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Abstract

We analyze the individualization of farm units in Mali in the sense of a transformation of purely collective farms into mixed units in which private plots coexist with collective fields. While a moral-hazard-in-team problem plagues production on the latter, a dilemma arises insofar as the household head extracts his income form it. The head thus faces a trade-off between efficiency and capture. We show, within the framework of a patriarchal farm household model, that the choice is tilted toward private plot as land becomes more scarce.

On the basis of first hand data collected in Southern Mali, we test and confirm the above prediction. Moreover, the relationship between land scarcity and the presence of individual plots holds only when there are at least one married couple (besides the head) within the household. The explanation we put forward is that the presence or suspicion of labour-shirking on the collective field arise only when there are interferences by in-laws and differences in the size of conjugal units.

1 Introduction

The phenomenon of collective farms, in the sense of farm units wherein production is collectively carried out on jointly used fields, tends to be ignored nowadays because during the last century this organizational form has often been authoritatively imposed from the top (in Eastern Europe, the Soviet Union, and several developing countries including China, Cuba and Ethiopia). In fact, collective farms were more widespread in land-abundant contexts than is usually thought. This is attested by the presence of collective farms run by large and complex households in old-day Russia and Serbia, or in West Africa where they have persisted till recent times. In Burkina Faso, Gambia, Senegal and Mali, for example, extended households managing collective farms remain a characteristic feature of the rural landscape, even though a trend toward granting individual plots of land to family members has been observed during the last decades. Mixed farm structures have thus emerged in which individual plots coexist with the collective family field on which members continue to work as a team. While the output of individual plots entirely accrues to the members, the output of the family field is shared among all the co-workers after the head has retained his own portion. Transfers to the latter from the incomes that have been individually obtained are rarely observed, and while they are theoretically possible, they are hard to enforce owing to the high cost of monitoring harvests on private plots (especially when crops are harvested at frequent intervals).

An interesting question is how we can account for the emergence of mixed farm structures within households that were used to run large collective fields to the exclusion of any private farming. It is a well-known finding in the development literature that the movement toward increasing individualization of land tenure rules at the community level has been largely driven by land scarcity. We argue in this paper that the same force is actually explaining the rise of mixed farms in southern Mali. In other words, the growing value of land causes an individualization of the form of farm units as well as an individualization of property rights. To make this point, we construct a simple argument based on the idea that integrated collective farms are run by a household head acting as an all-powerful patriarch. This patriarch is confronted with a dilemma that becomes increasingly acute as land becomes scarce: while efficiency is enhanced by the granting of individually farmed plots, the possibility to extract incomes for himself is exclusively ensured through collective production, since the patriarch cannot tax individual production. To the extent that the patriarch must meet reservation utility constraints for the family members, a higher level of land scarcity compels him to pay more attention to efficiency considerations.

The above argument is developed with the help of a simple model that is presented in Section 3, after we have reviewed the existing literature in Section 2. Sections 4 and 5 are then devoted to testing the central prediction of the model by using first-hand data which we have systematically collected in the Koutiala-San-Sikasso region of Mali. In Section 4, we first provide general information about our sample data. Thereafter, we present descriptive evidence about the farm and family structures encountered in our survey area, and proceed by discussing qualitative evidence in support of the main assumptions underlying our model. In Section 5, we propose an econometric analysis to test the prediction from our econometric model. An important finding, which we discuss extensively, is that land scarcity explains the presence of private plots only when at least two married couples reside inside the household. Section 6 concludes the paper.

2 Review of the literature

This paper is concerned with the question as to why and under which conditions individual plots of land can coexist with a collective field within a given farm structure. Such an issue has been addressed in three different strands of the economic literature. The first strand deals with agricultural producer cooperatives (APCs), the second strand with large-scale feudal-like farms, such as haciendas and plantations, and the third strand with family farms.

By far the most significant, the writings devoted to APCs have proposed various lines of argument to explain why cooperative units may choose to have some lands allocated to private production and managed by the member households. Putting the question in the converse way, it becomes: assuming that collective farming is not imposed on them and they have a real institutional choice, why farmers could be interested in pooling some of their individually owned lands?

If certain activities are subject to scale economies while others are not, it seems natural for farmers to undertake the former on collective fields while retaining private plots for the latter. This organizational choice was observed in Hungarian cooperatives, where activities intensive in husbandry skill were left for households to conduct on their private plots whereas activities easy to standardize and monitor remained the province of collective work on the cooperative fields (Swain, 1985; Guillaume, 1987; see also Chayanov for Russia, 1991: Chap. 13).[1] Collective production is often plagued with a moral-hazard-in-team problem when information regarding contributions to collective production is imperfect, forcing the cooperative to pay all workers equally (Holmström, 1982). Then collective production is desirable only if this incentive failure is outweighed by the benefits of scale economies, or else by the intrinsic motivations of members (Putterman, 1981, 1985).

Louis Putterman and Marie DiGiorgio (1985) develop a more sophisticated argument based on work incentive considerations but in a context where individual contributions to collective production are measurable. They assume that the reward function in the collective sector of a cooperative is a combination of two opposite principles: distribution according to needs (equal sharing) and distribution according to effort (the work-point system). The

[1]For example, Guillaume reports that the raising of piglets until they reach one year of age was collectively carried out in huge shelters heated with the help of powerful lamps and placed under the constant surveillance of veterinarians, hence the significance of indivisibleness. By contrast, the raising of pigs beyond one year was performed by the member households in their private compounds.

weights given to each system, as well as the allocation of the cooperative land between the collectively farmed field and the private plots, are endogenous variables democratically chosen by the members who are heterogeneous in terms of their income-leisure preferences. While a strict equal sharing rule is subject to the moral-hazard-in-team problem, a distribution according to work effort may cause a sort of "tragedy of commons": indeed, members seek to earn additional work-points bearing average net product returns although their additional work hours have a low marginal productivity (Putterman, 1989: 324). The presence of distribution according to needs mitigates this excessive incentive effect. The authors show that by distributing some revenue according to needs, the cooperative can achieve optimal work incentives (while increasing equality of income distribution). Land is then allocated between private and collective production in such a manner that the marginal product of land in the private plot of the household of median industriousness equals the marginal product of land in joint production.[2] Therefore, both the private and collective sectors can meaningfully exist, yet only in the presence of some economies of scale (see also Putterman, 1987).

Risk aversion and output uncertainty provide another justification for collective farming irrespective of scale economies. If natural contingencies strike randomly across members, pooling of land and labor may provide an insurance strategy (Putterman and DiGiorgio, 1985: 18, 20 fn. 32; Chayanov, 1991: Chap. 11). Michael Carter (1987) centers his analysis on the trade-off between risk sharing and incentives. Assuming that collective income is shared equally, he argues that complete parcellation of cooperative land is suboptimal in both static and dynamic terms. This is because the insurance that income sharing provides also shelters the individual from the full effect of his or her own slack behavior, thereby inducing lower work effort. Finally he shows that intermediate forms that preserve some

[2] If one of these marginal products would exceed the other over the whole range of possible values of inter-sectoral allocation of land, land would be allocated wholly to either the collective or the private sector (Putterman, 1989: 332).

degree of risk sharing may prove superior.

The second strand of literature relevant to our problem deals with asymmetric farm structures instead of democratic participatory agrarian institutions. In the advantageous position is the landlord or estate owner who enjoys a local monopoly power over land. In deciding how to use his land, he may opt for a combination of two systems: direct cultivation with the help of wage workers on a portion of his property, and renting out the remaining portion of the estate land to the same workers. There is typically no money exchange between the tenant and the landlord: the labor services supplied by the workers on the landlord's field (the field supervised and managed by the landlord) constitute the rent due for the use of individualized plots. Such a system has been widely observed, for example in the post-Carolingian manors of medieval Europe, in American plantations using slave labor and in Russian boyar estates using serf labor (Van Zanden, 2009: 56, fn 13; Blum, 1961; Kolchin, 1987), in feudal Japanese farms during the Tokugawa era (Smith, 1959), or among estate landlords of Latin America, such as those employing inquilino laborers in Chile after the middle of the 18th century (Bauer, 1975)[3]. This is a semi-feudal system of "subsistence farms internal to the precapitalist estate", in which "internal peasants", with their family labor, "work captive plots of land for which they pay rent in labor services and/or in kind" (de Janvry, 1981: 111)

An interesting theoretical explanation for the labor-service system has been proposed by Elisabeth Sadoulet (1992). The basic intuition is the following. In the presence of limited liability - tenant's liability is limited to his total wealth - the tenant does not bear the full risk of defaulting on his rental payment and thus has incentives to shirk. This decreases the rent

[3] In Japan, for example, during the second half of the 18th century both land and labor were increasingly transferred by the oyakata (landlord) to his nagos (clients). Since the oyakata was responsible for the livelihood of the nago, awarding land to the latter also implied that the burden of his labor services on the former's land be proportionately reduced. The land allocated to the nago was now under his own management and, although he was a tenant rather than a holder, he himself made many of the critical decisions of farming. More importantly, despite receiving the oyakata's continued protection in times of adversity, the nago took many of the risks associated with independent farming (Smith, 1959: 134).

the landlord can extract from land rental contracts. In the words of Sadoulet, the landlord "faces a dilemma between reducing the rent charged to lower the occurrence of default and increasing it to capture the full surplus that the tenant can obtain from the utilization of his family labor" (p. 1033). The labor-service contract, that is, the exchange of free labor for use on the landlord's field against free access to a private plot of land for personal use by the tenant, enables the landlord to impose an optimal level of insurance and, thus, efficient resource use on the tenant.

Another justification for the choice of this system of exchange in kind lies in risk considerations. In fact, the exchange of free labor services against free access to a piece of land is equivalent to a sharecropping contract that would be applied on the whole farm area and may thus be motivated by risk sharing (Allen, 1984). Yet, underlying this argument is the assumption that labor effort on the estate owner's field can be monitored at no cost. If monitoring is imperfect, the equivalence result does not hold anymore: granting sharecropping contracts to risk-averse tenants on the whole estate domain is more efficient than a system in which individual plots coexist with the landlord's field. In other words, the functional equivalent of the collective sector in a producer cooperative may not come into existence.

Finally, the third strand of literature has the family farm as its frame of reference. Marcel Fafchamps (2001) has thus proposed a model that attempts to explain the decision of the household head to allocate individual plots to family members. The idea is the following: because the head is unwilling or unable to commit to reward their work on the family field after the harvest, family members are tempted to relax their labor efforts or to divert them to other income-earning activities. To solve this commitment failure, the head decides to reward his wife and dependents for their labor on the collective field by giving them individual plots of land and the right to freely dispose of the resulting produce. It must be stressed, however, that the commitment problem only exists if the short-term gain of deviating from cooperation (which means here reneging on the promise to reward the workers for their effort on the collective field) exceeds the long-term flow of benefits ensuing from a smooth relationship between the household head and the working members. Fafchamps himself recognizes that this condition appears to be restrictive, since the game played within the family is by definition of a long (and indeterminate) duration, and future benefits are not heavily discounted (future cooperation among close relatives matters a lot). In other words, voluntary collaboration should in principle be induced by the threat of future non-cooperation. Even assuming that Fafchamps' hypothesis is valid, it remains unclear why there should be a tendency over time for collective farms to transform themselves into mixed farms.

An alternative account of the presence of individual plots may be inferred from the theory of individualization of farm production proposed by Foster and Rosenzweig (2002). They argue that the advantages of collective production arising from scale economies and also from savings associated with the financing of household public goods (which are jointly consumed) may be outweighed by diverging preferences over the household public good. According to them, conflicts over the provision of this good may increase as a result of increases in income and in within-household inequality, leading to a split of the stem household into independent units. In our context, however, Foster and Rosenzweig's argument is not quite relevant in so far as the rule of joint residence and joint consumption persists when the head awards individual plots to the members: meals continue to be organized at the household level with married women taking turns in preparing the food. We are therefore left with a relative shortage of pertinent accounts of the existence of individual plots in the setting of family farms.

