f, \ddot{s}, \ddot{l}_H^f, \ddot{l}_L^f} E(\Pi) = \pi + D\sum_{i=1}^{6} p_i \ddot{\pi}_i$$

$$= w_H(l_H^f)(\bar{l} - \overline{l_L} - l_H^f) + w_L(l_L^f)(\overline{l_L} - l_L^f) + F(s, l^f) + B\bar{s}$$

$$+D\{\pi^* p_1 + \pi^* p_2 + [\pi_0 + C(s, l^f)]p_3 + F(\bar{s}, \bar{l})p_4 + F(s, \bar{l})\, p_5 + C(s, l^f)p_6\}$$

$$+D[B\bar{s}(p_1 + p_4) + Bs(p_2 + p_5)] \tag{A2}$$

The second period does not involve any risks. When State 1 is realized, the household faces a situation as (A1) depicts. Therefore, $\ddot{\pi} = \pi^*$ and the corresponding use of land and labor follows. In State 2, the uncultivated part of land is lost. The household is left with only s units of land and an unchanged amount of labor. Under risks, a household could only make a higher expected income than π^* by cultivating more than s^*. Therefore, $s \geq s^*$ and s^* is still a feasible choice in the second period. The household again chooses s^* with l_H^{f*} and l_L^{f*}.

In the third state, all the land is lost and all the labor is allocated to off-farm sectors. The second period income is equal to $\pi_0 = w_H(0)(\bar{l} - \overline{l_L}) + w_L(0)\overline{l_L}$. In the last three states, off-farm employment is not available. All the labor has to make earnings from farming, using as much land as possible. In summary, $\ddot{s} = s^*$, $\ddot{l}_H^f = l_H^{f*}$ and $\ddot{l}_L^f = l_L^{f*}$ if the first two states are realized. In State 3, $\ddot{l}_H^f = \ddot{l}_L^f = 0$ and $s = 0$. In States 4 and 5, $\ddot{l}_H^f = \bar{l} - \overline{l_L}$ and $\ddot{l}_L^f = \overline{l_L}$ and all available land ($\bar{s}$ or s) is cultivated. In the last state, labor is unemployed. Second period variables are fully determined by the realization of risks and first-period choices.

The optimal land use in the first period can be obtained from the FOC below.

$$\frac{\partial E(\Pi)}{\partial s} = \frac{\partial \pi}{\partial s} + D\frac{\partial \ddot{\pi}}{\partial s} = \frac{\partial \pi}{\partial s} + D\left[\frac{\partial F(s,\bar{l})}{\partial s} p_5 + \frac{\partial C(s, l^f)}{\partial s}(p_3 + p_6) + B(p_2 + p_5)\right]$$

Mathematically, $\frac{\partial E(\Pi)}{\partial s}$ is equivalent to $\frac{\partial\left(\pi+D\left[F(s,\bar{l})\,p_5+C\left(s,l^f\right)(p_3+p_6)+Bs(p_2+p_5)\right]\right)}{\partial s}$. The same pattern is found with respect to the two labor variables. Therefore, the objective function can be transformed to

$$\max_{s,l_H^f,l_L^f,\ddot{s},\ddot{l}_H^f,\ddot{l}_L^f} E(\Pi) = \pi + D\left[F\left(s,\bar{l}\right) p_5 + C(s,l^f)(p_3+p_6) + Bs(p_2+p_5)\right].$$

Denote the second partition of the transformed objective function as $V\left(s,l^f|\bar{l},\bar{s},\mu,\eta,\rho,B,D\right)$ and call it the expected non-productive value of contract land. The objective function can then be written as function (1) in Section III, after excluding off-farm earnings from the H-type labor.

Considering land markets, a similar proof can be provided. Denote land rental as $R(q)$ which is exogenous and q refers to quality characteristics of the contract plots or plots to rent in. The endowment of contract land for a household is at most $\bar{s}$ by the start of period two. Specify a function of $I(s)$ which equals s if $\bar{s} \geq s$ and $\bar{s}$ if $\bar{s} < s$.