Is it possible to infer from the first two bodies of literature plausible explanations for the gradual emergence of individual plots within a collective farm structure? This is the question which we now want to address. A first conceivable reason behind such emergence is the diminishing importance of technological scale economies, or the growing significance of husbandry skill-intensive activities which gives rise to the so-called management diseconomies in agriculture. These phenomena are typically observed when land scarcity causes a shift to land-saving and labor-using agricultural techniques. As we have learned from the work of Ester Boserup (1965) and others, a key characteristic of these techniques is that labor quality, which is costly to monitor, becomes a critical input. Given the incentive problems associated with care-intensive activities, more individualized forms of agricultural organization, in which few co-workers (spouses and their children) are residual claimants, appear more efficient (see also Binswanger and Rosenzweig, 1986; Binswanger and McIntire, 1987; Pingali, Bigot and Binswanger, 1987; Binswanger, McIntire and Udry, 1989; Hayami and Otsuka, 1985). Boserup's line of argument has been advanced to explain the splitting of large family farms into smaller units based on the narrow family, the peasant farms, rather than the emergence of mixed structures involving the presence of individual plots of land side by side with a collective field. Another possible explanation is the decreasing need for risk-sharing as relatively cheap alternative insurance mechanisms become available, most typically in the form of off-farm income opportunities. Finally, the multiplication of these new income opportunities and the development of rural credit markets might reduce the limited liability problem confronting poor tenants.

In Mali, it is not clear that the rising importance of mixed farm structures is accompanied by technological change, credit market development or an increased access to insurance opportunities. In fact, agricultural techniques do not appear to have changed in our survey region during the last decades. Credit market failures remain glaring as the only way of obtaining loans is through the marketing-cum-credit interlinking provided by the parastatal agency in charge of cotton production and marketing (Compagnie Malienne de Developpement des Textiles). Finally, the opening of new migration possibilities may allow rural households to diversify risks, thereby blurring the effect of land scarcity on farm structure. We come back to this issue when presenting robustness checks in Section 5.3.

In the next section, as an alternative to the above-outlined theoretical frameworks, we therefore propose a theory of the patriarchal family that has the advantage of bringing explicitly into light the relationship between land scarcity and farm structure (whether the farm remains integrated as a collective unit or adopts a mixed form including individual plots). Unlike in the literature on producer cooperatives, decisions about the form of the farm are made by an authority figure, the family or household head, and, unlike what is assumed in Sadoulet's model, the patriarch does not interfere with the family members' allocation of effort. Two key assumptions in our model are (1) a simple sharing of collective output under conditions of unobservable effort, and (2) unenforceable transfers of output from the individual plots. We consider the situation of a family farm that is initially integrated, hence the difference with feudal or semi-feudal estates, and where a hierarchical relationship prevails, hence the difference with democratic producer cooperatives.[4]

3 A simple model of family farm structure

3.1 The general framework

The model is a simplified version of a more general model which is the focus of a companion paper (Guirkinger and Platteau, 2010) and allows for the possibility of household splitting in addition to the granting of individual plots.

[4] It is noteworthy that the transformation we observe from collective to mixed structures implies a process that is exactly the reverse of the process observed in many feudal or semi-feudal estates. In the latter instance, indeed, independent tenants have typically become re-integrated into a seigneurial estate when landlords decided to cultivate their land directly in response to favourable market conditions. The ability of estate owners to impose labor obligations on the tenants resulted from the weakened bargaining position of the latter, either because of financial crises leading to debt servitude (see, e.g., Sadoulet, 1992: 1032, with reference to the Chilean inquilinos in the latter half of the 18th century; or Blum, 1961: 241-46, with reference to Russia in the late 16th and early 17th centuries, or Van Zanden, 2009: 271-2, for Egypt under the Mamluks), or the concentration of coercive power in the hands of the landlords acting in collusion with state authorities (see Blum, 1957, 1961: esp. Chaps 13-14, 21, for Russian serfs during the 15-19th centuries). Such circumstances obviously affect the constraints set in the theoretical model. In particular, since the worker/tenant does not have any outside option left (if he runs away from his landlord, he will be traced and captured to be returned to his "owner"), no participation constraint can be assumed to exist.

A household head has n male family members who live and farm with him. Farm production $f(d, l)$ require two inputs, land d and labor l. The total land endowment of the extended family is na (where a denotes the average individual endowment) and labor is supplied by male dependants (there are no land or labor markets). An individual's utility is $x - v(l)$, where x is the production that the individual consumes and l the level of labor he exerts. The function $v(l)$ is the disutility of labor.

The head allocates available land na between a collective field, where the male members work together, and individual fields, where each works individually and for his own benefit. We assume that members receive an equal treatment with respect to both the distribution of the produce of the collective field (hence the existence of a moral-hazard-in-team problem) and the division of the land earmarked for individual farming. Therefore, if the head decides to grant individual plots, each member receives h. The size of the collective field is then $n(a - h)$.

Members consume the whole production of their individual fields, implying that the father's entire consumption R is obtained from his share of the output produced on the collective field. In keeping with our field observations again, we thus assume that there is no possibility of income transfer from household members to the head.[5] Attention is restricted to pure share contracts where the head's rent is $R = \alpha f(-)$.[6] When $h = 0$, we say that the farm structure is purely collective, whereas if $h > 0$, it has a mixed form.

One unit of labor, whether applied on the collective field or on the individual plot, causes the same disutility. Therefore, member's j utility can be written as $x_j - v(l_j^C + l_j^I)$, where x_j is the sum of the share received from the collective field and the production from his

[5] This assumption is discussed at length in Guirkinger and Platteau (2010).

[6] We argue elsewhere (Guirkinger and Platteau, 2010) that, given the specific context of a family farm, a share system appears as the second best efficient contract, even when risk consideration are abstracted from. This becomes evident when, following an argument developed by Eswaran and Kotwal (1985), the contract choice problem is viewed as a trade-off between the need to provide tenants with adequate incentive to apply effort, on the one hand, and the need to use the land owner's management skills to the best possible extent, on the other hand. We also show that no Nash Equilibrium exists when a remuneration contract with a fixed component is used to distribute the proceeds of collective production in the presence of individual plots.

individual plot, l_j^C is the level of effort applied to the collective field, and l_j^I that applied to the individual field. We thus assume perfect substitutability between consumption stemming from individual and from collective production. In the line of the argument proposed by Foster and Rosenzweig (2002), members might be assumed to have a preference for individual consumption. There are two reasons why we refrain from making this effect explicit in the present model. First, since it clearly strengthens the case for individual plots, no new important insight would be gained by modeling it. Second, it bears emphasis that individual consumption is not incompatible with collective production, since the head could always decide to remunerate the members, at least in part, in the form of cash payments.[7] Therefore, in our framework, the preference for individual consumption alone could not account for individualization. Finally, members have an outside option that provides them utility $\underline{u}$, giving rise to a participation constraint.

The problem is a two-stage game. In the first stage, the head chooses α and h. In the second stage, members observe these choices and individually decide how much effort to apply to the collective field and how much to their individual plot is such plot is available. We restrict our attention to symmetric Nash equilibria in the second stage. This allows us to solve for a single pair (l^C, l^I), and to write the whole problem as follows:

$$
\begin{aligned}
\text{Max}_{\alpha,h} R &= \alpha f\left(n(a-h), nl^C\right) \\
\text{s.t.: } \{l^C, l^I\} &= \text{Argmax}_{l_j^C, l_j^I} \frac{1}{n}\left[(1-\alpha) f\left(n(a-h), l_j^C + (n-1)l^C\right)\right] + f\left(h, l_j^I\right) - v(l_j^C + l_j^I) \\
l^C &\geq 0 \text{ and } l^I \geq 0 \\
\underline{u} &\leq \frac{1}{n}\left[(1-\alpha) f\left(n(a-h), nl^C\right)\right] + f\left(h, l^I\right) - v(l^C + l^I) \\
0 &\leq h \leq a
\end{aligned}
$$

[7] Our observations actually reveal that the incomes derived from cotton production are sometimes distributed in cash.

Total labor on the collective field in the incentive compatibility constraint is written $l_j^C + (n-1)l^C$ to stress that each member takes the behavior of others as given when deciding how much effort to apply to that field.

3.2 The head's rent in the strictly collective regime

In the collective regime, $h = 0$, $l^I = 0$ and the members' choice of effort on the collective field is a concave problem with a unique solution. We can therefore represent it by its first-order conditions. The father's rent is the solution of the following program:

$$\begin{aligned} \text{Max }_{\alpha} R &= \alpha f\,(na, nl) \\ \text{s.t.: } 0 &= \frac{1-\alpha}{n} f_L(na, nl) - v'(l) \\ \underline{u} &\leq \frac{1-\alpha}{n} f\,(na, nl) - v(l) \end{aligned}$$

The moral-hazard-in-team problem is captured by the incentive compatibility constraint: receiving $\frac{1-\alpha}{n} f_L(na, nl)$ instead of his full marginal product, each member under-applies labor. We show in the Appendix that the solution has an explicit solution with a Cobb-Douglas production function $f(a, l) = a^{\varepsilon} l^{1-\varepsilon}$, and the linear cost of effort, $v(l) = \omega l$.

$$\begin{cases} \text{If } a < \left(\frac{n\omega\epsilon}{1-\epsilon}\right)^{\frac{1}{\epsilon}} \frac{n\underline{u}(1-\epsilon)}{n\omega-\omega+\omega\epsilon} \text{ then } R = na^{\epsilon}\left(\frac{\underline{u}(1-\epsilon)}{n\omega-\omega+\omega\epsilon}\right)^{1-\epsilon} - \frac{n^2\underline{u}}{n-1+\epsilon} \\ \text{If } a > \left(\frac{n\omega\epsilon}{1-\epsilon}\right)^{\frac{1}{\epsilon}} \frac{n\underline{u}(1-\epsilon)}{n\omega-\omega+\omega\epsilon} \text{ then } R = na\epsilon\left(\frac{(1-\epsilon)^2}{\epsilon n\omega}\right)^{\frac{1-\epsilon}{\epsilon}} \end{cases} \tag{1}$$

We obtain two expressions for the father's rent in that regime, depending on whether or not the members' participation constraint is binding. If land is abundant, to increase work incentives, the head rewards members beyond their reservation utility and his rent is independent of $\underline{u}$ (second expression in the above system). Conversely, when land is scarce, participation constraints are binding and the head's rent is a decreasing function of the member's reservation utility.

3.3 Giving out individual plots?

The question of the distribution of individual plots is not trivial since there are two forces working in opposite directions. On the one hand, unlike the collective field where the workers suffer from the moral-hazard-in-team problem, individual plots are used efficiently. As a consequence, a smaller amount of land has to be dedicated to meeting the members' reservation utility under a mixed system than under a pure collective regime. On the other hand, incentives to work on the collective field are further eroded when there is competition between the family field and private plots. The output obtained on the land wherefrom the father derives his income is therefore lower than it would be in the absence of these plots.

To understand the underlying logic of the model, it is useful to analyze the trade-off faced by the head when he decides to allocate individual plots. We consider the problem in a sequential manner. First, let us define $\alpha^*(h)$ which is the optimal α for a given h. We can then examine how the value function of this degenerate problem varies when h changes. If $\frac{\partial V}{\partial h}(\alpha^*(h)) < 0$ for all h such that $0 \leq h < 1$, the head will not allocate individual fields. On the contrary, if $\frac{\partial V}{\partial h}(\alpha^*(h)) > 0$ over some range, the head may choose to allocate individual fields.

Suppose that h is fixed. When there exist both a collective field and individual plots, we can replace the members' maximization problem by the first-order conditions with respect to l^C and l^I, and write the following Lagrangian:

$$L\left(l^C, l^I, \alpha\right) = \alpha f\left(n(a-h), nl^C\right) - \lambda\left(v'(l^C + l^I) - \frac{1-\alpha}{n} f_L(n(a-h), nl^C)\right)$$
$$-\mu\left(v'(l^C + l^I) - f_L\left(h, l^I\right)\right) \quad (2)$$
$$-\nu\left(\underline{u} - \frac{1-\alpha}{n} f\left(n(a-h), nl^C\right) - f\left(h, l^I\right) + v(l^C + l^I)\right)$$

In order to analyze the sign of $\frac{\partial R}{\partial h} = \frac{\partial V}{\partial h}$, we apply the envelop theorem and obtain the following expression:

$$\frac{\partial V}{\partial h} = \frac{\partial L}{\partial h} = -n\alpha f_A^C - \lambda(1-\alpha) f_{LA}(n(a-h), nl^C) + \mu f_{LA}\left(h, l^I\right)$$
$$-\nu(1-\alpha) f_A(n(a-h), nl^C) + \nu f_A\left(h, l^I\right) \quad (3)$$

As h marginally increases, the size of the collective field decreases (by n), and the first term indicates how, everything else being constant, the family head's rent declines with the size of the field from which it is extracted. The second term captures the lower incentives for male members to work on the collective field as h increases (we show in the Appendix, section 7.2.1, that λ is positive). For a given amount of effort, indeed, the marginal product of labor falls when land becomes smaller. The third term reflects the negative impact on R caused by the enlarged size of the individual plots: members have more incentive to spend effort on their individual plot because the marginal productivity of labor has increased for a given amount of effort. As a result, the cost of their effort on the collective field is now higher (we show in the Appendix, section 7.2.1, that μ is negative).

The last two terms of equation 3 indicate how a change in h modifies the participation constraint, and how this affects the head's utility (bear in mind that $\nu \geq 0$ since the head's rent increases if the participation constraint is relaxed). Other things being equal (the distribution of labor efforts being constant), reallocation of land from the collective field to individual plots has the effect of enhancing the ability to produce $\underline{u}$ on the latter and simultaneously decreasing the ability to do so on the former. Measured by the marginal productivity of land in the two locations, this combined effect is positive overall because incentive problems exist on the collective field but not on the individual plots.[8]

Using the functional forms previously introduced, it is impossible to derive an explicit solution for the optimal size of individual plots or the head's rent in this regime (we derive an expression for $R(h)$ in the Appendix, Section 7.2.2). In the coming section, we nevertheless show that the head's rent in the mixed regime is greater than in the collective regime when land pressure is acute.

3.4 The attractiveness of the mixed regime when land pressure increases

We are able to show that whether the household head chooses to grant individual plots to members or not depends on land availability. More precisely, assuming a cobb-douglas production function and a linear cost of effort, we can state the following result:

Proposition 1 *When land is very abundant, the head always prefers a pure collective farm to a mixed structure where male members have individual plots that they cultivate for their own benefit. As land becomes scarce, however, the mixed structure becomes more attractive. In particular, there exists a level of land endowment, a^I, for which the head is indifferent between a mixed and a collective farm. If the land endowment is greater than this threshold, $a > a^I$, the head chooses a collective farm structure, while if it is below, $a < a^I$, the head chooses a mixed structure.*

Furthermore, we can show that the portion of the land dedicated to individual production is a decreasing function of land availability. The following proposition states this result.

[8] Indeed, assuming constant returns to scale, we have $f_A(h, l^I) > f_A(n(a-h), nl^C)$ (a formal proof is in Appendix 7.3, starting with equation 22). This implies, a fortiori, that: $-\nu(1-\alpha)f_A(n(a-h), nl^C) + \nu f_A\left(h, l^I\right) > 0$.

Proposition 2 *The share of farm area dedicated to individual production,* $\frac{h}{a}$*, is monotonically decreasing in land availability,* a*. When the mixed regime dominates* $a < a^I$*, a decrease in land endowment strictly increases the share of land dedicated to individual plots.*

Formal proofs for both proposition are presented in the Appendix, sections 7.3 and 7.4.

4 Land scarcity and individual plots in Mali: descriptive evidence

4.1 The data

The data used in this paper is first hand data collected in Mali in 2006 and 2007. Located in the Sahelian West African region, Mali is among the poorest countries of the world with a PPP annual income of $ 1090 per capita (for the year 2008). Close to four-fifths of the Malian population earn less than $ 2 a day and 70% live in rural areas (WDR, 2008, 2010). An interesting feature of Mali is that family farms appear to be in a state of flux: traditional collective farms headed by a patriarch are still widespread although, as pointed out in the introduction, there is an increasing tendency toward more individualized forms of cultivation.

We randomly sampled 50 villages in the three districts of Koutiala, Sikasso and San, which belong to the old cotton zone of Southern Mali. Within each village, we randomly selected 12 households from a complete listing of the local household population. In this paper, we restrict attention to the 437 households that count at least one male member above 18 beside the household head, so that there is at least one male member eligible for an individual plot in the household.[9]

Our main survey instrument is a questionnaire administered to the household heads. In addition to detailed information on the composition of the household as well as on the

[9] Some robustness checks are run on the complete sample. When we change sample, we mention it.

size and structure of the associated farm, it includes qualitative queries about the reasons underlying the granting of individual plots and the possible problems that ensued. In order to have a more complete view about the rights and duties of the different participants to the household, we also interviewed a sample of household members who cultivate an individual plot.

4.2 The broad picture

To define households, we follow Matlon (1988 cited from Udry 1996: 1016) for whom a household is a group of individuals who "work jointly on at least one common field under the management of a single decision-maker", and "draw an important share of their staple foodstuffs from one or more granaries which are under the control of that same decision-maker." Traditionally, a West African rural household is large and complex. It extends both vertically (in the sense that married sons continue to live with their father) and horizontally (brothers of the head, their wives and children are part of the household). It needs not be so, however, as recent trends indicate.

In our sample, 48% of household heads live with their brothers (or their brothers' children) while, at the other extreme, only 13% have neither brothers nor married sons around (strictly speaking, they are nuclear households). Moreover, 62% of the household heads are polygamous. On average, the sample households count 11.6 individuals above 12 with a maximum family size of 33.

Mixed farming units coexist with traditional collective farms in our study area. Individual plots are allotted to male members living on the farm in 28.8% of the households. Even more households give individual plots to women (71% of households surveyed in 2007), although women's plots are significantly smaller than men's plots.[10][11]There are two impor-

[10]We use the 2007 survey, as in 2006 some enumerators ignored very small garden plots cultivated by women.

[11]Women interviewed cultivate on average 0.41 ha of private land, to be compared with 0.85 ha for men.

tant differences between men's and women's individual plots. First, women are traditionally expected to use their private plots - called garden plots - mainly to produce ingredients of the collective meals, condiments in particular. As we have pointed out, no such requirement is imposed on the male members who keep their private production for their private use. Second, women owning an individual plot are generally freed from the duty to work on the collective field, so that there is less direct competition in effort allocation between collective and private plots as far as they are concerned. Because the awarding of individual plots to men and women obey different logics, attention is restricted to men's private activities.

Interestingly, the practice of granting private plots to the latter seems to be spreading: when asked whether male members had individual plots while they were cultivating under the authority of the former head, current heads answered "yes" in only 19.5% of the cases. Also note that in mixed farms all male members above a certain age are typically granted a plot. In the few cases where the head's brothers have an individual plot while sons do not, the latter tend to be very young.

Land markets are almost non-existent in the study area: 80% of the parcels were inherited (post or pre-mortem), 10% were cleared by the owner a few decades ago when there was still land available in the open access zones, and 9% have been borrowed by the interviewed households.[12] Low activity of land markets persists in spite of rising land pressure resulting in the quick disappearance of idle lands during the last decades. Until quite recently, indeed, land in the region was still rather abundant, and it was possible for new settlers into a village to be given land by local authorities. In addition, the labor market is hardly developed so that land available per unit of labor is not equalized across farms. In other words, the sample farms are heterogeneous in terms of land-labor endowment.

[12]Land lending is not synonymous of renting. We carefully asked to both borrowers and owners whether there was any type of cash payment, or goods and services exchanged for the land, and the answer was always negative. The land is often borrowed over several generations. With increasing land pressure, however, conflicts between owners and borrowers have become more common, frequently because the family which borrowed land a generation ago is reluctant to return it to the owner.

4.3 Functioning of the farm: the strengths and limitations of patriarchal power

Family farms are ruled by a patriarch who is typically the eldest man in the household. His authority is exerted both in the production and consumption spheres. The former is most evident on the collective field where the head has absolute power over all management decisions. Furthermore, to have access to an individual plot of land, the rule is that household members have to seek approval of the head. Justification is twofold: (1) as an authority figurehead, the head can decide "everything", so that not consulting him amounts to a lack of respect (47%); (2) "free" decisions by members are likely to cause conflicts within the family (30%).

The equal sharing rule is clearly predominant in our survey area: about 90% of the heads explicitly state that they give equal shares to the male members working on the collective field. To the extent that the head imperfectly measures individual labor effort, the equal sharing rule appears natural (see Section 2). What needs to be emphasized is that such a rule may be appropriate even when individual effort is observable. This is because differentiating payments among members may spark off accusations of unfair discrimination and cause serious intra-family conflicts, thereby undermining the cooperative spirit that is so important in family production. This argument, which has been mentioned several times in our interviews with household heads, has been occasionally discussed in the economic literature: excessive metering creates a calculative atmosphere that destroys trust and cooperation (Williamson, 1985, 1996: chap. 10; Platteau and Nugent, 1992).

When individual plots exist, management decisions including the choice of crop and supervision of effort belong to the landholding member, yet the allocation of labor time between the collective field and the individual plot is fixed by the head. Our data show that in the rainy season 38% of plot managers are free to work on their own field every day before and after their collective labor duty. The others are allowed to spend only one to two days per week on their individual plot. In the dry season, when competition between the collective field and individual plots is less acute, about 90% of plot managers are allowed to work on their plot every day.

It bears emphasis that the ability of the head to set the timetable for work on the collective field does not imply that he can control the allocation of actual labor effort between collective and individual activities. This point was made in the context of Gambia by von Braun and Webb (1989) who stress that competition unavoidably arises between personal interest and cooperation with the rest of the household when effort is allocated between collective and private production. It is revealing that in our study area almost half of the plot managers admit that they tend to give priority to cultivation of their individual plot at the expense of collective production. This is amply confirmed by the household heads who complain that family members tend to relax their effort on the collective field, thereby causing yields to fall. For example, one of them said that “more effort is applied to the individual plots and when members work on the collective plot, they are tired”. Another one complained that when they work on the collective field, his sons “are prone to keep energy in reserve for their individual plots”.[13] This sort of statements suggest that the granting of individual plots exacerbates the problem of moral-hazard-in-team on the collective field.

Detailed evidence based on the same dataset and reported in a companion paper (Goetghebuer, Guirkinger, Platteau, 2011) provides additional quantitative support to the existence of an incentive problems in collective production. It is shown there that yields on individual plots are significantly higher than yields on the collective plot, especially for care-intensive crops (e.g., rice, peanuts). This result holds in a multivariate framework when we compare plots with similar characteristics planted to similar crops within the same household. It argues for the presence of moral-hazard-in-team on the collective plot, and shows

[13] In French language, “ils se réservent”.

that it exists when care-intensive crops are considered and is reinforced when there are married male adults among the workforce.