The endowment of contract land in period two does not affect the optimal choices of land and labor, provided with perfect land rental markets. The income from farming and nonfarm activities is identical in the first three states, though the rental payments/earnings differ. Denote the income from farm and nonfarm activities as π^* and the optimal cultivation size as s^*. Similarly, the farming income is the same for the last three states, while the rental payments/earnings differ. Denote the farm income as F^* and the optimal cultivation size as s^{**}. The expected income is expressed below.

$$\max_{s,l_H^f,l_L^f,\ddot{s},\ddot{l}_H^f,\ddot{l}_L^f} E(\Pi) = \pi + R(s-\bar{s}) + B\bar{s}$$

$$+D\{\pi^*(p_1+p_2+p_3) + R(\bar{s}-s^*)p_1 + R(I(s)-s^*)p_2 + R(-s^*)p_3 + F^*(p_4+p_5+p_6) +$$

$$R(\bar{s}-s^{**})p_4 + R(I(s)-s^{**})p_5 + +R(-s^{**})p_6 + C(I(s),l^f)(p_3+p_6)\}$$

$+D[B\bar{s}(p_1 + p_4) + BI(s)(p_2 + p_5)].$

Allowing for active land markets, the second period choices of land and labor are still fully determined by the realization of risks and the first-period farming activities. The objective function can be transformed to the following function.

$$\max_{s, l_H^f, l_L^f, \ddot{s}, \ddot{l}_H^f, \ddot{l}_L^f} E(\Pi) = \pi + R(\bar{s} - s) + D[(R + B)I(s)(p_2 + p_5) + C(I(s), l^f)(p_3 + p_6)].$$

The third partition of the transformed objective function is denoted as $V\big(I(s), l^f | q, \bar{l}, \bar{s}, \mu, \eta, \rho, B, D\big)$. Function (2) in Section III can then be written.

The FOC with respect to the cultivation size has two segments are specified in (A3). When a household rents in land, the marginal productivity of cultivated land equals the land rental rate. Efficient allocation of land is hence achieved. However, for a household that rents out land or stays autarky, the wedge between the marginal productivity of cultivated land and the land rental rate persists.

$$\begin{cases} \frac{\partial F(s,l^f)}{\partial s} + (R + B)D(1 - \eta)\mu + \frac{\partial C(I(s),l^f)}{\partial s} D\eta = R, \forall s \leq \bar{s} \\ \frac{\partial F(s,l^f)}{\partial s} = R, \forall s > \bar{s} \end{cases} \tag{A3}$$

APPENDIX II: DERIVATION OF COMPARATIVE STATICS

FOCs of function (1) in Section III for interior solutions can be expressed below. Seasonality is ignored without loss of generality.

$$\frac{\partial F\left(s,l_L^f\right)}{\partial s}+\frac{\partial V\left(s,l_L^f\right)}{\partial s}=0 \qquad (\mathcal{L}1)$$

$$\frac{\partial F\left(s,l_L^f\right)}{\partial l_L^f}+\frac{\partial V\left(s,l_L^f\right)}{\partial l_L^f}-w_L\left(l_L^f\right)+\frac{\partial w_L\left(l_L^f\right)}{\partial l_L^f}\left(\overline{l_L}-l_L^f\right)=0 \qquad (\mathcal{L}2)$$

Parameters of interest include the endowments of contract land ($\bar{s}$) and of labor ($\overline{l_L}$), the technological efficiency of farm production (A), subsidy rate (B), risks (ρ, μ and η), human capital (M_L) and the time discount factor (D). Apply the IFT to ($\mathcal{L}1$) with respect to $\bar{s}$.