Since in the presence of individual plots, the output of the collective field remains jointly consumed in the form of collective meals, it is unlikely that the incentive problems plaguing collective production originate in the consumption sphere. In other words, it is not plausible that individualization of productive activities is caused by conflicts over the ingredients of the jointly consumed meals or the collective organization of the daily meals. Furthermore, the head has the ability to make cash payments to remunerate effort on the collective field, so that he does not need to resort to individual plots to overcome consumption conflicts. It is thus telling that as many as 60% of our sample heads declare to be used to distribute part of the proceeds of the collective fields in the form of individualized allocations. Many of them are actually aware that this mode of remuneration offers the advantage of motivating members to work on the collective field.[14]

While we are thus confident that the presence of individual plots must be explained by incentive problems on the collective field, the precise source of productive inefficiency is not clear. As is evident from the theory proposed in Section 3, there are two effects that reinforce each other and which are hard to disentangle empirically. First, the head appropriates a share of the collective output whereas the totality of the output of a private plot accrues to the worker. Second, the collective output net of the head's share is to be divided equally among the members, giving rise to the moral-hazard-in-team problem.

The frequent mentioning by our respondents of the existence, or the fear, of intra-family conflicts and jealousies may just be revealing of pervasive incentive problems. As a matter of fact, suspicions or accusations of misbehavior and exploitation of fellow members inside the family are likely to be rooted in manifestations of labor shirking on the collective field. Likewise, as again revealed by our interviews, tensions between members and the head often

[14]To the question "How do you motivate members to work on the collective field?", 35% of household heads answered that they distribute individualized allocations from the proceeds of this field.

involve a disagreement about the excessive share of collective output retained by the head for his private consumption.

The preceding discussion deals with the nature and limitations of patriarchal decision-making power in the production sphere. It remains to be added that such power stretches beyond productive activities. Thus, when asked whether members of their family seek their approval before taking a loan, hardly 6% of the household heads answered "no". And when queried about whether in the past they have sometimes opposed such a demand, more than 87% answered "yes". In justifying their attitude, the majority argued that they consider themselves responsible for the family in general, and for repayment of defaulted loans taken by family members, in particular. Hence their perceived right to decide if members may borrow.

A final observation is in order. We observe that the awarding of individual plots to members goes hand in hand with the devolution of non-food expenditures to them. As compensation for this new burden, the members who have received private plots are not expected to transfer part of their private production to the head. From our interviews with the household heads, it is apparent that only 6% of these members have "helped" the head during the previous year through either cash or crop transfers. The figure is slightly higher when the members themselves were asked the same question, yet both the head and the members agree that when transfers are made the amount involved is typically very small.

4.4 Descriptive statistics

The prediction from our theory of the patriarchal family is that individual plots are more likely to be observed in households where land pressure is acute. Before turning to the econometric analysis, we compare the means of key variables between the two types of farms.

Table 1 reveals that land availability per man (ha_tot_pc) is larger for purely collective than for mixed farms. This difference is driven by the availability of dry land (ha_rain_pc), since mixed farms have actually more bottom land (ha_btom_pc) than purely collective farms. Bottom land[15] corresponds to plots located in a flood-recession area or irrigable with a well, so that they can be possibly cultivated beyond the rainy season and allow the growing of more water-demanding crops, such as vegetables. Equally noteworthy is that the total farm area is actually larger in mixed farms, implying that the household size is also larger. On average, households in mixed farms count close to 14 members (hh_size) against 10.6 members in collective farms. A breakdown of family into married men (married_men) and other members (others) further shows that, in mixed farms, there is about one additional married man and, therefore, one additional conjugal unit. In the same line, mixed farms have a more complex, or extended, structure than collective farms: there is larger proportion of them in which at least one brother of the head is present. Finally, and unsurprisingly, there is a noticeable continuity in the practice of awarding individual plots: the proportion of current heads who received individual plots when they were under the authority of the previous head is 36.5% in mixed farms, compared with hardly 12.5% in collective farms.

5 Land scarcity and individual plots in Mali: econometric analysis

As noted above, descriptive statistics suggest that an inverse relationship exists between land availability and individualization of agricultural production. There is, however, a need to test this relationship in a multivariate framework where proper controls are introduced. Moreover, we have seen that the composition of households varies from simple to complex structures. These differences are likely to affect the relationship between land availability and the distribution of individual plots. In particular, there is ground to suspect that the

[15] Bas-fond in French

intensity of the moral-hazard-in-team problem does not depend only on the size of the working team but also on its composition. Hence the need to also explore the effects of interactions between land availability and household composition.

In addition, the simple dichotomous comparison between collective and mixed farms, presented in the above section, does not allow us to test Proposition 2 derived in Section 3.4. This requires that we assess how the private plot area is continuously adjusted to land scarcity, making it necessary to estimate the relationship between land scarcity and the proportion of farm area devoted to private plots.

In the following we proceed in two steps. First we analyze the determinants of the probability that a household head awards individual plots to members and, second, we examine why the ratio of individualized to total land varies across households. In both cases, primary attention is given to the role of land availability.

5.1 The determinants of the probability of granting individual plots to members

We estimate a linear probability model for the probability that individual plots exist on the farm:

$$IP_{iv} = \alpha + \beta' Land_{iv} + \gamma' HHComposition_{iv} + \delta' Interaction_{iv} + \eta' Controls_{iv} + \zeta' Villages + \varepsilon$$

The dependant variable IP_{iv} is a binary variable equal to one when at least one male member of household i in village v cultivates an individual plot. Dependant variables are grouped into four vectors, the composition of which varies across specifications. Land availability (vector *Land*) cannot be measured by a single variable, owing to quality heterogeneity. In all the specifications, we control for the presence of bottom land, either through a discrete or a continuous variable. Land availability as such is measured continuously either as the total land area (dry and bottom), or the dry land area per man above 12 years old.

Regarding household composition (vector *HHComposition*), we control for household size with the help of two variables, the number of married men (married_men) and the number of other members (above 12) (others). Moreover, we include a binary variable to measure horizontal extension of the family: "brother" takes value 1 when a brother or nephew of the head is living on the farm. On the other hand, to test for the possibility that household composition affects the relationship between land availability and the distribution of private plots, we introduce appropriate interaction terms (vector *Interaction*).

The controls included in the fourth vector (*Controls*) are the following. First, the past history of private plots in the household is captured by a binary variable equal to one when the current head received an individual plot when he was under the authority of the previous head. Second, "age_hh" stands for the age of the household head.[16] Finally, we include village fixed effects (vector *Villages*) to control for local variations in land quality. This implies that the estimation of coefficients on the other explanatory variables relies on variations across households within the same village. Because we believe that allowing for fixed effects is important, we prefer to use the linear probability model rather than a logit or probit model.[17]

Table 2 presents the results of the model estimation for four different specifications, labeled S1 to S4. The differences across specifications lie in the definition of land availability and the inclusion of interaction terms. Let us first focus on the effect of land availability and family size which are the focus of this paper. In the first column, the coefficient on total land available per man has the expected negative sign but is not significantly different

[16] The reader may wonder why polygamy does not appear in our regressions. Conceptually it is not clear why the probability to be awarded an individual plot should vary according to whether a man is married to only one or several women. Since we measure polygamy at the level of the household head only, we are unable to systematically test for this effect. (We tested for an effect of polygamy of the head and found none.)

[17] As illustrated in our robustness checks (Section 5.3), using a logit or a probit model would not change the main conclusions of our analysis.

from zero. By contrast, the other land variable, the bottom land dummy, has a positive and highly significant coefficient. When we break down the land availability variable into its two components, dry and bottom lands measured continuously (S2), only bottom land appears to have a significant effect on the probability to distribute individual fields, and this effect is again positive. The effect of dry land availability remains negative but non-significant. On the face of it, these preliminary findings do not appear to confirm our theoretical predictions.

Interestingly in all regressions, the number of married men but not the number of other members of the household has a positive and significant effect on the probability of distributing private plots. Since we control for land availability measured on a per capita basis, these two results seem to be only partially consistent with our theory. Indeed, the theory suggests that when the size of the work force on the collective field is larger, the scope of the moral-hazard-in-team problem increases, which enhances the relative attractiveness of private plots where no efficiency problem arises. Since everybody works on the collective field, we would have expected that the coefficients of the two components of the workforce would have been positive and significant.

Upon careful thinking, this differentiated result is understandable and actually prompts us to refine the moral-hazard-in-team argument which plays a key role in our theory. As usually stated, indeed, this argument implies that the intensity of the moral-hazard-in-team-problem increases with the number of team members considered as equivalent units. The above result suggests that the assumption of an undifferentiated impact of group size is not applicable to the context of an extended or complex family. More precisely, the temptation to free ride on other members' efforts on the collective field appears to be perceptible when several married men work together. In our theoretical framework, this implies that n should be interpreted as the number of conjugal units rather than as the number of individual members.

Three types of explanations come to mind to explain the role of married couples. First, being strangers, daughters- or sisters-in-law bring heterogeneity into the household: they are not tied to the household by the same solidarity links and loyalty feelings as their husbands. They are therefore tempted to give precedence to their own private interests and those of their children over the collective interest of the larger family, to instill the same state of mind in their husbands, and to project onto others their tendency to free-ride. In this way, they contribute to create an atmosphere of suspicion and jealousy. Second, in the same line but in a more positive vein, thanks to their external position, daughters in law are more able and willing to question prevailing family norms and to bring latent conflicts to the surface. In this manner, they may activate pent-up feelings of frustration and resentment with the possible effect of prompting free-riding. Third, and perhaps most convincingly, when the families of married men are of unequal size, the sharing rule is bound to look arbitrary to a category of parents. Thus, if the sharing rule provides for equal incomes to all married adults regardless of the size of their family, parents with more children feel discriminated. Whereas, if shares are proportional to family size, parents with fewer children feel exploited because they work partly for the benefit of larger conjugal units. These two weaknesses of complex households have been often pointed to us in the field, and they are also stressed in anthropological and historical literature (see, for example, Worobec, 1995 p.81 for pre-communist Russia).

The implication of the above is that productive inefficiency is likely to be greater in households comprising a larger number of conjugal units. As a result, the effect of land availability on farm structure should be stronger in those households. This prediction is tested in S3 and S4 through the introduction of an interaction term between land availability and the number of married men. While in S3 the number of married men is interacted with total land available per man, in S4 it is interacted with the amount of dryland per man. In conformity with the refined theory, the coefficient of the interaction term is negative and statistically significant (at 95% confidence level) in both regressions: in families with at least one married couple (beside the head), land scarcity favors the distribution of individual plots.

Since food consumption remains collective whether individual plots exist or not and since the head has the ability to make payments in cash, an explanation of individualization stressing the benefit of individual consumption in the presence of heterogeneous preferences is not plausible (see supra, Section 4). In addition, while Foster and Rosenzweig (2002) argue that conflicts over consumption increase with wealth (when people are richer, they tend to claim more freedom for their consumption choice), our findings indicate instead that conflicts arising from the coexistence of several married couples become more important when land is more scarce. Our interpretative story therefore appears as a plausible account that offers the advantage of not only accounting for the interaction between land availability and the number of married couples, but also matching the qualitative and quantitative evidence presented in Section 4.