$$\frac{\alpha s}{\alpha \bar{s}}=-\frac{\frac{\alpha \mathcal{L}1}{\alpha \bar{s}}}{\frac{\alpha \mathcal{L}1}{\alpha s}}=-\frac{\frac{\partial^2 F\left(s,l_L^f\right)}{\partial s \alpha \bar{s}}+\frac{\partial^2 V\left(s,l_L^f\right)}{\partial s \alpha \bar{s}}}{\frac{\partial^2 F\left(s,l_L^f\right)}{\partial s^2}+\frac{\partial^2 V\left(s,l_L^f\right)}{\partial s^2}} \qquad (A4)$$

From Appendix I, I know that $\frac{\partial V\left(s,l_L^f\right)}{\partial s}=D\left[\frac{\partial F(s,\bar{l})}{\partial s}\rho(1-\eta)\mu+\frac{\partial C\left(s,l_L^f\right)}{\partial s}\eta+B(1-\eta)\mu\right]$.

Because the second order derivatives of $F\left(s,\bar{l}\right)$ and $C\left(s,l_L^f\right)$ in s are strictly negative by assumption, the denominator of (A4) is strictly negatively. The sign of $\frac{\alpha s}{\alpha \bar{s}}$ depends solely on the numerator. It turns out that $\frac{\partial^2 F\left(s,l_L^f\right)}{\partial s \alpha \bar{s}}=\frac{\partial^2 F(s,\bar{l})}{\partial s \alpha \bar{s}}=0$ and $\frac{\partial^2 C\left(s,l_L^f\right)}{\partial s \alpha \bar{s}}>0$. The numerator of (A4) is hence positive, and so is $\frac{\alpha s}{\alpha \bar{s}}$. The optimal cultivation size increases in the endowment of land.

Similarly, I can show that $\frac{\alpha s}{\alpha \bar{l}}>0$, $\frac{\alpha s}{\alpha A}>0$, $\frac{\alpha s}{\alpha B}>0$, $\frac{\alpha s}{\alpha \rho}>0$, $\frac{\alpha s}{\alpha \mu}>0$, and $\frac{\alpha s}{\alpha D}>0$. The interpretation is intuitive. When the endowment of contract land and labor or the marginal productivity of land increases, the optimal cultivation size increases. If the subsidy rate increases, or risks of layoff/reallocation increase, or the *present bias* decreases, the optimal cultivation size also goes up.

When it comes to the risk of expropriation, the proof becomes harder. The sign of $\frac{\partial^2 V\left(s, l_L^f\right)}{\partial s \alpha \eta}$ is determined by the expression below.

$$-\frac{\partial F(s,\bar{l})}{\partial s}\rho\mu + \frac{\partial C\left(s, l_L^f\right)}{\partial s} - B\mu \tag{A5}$$

Because the risk parameters are smaller than one, it must be that $\frac{\partial F(s,\bar{l})}{\partial s}\rho\mu < \frac{\partial F(s,\bar{l})}{\partial s}$. We know the compensation is worth considerably more than the farm output value in one year. It should be that $\frac{\partial C\left(s, l_L^f\right)}{\partial s} > \frac{\partial F(s,\bar{l})}{\partial s}$. The sign of (A5) can be determined positive, as long as B is relatively small.

The comparative statics of labor input is derived in a similar way. Regarding the optimal use of farm labor, apply the IFT to ($\mathcal{L}2$).

$$\frac{\alpha l_L^f}{\alpha \bar{s}} = -\frac{\frac{\alpha \mathcal{L}2}{\alpha \bar{s}}}{\frac{\alpha \mathcal{L}2}{\alpha l_L^f}} = -\frac{\frac{\partial^2 F\left(s, l_L^f\right)}{\partial l^f \alpha \bar{s}} + \frac{\partial^2 V\left(s, l_L^f\right)}{\partial l^f \alpha \bar{s}}}{\frac{\partial^2 F\left(s, l_L^f\right)}{\partial l_L^{f\,2}} + \frac{\partial^2 V\left(s, l_L^f\right)}{\partial l_L^{f\,2}} - 2\frac{\partial w_L}{\partial l_L^f} + \frac{\partial^2 w_L}{\partial l_L^{f\,2}}\left(\bar{l}_L - l_L^f\right)} \tag{A6}$$

The sign of the denominator seems ambiguous. Yet thinking about ($\mathcal{L}2$), we can be quite sure that the denominator is negative. Here is the intuition.