The category of bottom land has been singled out in all regressions. Furthermore, it has received an asymmetric treatment in S4 since we left it out of the interaction term. In apparent contradiction with our theoretical predictions, but in agreement with Boserup's hypothesis, in both S2 and S4, bottom land availability is positively correlated with the existence of individual fields. In fact, as pointed out earlier, thanks to their better access to water, bottom lands allow for different crops, which are often of comparatively high value and require more care-intensive efforts. These two characteristics imply that incentive problems are more serious on bottom than on dry lands. On the one hand, because of the higher value of the crops, the cost of inefficiency in money terms is larger on bottom lands. On the other hand, labor shirking problems are more important when quality of effort matters. Both arguments can be found in the literature. The first has actually been used to explain why regions suitable for the cultivation of high value crops experienced an earlier individualization of land tenure rules at the community level (Platteau, 2000 chap 3; Baland and Platteau, 1998). The second argument is discussed by Binswanger and Rosenzweig (1986) and by Hayami and Otsuka (1993 chap 1) who stress the existence of management diseconomies when land-saving and labor-using techniques are used. To sum up, there are two strong reasons why collective cultivation of bottom lands is less efficient than collective cultivation of dry lands. It follows that where households have more access to bottom lands individual plots are more commonly encountered.[18]

Finally, it is striking yet not surprising that in all four regressions, the history of the household influences the current farm structure. When private plots were present in the stem household, they are more likely to be observed today, and this relationship is strongly significant. It could be objected that since the distribution of individual plots in the past is influenced by the same factors as these at work in the present, our historical variable should be omitted from the regression. Our main results remain unchanged if we drop this variable. (results not shown).

In order to assess the relative magnitudes of the different effects highlighted above, we provide for S3 and S4 the coefficients estimated on the standardized explanatory variables. Variation in the number of married men is the dominant factor explaining differences in farm structure across households. When the number of married men is one standard deviation above the mean, the probability that individual plots exist increases by 0.15 in S3 and 0.16 in S4. This effect is strongly compounded by land scarcity: if land available per man decreases by one standard deviation at the same time as the number of married men increases by one standard deviation, the probability that individual plots exist increases by 0.25 in S3 and 0.26 in S4.

[18]If households with bottom land have less dry land available than those with no bottom land, we may worry that the results of S3 and S4 would be driven by the presence of bottom land. Land quality alone would then explain the granting of individual plots. To check that this is not the case, we run S3 separately on the sample of households with bottom land and on the sample of those with no bottom land. The variable "married men" is significant in both samples while the interaction term is significant only for those with no bottom land available. We are thus confident that our results are not driven by the presence of bottom land in some households.

5.2 The determinants of the share of individual plots in total farm area

In the following, we want to measure the influence of the same determinants as those used above on the share of the total farm area allotted to individual production. Our econometric model needs to account for the fractional nature of the dependent variable. Being a proportion, it is bounded by zero and one, and, in our sample, there is also a large proportion of zeros. We use the strategy proposed by Papke and Wooldridge (1996) to handle proportion models with zeros or ones. Formally, we assume that the expected value of the share of farm land dedicated to individual plots conditional on our control variables is such that:

$$E(ShareIP_i|Land_i,\ HHComp_i,\ Controls_i) = G(\alpha+\beta' Land_i+\gamma' HHComposition_i+\eta' Controls_i)$$

where G is a logistic function. To estimate the parameters, we use Bernoulli quasi-maximum likelihood estimators recommended by the authors.

In Table 3, we present three different specifications (S5 to S7) which differ according to the way we measure land availability and the way we compute the dependent variable. We report raw parameter estimates as well as marginal effects. These marginal effects appear small, but this is related to the fact that a large number of households have no individual plots. In S5, land availability is captured by two variables, the total farm area per man and a dummy for the presence of bottom lands. The dependant variable is simply the ratio of the area under individual production to the unweighted total farm area. Overall, an average 2.51% of total farm area is dedicated to individual production (the standard deviation of the share is 0.064), while in households with individual plots, these plots occupy on average 8.79% of the land (the standard deviation is 0.094). In S6, we use the same definition of the dependant variable but land availability is now broken down into two continuous variables: the area of dry land per man and the area of bottom land per man. Finally, in S7, we stick to that definition of land availability but measure differently the share under individual production. Since bottom lands are more productive than dry lands (see above) and also more likely to be cultivated individually, the correct measure of the dependant variable requires that we compute it by associating a greater weight to bottom land. In the absence of precise estimates regarding the relative productive potential of the two types of land, we are compelled to follow a rule-of-thumb, specifically we consider that one hectare of bottom land is three times as productive as one hectare of dry land.[19]

Regarding the independent variables, there are two differences between this and the previous sets of estimations. First, the following estimations do not feature any interaction term. As mentioned in our descriptive section, once individual plots exist, they are awarded to all male family members above a certain age. Therefore, once the decision is made by the head to grant individual plots, it is not clear that land scarcity should influence the relative size of private lands through the number of married men rather than directly. In fact, when included these interaction terms turn out to be non-significant and to affect the significance of the component variables. Second, village fixed effects are not included because of the incidental parameter problem that arises in the type of model used. Instead, we add two binary variables to allow for district effects.[20] Specifically, K1 is equal to one when the household was surveyed in 2006 and to zero when the household was surveyed in 2007, while Koutiala and San are equal to 1 when the household belongs to the district of the same name.

Regarding land scarcity, the estimation results confirm the theoretical prediction once we distinguish between dry and bottom lands continuously: when dry land available per man decreases, the share of private land in the total farm area increases (see S6 and S7). As for the effect of bottom land availability, it remains positive as in the previous series of

[19]With this definition, the mean (standard deviation) of the dependent variable become 3.45% (0.080) for the whole sample and 11.97% (0.111) for households with individual plots. Note that our results hold when we use alternative weights (between 1 and 5)

[20]There are three district, "cercles" in French in the sample.

estimations. The demographic composition of the household again appears to matter. Thus, a larger number of married men induces the head to increase the share of total family land allotted to private plots. Relatedly, the number of other members has no impact on the dependent variable. It is interesting to note that, when the dependent variable is measured continuously rather than discretely (as was the case in the previous set of regressions), it is affected by whether brothers of the head live in the household (variable "brothers"). Horizontal extension of the household increases the share of land dedicated to independent private production.[21]

Finally, as before, the history of the household influences the dependent variable in all the specifications used: when private plots were present in the stem household, their relative importance in the current household is larger.[22]

5.3 Robustness checks

In the following, we propose to examine two series of estimations with a view to testing the robustness of our results. In the first series, we undertake a number of classical robustness checks in which the definitions of our independent variables remain unchanged, but the model used varies. In the second series, we allow for the fact that migration, together with changes in the farm structure constitutes a possible response to land scarcity.

In table 4 we show the results obtained when we re-estimate the specifications S1 to S4 by dropping village fixed effects (S1' to S4'), using a logit model (S1 logit to S4 logit) and using a probit model (S1 probit to S4 probit). It is easily seen that our main conclusions stay unchanged.

[21]Since the "brothers" variable is obviously correlated with the number of married men, their simultaneous presence in the regression dampens the effect of the latter variable. Indeed when we drop the "brothers" variable from the regression, the significance and the size of the coefficients on married men increase in all three specifications, thus strengthening our conclusion about the importance of the number of married couples in the household (results not shown).

[22]Our results on the effect of land scarcity and family composition hold when this variable is not included (results not shown).

The presence of migrants in some of the sample households (in one-third of them, there is at least one migrant son) may create a problem for the interpretation of our results. This would be the case if the head responds to land scarcity by prompting male members to migrate, thereby increasing land available per remaining member. Migrants, indeed, would not receive private plots since they would be unable to cultivate them. As a result, the distribution of individual plots is less likely to occur in those families. The relationship we have observed between land scarcity and the incidence of private plots could then be spurious. In order to test for this possibility, we redefine the land availability variables by accounting for the presence of migrants. We have information about every living child of the household head (but not about his nephews and nieces), and know where he or she resides.[23] We can thus construct a lower bound on the number of male migrants in the sample households, and redefine land availability as the total farm area divided by the number of male members (i.e., those who reside on the farm) augmented by the (minimum) number of nale migrants. Tables 5 and 6 report the results that are obtained when we thus re-estimate S1 to S7. It is evident that our results are not affected by the redefinition of the land availability variables.

To further probe into the issue, we estimate a new model in which migration and the distribution of private plots are simultaneously explained. Specifically, we estimate a multinomial probit model where the dependant variable is a categorical variable allowing for four possibilities: no migration & no private plot (the reference category), migration & no private plot, migration & private plots and no migration & private plots.[24] In this set of estimations, the new definition of land availability is adopted (we include migrant sons in the denominator.) The results are shown in Table 7. The salient finding is that the factors explaining migration are broadly similar to those explaining the distribution of private plots. This

[23] For nephews this data is not available in the complete sample, but it is in a small sub-sample of 44 households. In this sub-sample it appears that nephews of the head are much less likely to migrate than sons.

[24] The model is estimated on the complete sample of households, 501 observations, without excluding those with no male dependent in the households, since those may have migrated.

seems to suggest that both mechanisms constitute responses to land scarcity. In particular, land availability is inversely related, and the number of married men positively related, to the probability of migration. Regarding the influence of the number of married men, the explanation put forward in Section 5.1 also applies here: the growing incidence of labor-shirking and intra-family conflicts caused by a larger number of married men induces both a more frequent distribution of individual plots and greater migration. Note that, for the last category (no migrant and private plots), the coefficient of married men is not significant but becomes significant when the variable *brothers*, with which it is correlated, is dropped.

There are two differences between the determinants of migration and those of individual plots. First, the "brothers" variable has a significant and negative impact on the migration & no private plot category, yet has no influence on the other categories. Several stories are plausible to explain this relationship but our data does not allow us to differentiate between them. For example, migration may be a less risky step when the family has no horizontal extension because the inheritance rights of departing members are more secure. Or, migration is more easily accepted by the head in the context of a small vertical family because the expected remittances will be less diluted. Second, the presence of bottom land has contrasted effects on migration and the distribution of private plots: when bottom land is measured by a discrete variable, it has no effect on migration, and when measured continuously, it is negatively correlated to migration, thus evincing a pattern similar to dry land. This last finding is actually not surprising: reduced availability of land encourages migration whether land is of a low or of a high quality but especially so if it is of a high quality (compare the coefficients on "ha_rain_pcm" and "ha_btom_pcm" in the first part of Table 7). By contrast, the positive effect of bottom land availability on the incidence of individual plots must be traced, as explained earlier, to the special characteristics of this type of land in terms of labor skills requirements.

A final remark is in order. The point can be made that our married men variable is endogenous because the head could influence the age of marriage of members. As a result, we cannot rule out the possibility that an omitted variable (e.g., the bargaining power of the member) simultaneously explains the distribution of private plots and the number of married men in the family. In this case, our estimators would be biased. We are not in a position to firmly exclude such a possibility, but we believe that it is limited. Our qualitative interviews with the sample heads have indeed revealed that the desire to marry is a strong pressure exerted on them by the members, and they feel relatively unable to counter it. Unfortunately, we do not have systematic information regarding the age at first marriage of male members. Reassuringly, for the small sub-sample (44 households) for which we know the age at marriage of male members who got married in the last three years preceding the survey (32 first marriages), this variable is not significantly different in households with (29.9 years) and without individual plots (30 years). Given the type of data that we analyze but also the nature of our research question, the evolution of farm and family structures, clean identification strategies such as experimental designs are difficult to conceive and implement. We believe that, even if the skeptical reader only reads correlation where we mention causality, our study provides rich insights into a largely unexplored field.

6 Conclusive remarks

The paper has yielded both an expected and an unexpected result. On the one hand, our prediction that increasing land scarcity should prompt household heads to give individual plots of land to (male) members is borne out by the evidence adduced on the basis of first-hand data collected in Mali. The intuition is that, when land becomes more scarce, the head has to give more weight to efficiency considerations compared to his rent-capturing ability. This is because he has to satisfy the members' participation constraints under harsher conditions than before. On the other hand, the above relationship holds only when there is at least one married couple (beside the couple of the head) within the household. Since the source of relative inefficiency of collective farm production lies in incentive problems, this suggests that the presence or suspicion of labor-shirking on the collective field does not arise when male members are all single so that consumption needs are essentially similar and there is no interference by in-laws.