When any parameter changes the optimal cultivation size, the equilibrium of ($\mathcal{L}2$) is broken. Consider a parameter that increases the optimal cultivation size as an example. When the optimal s increases, $\frac{\partial F\left(s, l_L^f\right)}{\partial l_L^f} + \frac{\partial V\left(s, l_L^f\right)}{\partial l_L^f}$ also increases, because land and labor are complements in farm production. However, $w_L\left(l_L^f\right) - \frac{\partial w_L\left(l_L^f\right)}{\partial l_L^f}\left(\bar{l}_L - l_L^f\right)$ stays the same. To reach an equilibrium again, the household must change l_L^f. When increasing l_L^f, assuming that $w_L\left(l_L^f\right)$ has relatively small marginal changes, $\frac{\partial F\left(s, l_L^f\right)}{\partial l_L^f} + \frac{\partial V\left(s, l_L^f\right)}{\partial l_L^f}$ falls and can equalize $w_L\left(l_L^f\right) - \frac{\partial w_L\left(l_L^f\right)}{\partial l_L^f}\left(\bar{l}_L - l_L^f\right)$ at a new and larger l_L^f. The changes of optimal land and labor in $\bar{s}$ are of the same direction. Given that $\frac{\partial^2 V\left(s,l_L^f\right)}{\partial l^f \alpha \bar{s}}$ and $\frac{\alpha s}{\alpha \bar{s}}$ are positive, the denominator of (A6) ought to be negative.

The sign of (A6) thus depends on the sign of the numerator. The comparative statics of optimal labor and land inputs take the same signs for all common parameters. When human capitals of individuals increase, the numerator equals $-2\frac{\partial w_L}{\partial M_L} + \frac{\partial^2 w_L}{\partial l_L^f \partial M_L}\left(\overline{l_L} - l_L^f\right)$. This expression is negative if $\frac{\partial^2 w_L}{\partial l_L^f \partial M_L}$ is zero or negative. It suggests that the L-type labor would put less labor on the farm if being endowed with more human capital (i.e., higher opportunity costs of self-cultivation).

Considering land markets, the non-productive value function becomes $V\left(I(s), l_L^f\right) = D\left[(R+B)I(s)(1-\eta)\mu + C\left(I(s), l_L^f\right)\eta\right]$. The comparative statics in land endowment (i.e., $\bar{s}$), labor endowment (i.e., $\overline{l_L}$), the technological efficiency (i.e., A), subsidy rate (i.e., B), and human capital (i.e., M_L) are unchanged. The sign of $\frac{\alpha s}{\alpha q}$ is negative, because $D(1-\eta)\mu < 1$. Thus, the cultivation size decreases in the rental rate. It is also straightforward that $\frac{\alpha s}{\alpha \mu} > 0$ and $\frac{\alpha s}{\alpha \rho} = 0$. The sign of $\frac{\alpha s}{\alpha \eta}$ depends on $-(R+B)\mu + \frac{\partial C\left(I(s), l_L^f\right)}{\partial s}, \forall s \le \bar{s}$. Because $\frac{\partial C\left(s, l_L^f\right)}{\partial s} > \frac{\partial F(s,\bar{l})}{\partial s} \ge R$ in perfect land markets, $R\mu$ is smaller than $\frac{\partial C\left(s, l_L^f\right)}{\partial s}$. The sign of $\frac{\alpha s}{\alpha \eta}$ is positive if B is relatively small. If $s > \bar{s}$, then $\frac{\alpha s}{\alpha \eta} = 0$. A similar derivation applies to the comparative statics of the optimal on-farm labor.

When parameter changes increase the optimal labor input of the L-type laborers, on-farm time of the H-type labor tends to increase. For example, because $\frac{\alpha l_L^f}{\alpha \bar{s}} > 0$, $\frac{\alpha l_H^f}{\alpha \bar{s}}$ should be nonnegative. The same logic applies to other parameters.