It could be objected that intra-family conflicts in the presence of married couples may well arise from circumstances independent of productive inefficiencies (and divergent consumption preferences) and directly lead to the individualization of production activities. If tensions make common life unbearable, an obvious solution consists indeed of providing maximal physical distance between the places of the members' activities. In the case of our study area, however, this line of interpretation is not very convincing because members, even when granted individual plots, continue to work on the collective field. Furthermore, it is hard to imagine how intra-family conflicts could increase with land scarcity without being manifested in incentive problems on the level of production, or in conflicts over consumption choices.

Of course, we cannot rule out other possible responses to land scarcity by household heads. Migration immediately springs to mind as a complement to the practice of individual plots, and this is amply confirmed by our data. Another likely type of response consists of the break-up of the original (stem) household accompanied by a (partial) splitting of the family land assets. Although in a companion paper (Guirkinger and Platteau, 2010) we have shown formally that land pressure ought to accelerate family break-ups, our dataset does not contain sufficiently detailed information to put that relationship to test. Future research efforts should therefore be directed at estimating simultaneously the effect of land scarcity on the incidence of family break-ups and the presence of individual plots within stem households (in addition to its effect on migration). It may nevertheless be noted that the incidence of private plots is larger among bigger and more complex households, hinting at the possibility that the awarding of such plots is a substitute for household splitting.

Finally, in order to fully account for the incidence of private plot, we need to combine our explanation based on a trade-off between efficiency and rent capture considerations with an explanation based on the importance of effort incentives when labor quality matters. While the former yields the prediction that the incidence of private plots is higher when land endowment is smaller, the latter suggests that it should be more frequently observed when higher quality land necessitating care-intensive effort is present in the household's land endowment.

References

Allen, F. (1984). Mixed wage and rent contracts as reinterpretation of share contracts. *Journal of Development Economics*, 16(3):313–317.

Baland, J. and Platteau, J. (1998). Dividing the commons - a partial assessment of the new institution economics of property rights. *American Journal of Agricultural Economics*, 80:644–650.

Bauer, A. (1975). *Chilean Rural Society from the Spanish Conquest to 1930.* Cambridge University Press, Cambridge.

Binswanger, H. and McIntire, J. (1987). Behavioural and material determinants of production relations in land-abundant tropical agriculture. *Economic Development and Cultural Change*, 36:73–99.

Binswanger, H., McIntire, J., and Udry, C. (1989). Production relations in semi-arid african agriculture. In Bardhan, P., editor, *The Economic Theory of Agrarian Institutions*, pages 122–144. Clarendon Press, Oxford.

Binswanger, H. and Rosenzweig, M. (1986). Behavioural and material determinants of production relations in agriculture. *Journal of Development Studies*, 3:503–539.

Blum, J. (1957). The rise of serfdom in eastern europe. *American Historical Review*, 63:807–836.

Blum, J. (1961). *Lord and Peasant in Russia From the Ninth to the Nineteenth Century.* Princeton University Press, Princeton, New Jersey.

Boserup, E. (1965). *Conditions of Agricultural Growth.* Aldine Publishing Co., Chicago.

Carter, M. (1987). Risk sharing and incentives in the decollectivization of agriculture. *Oxford Economic Papers*, 39:577–595.

Chayanov, A. (1991). *The Theory of Peasant Cooperatives.* I.B Tauris & Co Ltd, London & New York.

DeJanvry, A. (1981). *The Agrarian Question and Reformism in Latin America.* The Johns Hopkins University Press, Baltimore & London.

Eswaran, M. and Kotwal, A. (1985). A theory of contractual structure in agriculture. *American Economic Review*, 75(3):352–367.

Fafchamps, M. (2001). Intrahousehold access to land and sources of inefficiency: Theory and concepts. In A. DeJanvry, G. Gordillo, J. P. and Sadoulet, E., editors, *Access to Land, Rural Poverty and Public Action*, pages 68–96. Oxford University Press, Oxford.

Foster, A. and Rosenzweig, M. (2002). Household division and rural economic growth. *Review of Economic Studies*, 69:839–869.

Goetghebuer, T., Guirkinger, C., and Platteau, J. (2011). Productive inefficiency in patriarchal family farms: evidence from mali. Mimeo. University of Namur.

Guillaume, M. (1987). Développement agricole et institutions: les leçons de l'expérience socialiste hongroise. Master Thesis. University of Namur.

Guirkinger, C. and Platteau, J. (2010). Transformation of the family under rising land pressure: A theoretical essay. Mimeo. University of Namur.

Hayami, Y. and Otsuka, K. (1993). *The Economics of Contract Choice -An Agrarian Perspective.* Clarendon Press, Oxford.

Holmstrom, B. (1982). Moral hazard in teams. *The Bell Journal of Economics*, 13(2):324–340.

Kolchin, P. (1987). *Unfree Labor -American Slavery and Russian Serfdom.* The Belknap Press of Harvard University Press, Cambridge, Msstts & London.

Matlon, P. (1988). *The ICRISAT Burkina Faso Farm Level Studies: Survey Methods and Data Files.* Economic Group. VLS Miscellanous Paper Series, ICRISAT, Hyderbad, India.

Papke, L. and Wooldridge, J. (1996). Econometric methods for fractional response variables with an application to 401(k) plan participation rates. *Journal of Applied Econometrics*, 11:619–632.

Pingali, P., Bigot, Y., and Binswanger, H., editors (1987). *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa.* The Johns Hopkins University Press, Baltimore & London.

Platteau, J. and Nugent, J. (1992). Share contracts and their rational: Lessons from marine fishing. *Journal of Development Studies*, 28(3):286–422.

Platteau, J.-P. (2000). *Institutions, Social Norms and Economic Development.* Harwood Academic Publishers.

Putterman, L. (1981). Is a democratic collective agriculture possible? *Journal of Development Economics*, 9:375–403.

Putterman, L. (1985). Extrinsic versus intrinsic problems of agricultural cooperation: Anti-incentivism in tanzania and china. *Journal of Development Studies*, 21:175–204.

Putterman, L. (1987). The incentive problem and the demise of team farming in china. *Journal of Development Economics*, 26:103–127.

Putterman, L. (1989). Agricultural producer co-operatives. In Bardhan, P., editor, *The Economic Theory of Agrarian Institutions*, pages 319–339. Clarendon Press, Oxford.

Putterman, L. and Digiorgio, M. (1985). Choice and efficiency in a model of democratic semi-collective agriculture. *Oxford Economic Papers*, 37:1–21.

Sadoulet, E. (1992). Labor-service tenancy contracts in a latin american context. *American Economic Review*, 82:1031–1042.

Smith, T. (1959). *The Agrarian Origins of Modern Japan*. Stanford: Stanford University Press.

Swain, N. (1985). *Collective Farms which Work?* Cambridge University Press.

Udry, C. (1996). Gender, agricultural production and the theory of the household. *Journal of Political Economy*, 5:1010–1046.

van Zanden, J. (2009). *The Long Road to the Industrial Revolution. The European Economy in a Global Perspective, 1000-1800*. Brill, Leiden and Boston.

von Braun, J. and Webb, P. (1989). The impact of new crop technology on the agricultural division of labor in a west african setting. *Economic Development and Cultural Change*, 37:513–534.

Williamson, O. (1985). *The economic institutions of capitalism: Firms, markets, relational contractin*. Free Press, New York and London.

Williamson, O. (1996). *The mechanisms of governance*. Oxford University Press.

World Developmennt Report (2008). Oxford University Press, New York.

World Developmennt Report (2010). Oxford University Press, New York.

Worobec, C. (1995). *Peasant Russia: family and community in the post-emancipation period*. Northern Illinois University Press.

7 Appendix

7.1 Optimization in the collective regime

With a Cobb-Douglas production function, $f(a,l) = a^{\varepsilon} l^{1-\varepsilon}$, and the linear cost of effort, $v(l) = \omega l$, the head's rent is $R = \alpha(na)^{\epsilon}(nl)^{1-\epsilon}$, where l is the solution to:

$$\begin{aligned}
\frac{1-\alpha}{n} f_L(na, nl) &= v'(l) && (4)\\
\Leftrightarrow (1-\epsilon)\frac{1-\alpha}{n}(na)^{\epsilon}(nl)^{-\epsilon} &= \omega && (5)\\
\Leftrightarrow a\left(\frac{(1-\alpha)(1-\epsilon)}{n\omega}\right)^{\frac{1}{\epsilon}} &= l && (6)
\end{aligned}$$

The production on the collective field is: $f^C = na\left(\frac{(1-\alpha)(1-\epsilon)}{n\omega}\right)^{\frac{1-\epsilon}{\epsilon}}$ and the head's rent is: $R = \alpha na\left(\frac{(1-\alpha)(1-\epsilon)}{n\omega}\right)^{\frac{1-\epsilon}{\epsilon}}$. This function is maximized for $\hat{\alpha} = \epsilon$, but $\hat{\alpha}$ can only be chosen by the head if the participation constraints of the members is satisfied. The participation constraint defines the maximal share the father may extract, α^M.

$$\begin{aligned}
\underline{u} &= \frac{1-\alpha^M}{n} f(na, nl) - \omega l\\
\underline{u} &= \frac{1-\alpha^M}{n}(na)\left(\frac{(1-\alpha^M)(1-\epsilon)}{n\omega}\right)^{\frac{1-\epsilon}{\epsilon}} - \omega a\left(\frac{(1-\alpha^M)(1-\epsilon)}{n\omega}\right)^{\frac{1}{\epsilon}}\\
\underline{u} &= (1-\alpha^M)^{\frac{1}{\epsilon}} a\left(\frac{1-\epsilon}{n\omega}\right)^{\frac{1}{\epsilon}}\left(\frac{n\omega}{1-\epsilon} - \omega\right)\\
\alpha^M &= 1 - \frac{n\omega}{1-\epsilon}\left(\frac{\underline{u}(1-\epsilon)}{a(n\omega - \omega + \omega\epsilon)}\right)^{\epsilon}
\end{aligned}$$

If $\alpha^M < \hat{\alpha}$, then $\alpha^* = \alpha^M$ otherwise $\alpha^* = \hat{\alpha}$. The inequality $\alpha^M < \hat{\alpha}$ is equivalent to $a < \left(\frac{n\omega\epsilon}{1-\epsilon}\right)^{\frac{1}{\epsilon}} \frac{n\underline{u}(1-\epsilon)}{n\omega-\omega+\omega\epsilon}$. Thus, if

$$a < \left(\frac{n\omega\epsilon}{1-\epsilon}\right)^{\frac{1}{\epsilon}} \frac{n\underline{u}(1-\epsilon)}{n\omega - \omega + \omega\epsilon}$$

we have that

$$
\begin{aligned}
R &= \left(1-\frac{n\omega}{1-\epsilon}\left(\frac{\underline{u}(1-\epsilon)}{a(n\omega-\omega+\omega\epsilon)}\right)^{\epsilon}\right)na\left(\frac{\underline{u}n(1-\epsilon)}{na(n\omega-\omega+\omega\epsilon)}\right)^{1-\epsilon} \\
&= na^{\epsilon}\left(\frac{\underline{u}(1-\epsilon)}{n\omega-\omega+\omega\epsilon}\right)^{1-\epsilon}-\frac{n^2\underline{u}}{n-1+\epsilon}
\end{aligned}
$$