TABLE AI: OVERVIEW OF SAMPLE COUNTIES

	(1)	(2)	(3)	(4)
Distance from Chengdu (km)	27.8	25.1	95.8	142.1
Area (km^2)	438	1,032	1,245	841
Population (1,000)	558.6	532.6	520.0	420.0
Urbanization (%)	64.5	66.5	45.8	34.0
Per capita GDP (RMB)	76,391	111,528	36,294	14,727
Agricultural GDP (%)	4.9	2.4	15.0	30.8
Landform	Plain	Mostly plain	Semi-plain	Hilly
Farmland (km^2)	208	442	607	473
Sample selection				
Number. townships sampled	1	1	3	2
Number villages sampled	2	2	6	4
Number households sampled	54	36	301	121

Note. Standard deviation are in parentheses. Information is found from the website of Sichuan Provincial Bureau of Statistics (http://www.sc.stats.gov.cn). Columns (1) to (4) correspond to counties 1 to 4, respectively. I report 2015 demographic and GDP and 2014 urbanization rates. The rate of urbanization equals the proportion of urban population in a county. The selection of households was randomized. I first selected one to three townships in a county. In each township, two villages were picked. Households were then randomly drawn out of all villagers.

TABLE AII: SUMMARY STATISTICS OF DEPENDENT AND EXPLANATORY VARIABLES

	Type	Mean	Std. dev.	Min	Max
Dependent variables					
Cultivation size (*mu*)	Continuous	5.8	4.1	0	29.6
No. full-time farmers	Integer	1.3	0.8	0	4
No. part-time farmers	Integer	0.6	0.9	0	4
No. full-time workers	Integer	0.8	1.0	0	6
Individual-level					
No. days worked on-farm	Integer	64.3	100.7	0	330
No. days worked off-farm	Integer	114.8	139.0	0	360
Explanatory variables					
Individual-level (P_{jipt})					
Male	Dummy	0.5	0.5	0	1
Age	Integer	48.2	16.0	17	95
Born local	Dummy	0.9	0.3	0	1
Education	Categorical	2.5	1.1	1	6
Married	Dummy	0.8	0.4	0	1
CCP member	Dummy	0.1	0.2	0	1
Household-level (H_{jit})					
No. generations	Integer	2.2	0.8	1	3
No. laborers	Integer	3.0	1.1	0	6
No. dependents	Integer	0.8	0.9	0	5
No. high school graduates	Integer	0.5	0.7	0	3
No. middle school graduates	Integer	1.0	1.0	0	4
No. young males (17-50)	Integer	0.8	0.7	0	4
No. young females (17-45)	Integer	0.6	0.6	0	2
Size of contract land (*mu*)	Continuous	8.2	4.3	0	30.0
Avg. size of contract plot (*mu*)	Continuous	0.7	0.4	0.04	4.2
% paddy of contract land	Percentage	80.1	24.5	12.5	100.0
Land certificate	Dummy	0.2	0.4	0	1
Land reallocated	Dummy	0.01	0.1	0	1
Land expropriated	Dummy	0.1	0.3	0	1
Land-based subsides (RMB)	Continuous	473.1	449.2	0	3300.0
Size of housing land	Continuous	0.4	0.3	0.04	3.0
Village-level (V_{jt})					
% land cultivated by large farms	Percentage	21.2	15.8	0	49
Local skilled wage (RMB/day)	Integer	174.2	36.2	120	260
Local unskilled wage (RMB/day)	Integer	99.2	21.6	60	150
No. local firm employees	Integer	50.9	78.3	0	334

TABLE AII

(CONTINUED)

Variables	Type	Mean	Std. dev.	Min	Max
% seniors	Percentage	20.2	4.1	15.1	28.4
% households left	Percentage	12.1	13.6	0.5	49.8
% tilled by machines	Percentage	85.8	26.5	15	100.0
% transplanted by machines	Percentage	12.1	11.4	0	36
% harvested by machines	Percentage	67.1	44.0	0	100.0

Note. The number of observations for household variables equals 1012, except for the variables of average plot size and the percentage of paddy field out of contract land. Their observation number is 1006, because three households are entitled to no contract land in both years. The number of individual-level observations equals 3059 as only laborers are included. The variable of education is categorical. It is equal to 1 if an individual has not finished primary school, 2 if finished primary school, 3 if finished middle school, 4 if finished high school, 5 if finished college, and 6 if finished graduate school. The term CCP stands for Chinese Communist Party. The dummy variable *land certificate* equals one if a household holds a land certificate by the beginning of a cropping year. The dummy variable *land reallocated (expropriated)* equal one if the household has experienced land reallocation (expropriation) within the recent ten years. The variable *% land cultivated by large farms* is the percentage of village farmland that is cultivated by large farms. The variable *No. local firm employees* is the number of employees hired by local nonfarm firms. The variable *% seniors* is the proportion of village popular that is more than 60 years old. The variable *% households left* is proportion of registered households that have left the village. The last three variables are the percentages of village farmland that is tilled, transplanted, and harvested by machines, respectively. Village-level variables are weighted by numbers of households in the sample when means and standard deviations are computed. The denotation of H_{jit}, V_{jt} are defined in equation (3), and that of P_{jipt} is introduced in (5).

TABLE AIII: ESTIMATION OF HOME PRODUCTION FUCTIONS

Household level	(1)	(2)
Dep. Var.	Log of home production value	
Log of cultivation size	0.26**	0.31***
	(0.115)	(0.075)
Log of home production days	0.13***	0.02
	(0.024)	(0.020)
Log of home production costs	0.92***	0.62***
	(0.025)	(0.069)
Zero obs. transformed	Yes	No
Year fixed-effects	Yes	Yes
Village fixed-effects	Yes	Yes
Constant	0.93**	3.14***
	(0.407)	(0.486)
No. Obs.	997	927
R^2	0.91	0.80

Note. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. OLS models are used. Large farms and ranches are excluded. Control variables include the numbers of generations and laborers in a household, the dummy variable of whether the household grows perennial crops, , the dummy variable of whether land certificate is held, the dummy variable of whether having experienced land changes, size of contract land, the value of machinery owned by the household, and gender, age and education of the household head. Standard errors are clustered at the natural village level.

TABLE AIV: ESTIMATION OF ANTICIPATION EFFECTS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Household level			Individual level			
		Numbers of laborers			H-type labor (days)		L-type labor(days)	
Dep. Var.	CultS	FTF	PTF	FTW	On-farm	Off-farm	On-farm	Off-farm
Land certificate	-0.96	0.46	-0.44**	0.20	-24.23	46.36	31.18	-13.40
	(1.260)	(0.277)	(0.183)	(0.299)	(23.601)	(41.609)	(30.576)	(18.397)
Land certificate ×	0.09	-0.09	0.06	0.003	1.70	-3.54	-2.92	10.65*
Years certif. owned	(0.220)	(0.056)	(0.040)	(0.049)	(3.010)	(7.627)	(5.252)	(5.943)
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. Obs.	1,006	1,006	1,006	1,006	883	875	2,156	2,156
R^2	0.47	0.33	0.23	0.49	0.34	0.38	0.26	0.28

Note. Standard errors are in parentheses; *** implies p<0.01, ** p<0.05, * p<0.1. OLS models are used. Eight observations are missing for H-type labor in off-farm working days. *Land certificate ×Years certif. owned* is the interaction term between the dummy variable of holding (*Land certificate*) a land certificate and the number of years that a household holds a land certificate (*Years certif. owned*). *CulS* stands for the cultivation size, *FTF* for full-time farmers, *PTF* for part-time farmers, and *FTW* for full-time nonfarm workers. All control variables listed in Table AII are included in the regressions. Standard errors are clustered at the natural village level.