If

$$
a > \left(\frac{n\omega\epsilon}{1-\epsilon}\right)^{\frac{1}{\epsilon}}\frac{n\underline{u}(1-\epsilon)}{n\omega-\omega+\omega\epsilon}
$$

then,

$$
R = na\epsilon\left(\frac{(1-\epsilon)^2}{\epsilon n\omega}\right)^{\frac{1-\epsilon}{\epsilon}}
$$

7.2 Optimization in the mixed regime

7.2.1 Signs of the Lagrangian multipliers

We start by showing that if the participation constraint does not bind, then $\frac{\partial V}{\partial A^I} < 0$, so that unless the participation constraint binds, it is always optimal for the father to decrease the size of the individual plots, or to increase the size of the collective field. This implies that the mixed regime can only arise if the participation constraint binds. In the following, to simplify notations, we use the subscript C for the production function on the collective field and I to designate the production function on individual plots and we ignore the arguments of the production and disutility of effort functions. If the participation constraint does not bind, $\nu = 0$ and the FOC are:

$$
\begin{aligned}
\frac{\partial L}{\partial \alpha} &= f^C - \frac{\lambda}{n}f_L^C = 0 && (7) \\
\frac{\partial L}{\partial l^C} &= \alpha n f_L^C - \lambda\left(v'' - (1-\alpha)f_{LL}^C\right) - \mu v'' = 0 && (8) \\
\frac{\partial L}{\partial l^I} &= -\lambda v'' - \mu\left(v'' - f_{LL}^I\right) = 0 && (9)
\end{aligned}
$$

The first equation implies: $\lambda = \frac{nf^C}{f_L^C}$. Substituting λ in the last equation yields: $\mu = \frac{-v'' \frac{nf^C}{f_L^C}}{v'' - f_{LL}^I}$. Since λ is unambiguously positive while μ is unambiguously negative, $\frac{\partial V}{\partial h} = -\alpha n f_A^C - \lambda \frac{1-\alpha}{n} f_{LA}^C + \mu \frac{1}{n} f_{LA}^C$ is negative.

If the participation constraint is binding, the FOC of the maximization problem are:

$$\frac{\partial L}{\partial \alpha} = f^C - \lambda \frac{1}{n} f_L^C - \nu \frac{1}{n} f^C = 0 \tag{10}$$

$$\frac{\partial L}{\partial l^C} = \alpha n f_L^C - \lambda \left(v'' - (1-\alpha) f_{LL}^C \right) - \mu v'' - \nu \left(-(1-\alpha) f_L^C + v' \right) = 0 \tag{11}$$

$$\frac{\partial L}{\partial l^I} = -\lambda v'' - \mu \left(v'' - f_{LL}^I \right) - \nu \left(-f_L^I + v' \right) = 0 \tag{12}$$

Equation (12) implies: $\mu = -\lambda \frac{v''}{v'' - f_{LL}^I}$, since $-f_L \left(A^I, l^I \right) + v'(l^C + l^I) = 0$. Equation (10) implies:

$$\nu = n - \lambda \frac{f_L^C}{f^C} \tag{13}$$

Replacing μ and ν in equation (11) by these expressions yields:

$$\begin{aligned}
& \alpha n f_L^C - \lambda(v'' - (1-\alpha) f_{LL}^C) + \lambda \frac{v''^2}{v'' - f_{LL}^I} - n(-(1-\alpha) f_L^C + v') + \lambda \frac{f_L^C}{f^C}(-(1-\alpha) f_L^C + v') = 0 \\
\Leftrightarrow \quad & \alpha n f_L^C + (n-1)(1-\alpha) f_L^C + \lambda \left(-v'' + (1-\alpha) f_{LL}^C + \frac{v''^2}{v'' - f_{LL}^I} + \frac{(f_L^C)^2}{f^C}(1-\alpha)(-1+\frac{1}{n}) \right) = 0 \\
\Leftrightarrow \quad & \lambda = -\frac{(n-1-\alpha) f_L^C}{-v'' + (1-\alpha) f_{LL}^C + \frac{v''^2}{v'' - f_{LL}^I} + \frac{(f_L^C)^2}{f^C}(1-\alpha)(-1+\frac{1}{n})} \\
\Leftrightarrow \quad & \lambda = -\frac{(n-1-\alpha) f_L^C}{(1-\alpha) f_{LL}^C + \frac{v'' f_{LL}^I}{v'' - f_{LL}^I} + \frac{(f_L^C)^2}{f^C}(1-\alpha)(-1+\frac{1}{n})}
\end{aligned}$$

This implies that $\lambda > 0$ and, as a result $\mu < 0$.

7.2.2 The head's rent for a given h

The first-order conditions of the members' utility maximization problem yield explicit expressions for the labor efforts on the collective field and individual plots:

$$l^C = (a-h)\left(\frac{(1-\alpha)(1-\epsilon)}{n\omega}\right)^{\frac{1}{\epsilon}} \quad (14)$$

$$l^I = h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}} \quad (15)$$

From the participation constraint we may now extract an expression of α as a function of h. We have:

$$\underline{u} = \frac{1-\alpha}{n} f((a-h)n, nl^C) + f(h, l^I) - v(l^C + l^I) \quad (16)$$

$$\underline{u} = \frac{1-\alpha}{n}((a-h)n)\left(\frac{(1-\alpha)(1-\epsilon)}{n\omega}\right)^{\frac{1-\epsilon}{\epsilon}} - \omega(a-h)\left(\frac{(1-\alpha)(1-\epsilon)}{n\omega}\right)^{\frac{1}{\epsilon}} \quad (17)$$

$$+ \; h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1-\epsilon}{\epsilon}} - \omega h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}} \quad (18)$$

$$\underline{u} = (a-h)\left(\frac{(1-\epsilon)(1-\alpha)}{n\omega}\right)^{\frac{1}{\epsilon}}\left(\frac{n\omega}{1-\epsilon} - \omega\right) + \omega h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}\frac{\epsilon}{1-\epsilon} \quad (19)$$

$$\alpha = 1 - \frac{n\omega}{1-\epsilon}\left(\frac{\left(\underline{u} - h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}\frac{\omega\epsilon}{1-\epsilon}\right)(1-\epsilon)}{(a-h)(n\omega - \omega + \omega\epsilon)}\right)^{\epsilon} \quad (20)$$

Therefore

$$R = \left(1 - \frac{n\omega}{1-\epsilon}\left(\frac{\left(\underline{u} - h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}\frac{\omega\epsilon}{1-\epsilon}\right)(1-\epsilon)}{(a-h)(n\omega - \omega + \omega\epsilon)}\right)^{\epsilon}\right)(a-h)n\left(\frac{\left(\underline{u} - h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}\frac{\omega\epsilon}{1-\epsilon}\right)(1-\epsilon)}{(a-h)(n\omega - \omega + \omega\epsilon)}\right)^{1-\epsilon}$$

$$= (a-h)^{\epsilon} n\left(\underline{u} - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{1-\epsilon}\left(\frac{(1-\epsilon)}{n\omega - \omega + \omega\epsilon}\right)^{1-\epsilon} - \left(\underline{u} - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)\frac{n^2}{n-1+\epsilon}$$

7.3 Proof of proposition 1

We proceed in three steps. First, we note that in both regimes the head's rent is monotonically increasing in a and it tends towards infinity. We then show that a marginal increase in land endowment has a greater impact on the head's rent in the collective than in the mixed regime, which implies that the head's rent moves "faster" to infinity in the collective regime than in the mixed regime. Finally, we show that for very small land endowments the head prefers the mixed regime. This implies that there exists a level of land endowment for which the head is indifferent between the two regimes. Above this threshold, he opts for the collective regime and, below it, he opts for the mixed regime.

Monotonicity of R(a) in both regimes

To examine the impact of a on the head's rent in both regimes we apply the envelop theorem. Let us begin by defining the Lagrangian in the collective regime:

$$L(l, \alpha) = \alpha f(na, nl) - \lambda^c \left(v'(l) - \frac{1-\alpha}{n} f_L(na), nl) \right) - \nu^c \left(\underline{u} - \frac{1-\alpha}{n} f(na, nl) + v(l) \right)$$

The envelop theorem implies:

$$\frac{\partial R}{\partial a} = \frac{\partial L}{\partial a} = n\alpha f_A(na, nl) + \lambda^c (1-\alpha) f_{LA}(na, nl) + \nu^c (1-\alpha) f_A(na, nl)$$

To find an expression for λ^c and ν^c, we write the FOC of the maximization problem:

$$\begin{aligned}
\frac{\partial L}{\partial \alpha} &= f(na, nl) - \lambda^c \frac{1}{n} f_L(na, nl) - \nu^c \frac{1}{n} f(na, nl) = 0 \\
\frac{\partial L}{\partial l} &= \alpha n f_L(na, nl) - \lambda^c \left(v''(l) - (1-\alpha) f_{LL}(na, nl) \right) - \nu^c \left(-(1-\alpha) f_L(na, nl) + v'(l) \right) = 0
\end{aligned}$$

We need to distinguish two cases: $\nu^c = 0$ (unbinding participation constraint), and $\nu^c > 0$ (binding participation constraint). In the first case, we have $\lambda^c = \frac{nf}{f_L}$, and:

$$\frac{\partial R}{\partial a} = n\alpha f_A + (1-\alpha)\frac{nf}{f_L}f_{LA} = n\alpha f_A + (1-\alpha)nf_A\tau_{LA}$$

where $\tau_{LA} = \frac{ff_{LA}}{f_A f_L}$ is the elasticity of substitution between land and labor. Because $\tau_{LA} = 1$ in the case of the Cobb-Douglas function, the above expression reduces to:

$$\frac{\partial R}{\partial a} = nf_A$$

In the second case where $\nu^c > 0$, we have $\nu^c = n - \lambda^c \frac{f_L}{f}$, so that

$$\begin{aligned}\frac{\partial R}{\partial a} &= n\alpha f_A + \lambda^c(1-\alpha)f_{LA} + (1-\alpha)(n - \lambda^c\frac{f_L}{f})f_A \\ &= nf_A + \lambda^c(1-\alpha)f_{LA}(1 - \frac{1}{\tau_{LA}})\end{aligned}$$

Since $\tau_{LA} = 1$, the above expression reduces to:

$$\frac{\partial R}{\partial a} = nf_A$$

Whether or not the participation constraint binds, the head's rent is monotonically increasing in a and in both cases the impact of a marginal increase in land endowment on the rent is simply equal to the product of the number of members and the marginal productivity of land ($=nf_A$). Note also that the limit of $R(a)$ when a tends to infinity is infinity.

Let us now consider the situation under the mixed regime. For a given h, we have:

$$\frac{\partial R}{\partial a} = \frac{\partial L}{\partial a} = \alpha n f_A^C + \lambda\frac{1-\alpha}{n}f_{LA}^C + \nu\frac{1-\alpha}{n}f_A^C$$

Since again $\nu = n - \lambda \frac{f_L^C}{f^C}$, we can write:

$$\begin{aligned}
\frac{\partial R}{\partial a} &= \alpha n f_A^C + \lambda \frac{1-\alpha}{n} f_{LA}^C + (n - \lambda \frac{f_L^C}{f^C}) \frac{1-\alpha}{n} f_A^C \\
&= n f_A^C + \lambda \frac{1-\alpha}{N} f_{LA}^C \left(1 - \frac{1}{\tau_{LA}}\right) \\
&= n f_A^C
\end{aligned}$$

When h is fixed, the head's rent is monotonically increasing in a. Therefore, when the head can adjust the size of the individual field, he will a fortiori benefit from an increase in a. For a given h, the explicit expression we obtained for the father's rent clearly implies that it tends to infinity when a tends to infinity. An fortiori argument can be used when the head is allowed to adjust the size of the individual plots.

Comparison of $\frac{\partial R}{\partial a}$ across regimes

Let us show that a marginal increase in a has a greater impact on the head's rent in the collective regime than in the mixed regime, when h is fixed. We will then argue that even if h is allowed to vary the result holds. Bearing in mind that the subscripts *col* and *mix* refer to the optimal values of the parameters and functions in the collective regime and the mixed regime respectively, we first want to show that:

$$\left(\frac{\partial R}{\partial a}\right)^{col} > \left(\frac{\partial R}{\partial a}\right)^{mix} \tag{21}$$

$$\Leftrightarrow (f_A)^{col} > (f_A^C)^{mix} \tag{22}$$

With our Cobb-Douglas specification, this inequality is equivalent to:

$$\begin{aligned} \left(\epsilon\left(\frac{nl}{na}\right)^{1-\epsilon}\right)^{col} &> \left(\epsilon\left(\frac{nl^C}{n(a-h)}\right)^{1-\epsilon}\right)^{mix} \\ \Leftrightarrow \left(\frac{l}{a}\right)^{col} &> \left(\frac{l^C}{(a-h)}\right)^{mix} \end{aligned}$$

Using the expressions for the level of effort applied on the collective field in both regimes (Equations 6 and 14), we can rewrite the previous inequality:

$$\begin{aligned} \left(\frac{(1-\alpha^{col})(1-\epsilon)}{n\omega}\right)^{\frac{1}{\epsilon}} &> \left(\frac{(1-\alpha^{mix})(1-\epsilon)}{n\omega}\right)^{\frac{1}{\epsilon}} \\ \Leftrightarrow \alpha^{col} &< \alpha^{mix} \end{aligned}$$

As argued in Section 7.1, we have,

$$\alpha^{col} \leq 1 - \frac{n\omega}{1-\epsilon}\left(\frac{\underline{u}(1-\epsilon)}{a(n\omega-\omega+\omega\epsilon)}\right)^{\epsilon}$$

Furthermore, Equation 20 establishes:

$$\alpha^{mix} = 1 - \frac{n\omega}{1-\epsilon}\left(\frac{\left(\underline{u} - h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}\frac{\omega\epsilon}{1-\epsilon}\right)(1-\epsilon)}{(a-h)(n\omega-\omega+\omega\epsilon)}\right)^{\epsilon}$$

Finally,

$$\begin{aligned} \alpha^{col} &< \alpha^{mix} && (23) \\ \Leftarrow \frac{\underline{u} - h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}\frac{\omega\epsilon}{1-\epsilon}}{a-h} &< \frac{\underline{u}}{a} && (24) \\ \Leftarrow \underline{u} &< a\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1} && (25) \end{aligned}$$

We know that this last inequality is verified: the right-hand-side expression corresponds to the utility that would be obtained by a member if he would produce individually on a field of size a. Indeed $a^\epsilon l^{1-\epsilon} - \omega l$, where $l = a\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}$ is equivalent to $a\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1-\epsilon}{\epsilon}} - \omega a\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}$, which is itself equal to $\epsilon a\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}$, and corresponds to the maximum utility achievable with a per capita level of land endowment of a. It is necessarily greater than $\underline{u}$ since the problem would not yield any solution if this were not the case.

Finally, $\alpha^{col} < \alpha^{mix}$ and $\left(\frac{\partial R}{\partial a}\right)^{col} > \left(\frac{\partial R}{\partial a}\right)^{mix}$ for a given h. If h is allowed to vary, could the head's rent increase to a greater extent in the mixed regime? The answer is negative because a marginal increase in a has a greater impact on the head's rent in the collective than in the mixed regime for all h.[25]

The dominance of the mixed regime for very small a

Suppose that $\underline{a}$ is such that the father's rent is null in the collective regime, that is, $\underline{a}$ is such that when the farm is collectively cultivated, the production is just enough to meet the reservation utilities of the membe rs leaving nothing for the head. If $\underline{a}$ would instead be dedicated to individual plots, we know that each member would obtain a utility greater than $\underline{u}$ since the first best level of effort would be applied. As a consequence, the income net of effort cost would be greater than under collective production. Thus, there exists $\underline{h} < \underline{a}$ so that members can just achieve $\underline{u}$ from their individual plot only and, by allocating $n(\underline{a} - \underline{h})$ to collective production, the head would obtain a positive rent. (The optimal h is actually smaller than $\underline{h}$). We may therefore conclude that, for some small values of a the head prefers the mixed regime.

[25] To see this, consider a marginal increase in a from a_1 to a_2. Call $h^*(a)$ the optimal size of individual plots when total land endowment is a, $R^{col}(a)$ the head's rent in the collective regime and $R^{mix}(a, h^*(a))$, his rent in the mixed regime. We know that $R^{mix}(a_2, h^*(a_2)) - R^{mix}(a_1, h^*(a_2)) < R^{col}(a_2,) - R^{col}(a_1)$. By definition, it is also true that $R^{mix}(a_2, h^*(a_2)) - R^{mix}(a_1, h^*(a_1)) < R^{mix}(a_2, h^*(a_2)) - R^{mix}(a_1, h^*(a_2))$. It follows that $R^{mix}(a_2, h^*(a_2)) - R^{mix}(a_1, h^*(a_1)) < R^{col}(a_2,) - R^{col}(a_1)$. Even when the father adjusts h in the mixed regime, therefore, his rent does not increase as much as in the collective regime.

The succession of regimes when a goes from 0 to $+\infty$

Finally, we know that for small values of a the head prefers the mixed regime. As a increases the head's rent increases monotonically towards infinity in both regimes but it increases faster in the collective regime (since $\frac{\partial R}{\partial a}$ is greater in that regime). This implies that, as a goes from 0 to $+\infty$, the mixed regime first dominates but, once a certain threshold is reached, the collective regime becomes superior.

7.4 Proof of proposition 2

We want to prove that $\frac{d\left(\frac{h}{a}\right)}{da} < 0$.

$$\frac{d\left(\frac{h}{a}\right)}{da} = -\frac{1}{a^2}h + \frac{1}{a}\frac{\partial h}{\partial a}$$

We will show that $\frac{\partial h}{\partial a} < 0$, which implies that $\frac{d\left(\frac{h}{a}\right)}{da} < 0$. To derive an expression for $\frac{\partial h}{\partial a}$, we apply the implicit function theorem to $G(h^*, a) = \frac{\partial R}{\partial h} = 0$, which defines the optimal size of individual plots, $h^*(a)$.

$$\frac{\partial h}{\partial a} = -\frac{\frac{\partial G}{\partial a}}{\frac{\partial G}{\partial h}}$$

Let us first derive an expression for $G(h, a)$, using the explicit definition of $R(h)$ under the mixed regime:

$$\begin{aligned} G(h,a) &= \frac{\partial R}{\partial h} \\ &= -\epsilon(a-h)^{\epsilon-1}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{1-\epsilon}\left(\frac{1-\epsilon}{n\omega-\omega+\epsilon\omega}\right)^{1-\epsilon} n \\ &- (1-\epsilon)\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon}(a-h)^{\epsilon}\left(\frac{1-\epsilon}{n\omega-\omega+\epsilon\omega}\right)^{1-\epsilon} n \\ &+ \epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\frac{n^2}{n-1+\epsilon} = 0 \end{aligned}$$

We first show that $\frac{\partial G}{\partial a}$ is negative. To simplify the mathematical expressions, we set $K = \left(\frac{1-\epsilon}{n\omega-\omega+\epsilon\omega}\right)^{1-\epsilon} n$

$$\begin{aligned}
\frac{\partial G}{\partial a} &= -K\epsilon(\epsilon-1)(a-h)^{\epsilon-2}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{1-\epsilon} \\
&- K\epsilon^2(a-h)^{\epsilon-1}(1-\epsilon)\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon} \\
&= K\epsilon(1-\epsilon)(a-h)^{\epsilon-2}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon}\left[u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1} - \epsilon(a-h)\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right] \\
&= K\epsilon(1-\epsilon)(a-h)^{\epsilon-2}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon}\left[u - \epsilon a\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right]
\end{aligned}$$

The term $u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}$, which is equal to $u - \omega h\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}}\left(\frac{\epsilon}{1-\epsilon}\right)$, represents the part of the reservation utility obtained from working on the collective field (as can be verified from equation 19), and it is positive. The sign of $\frac{\partial G}{\partial a}$ is thus the same as the sign of the expression in square brackets. This expression is negative as established by Equation 25. Consequently, the above expression between square brackets must be negative.

We now check that $\frac{\partial G}{\partial h} = \frac{\partial^2 R}{\partial h^2}$ is negative.

$$\begin{aligned}
\frac{\partial G}{\partial h} &= K\epsilon(\epsilon-1)(a-h)^{\epsilon-2}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{1-\epsilon} \\
&+ K\epsilon^2\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}(1-\epsilon)\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon}(a-h)^{\epsilon-1} \\
&- K\epsilon^3(1-\epsilon)\left(\frac{1-\epsilon}{\omega}\right)^{\frac{2}{\epsilon}-2}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon-1}(a-h)^{\epsilon} \\
&+ K\epsilon^2(a-h)^{\epsilon-1}(1-\epsilon)\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon}
\end{aligned}$$

$$= -K\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon-1}(a-h)^{\epsilon-2}\epsilon(1-\epsilon)$$

$$\left[\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^2 + \epsilon^2(a-h)^2\left(\frac{1-\epsilon}{\omega}\right)^{\frac{2}{\epsilon}-2} - 2\epsilon(a-h)\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)\right]$$

$$= -K\left(u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}\right)^{-\epsilon-1}(a-h)^{\epsilon-2}\epsilon(1-\epsilon)\left[u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1} - \epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}(a-h)\right]^2$$

Since all the terms comprising the above expression are positive, including the term $u - h\epsilon\left(\frac{1-\epsilon}{\omega}\right)^{\frac{1}{\epsilon}-1}$ (see supra) and the expression is preceded by a minus sign, it is unambiguously negative. We have therefore established that $\frac{\partial h}{\partial a} < 0$, so that $\frac{d\left(\frac{h}{a}\right)}{da} < 0$. In words, the portion of the family farm area allotted to individual production declines as a increases.

Table 1: Descriptive statistics of key variables for households (hh) with and without individual plots (IP)

		Without IP		With IP	
Variable	Definition	Mean	Std. dev.	Mean	Std. dev.
ha_tot_pc	ha of farm area per men	2.476	1.313	2.215	1.213
bottom	1 if bottom land on farm	0.402	0.491	0.659	0.476
ha_rain_pc	ha of rain fed land per men in hh	2.332	1.362	2.020	1.203
ha_btom_pc	ha of bttom land per men in hh	0.144	0.281	0.195	0.304
hh_size	# hh members	10.601	5.459	14.008	6.511
married_men	# married men (beside head) in hh	1.881	1.685	2.786	2.010
others	# hh members (beside married men)	7.723	4.270	10.222	5.033
brothers	1 if a brother or a nephew of head lives in hh	0.521	0.500	0.643	0.481
IP_past	1 if IP existed in stem hh	0.125	0.332	0.365	0.483
age_hh	age of hh head	56.842	14.262	60.048	13.868

Table 2: Linear Probability Models of the determinants of the granting of individual plots to members

Variable	S1	S2	S3	S3 (std X)	S4	S4 (std X)
ha_tot_pc (v1)	−0.002		0.0334	0.0422		
ha_rain_pc (v2)		−0.0137			0.0247	0.0321
bottom	0.2344***		0.2359***	0.1180***		
ha_btom_pc		0.1947**			0.2063***	0.0596***
married men (v3)	0.0364**	0.0412***	0.0811***	0.1485***	0.0864***	0.1583***
others	0.0074	0.0077	0.0067	0.0309	0.0068	0.0317
v1 * v3			−0.0199**	−0.0973**		
v2 * v3					−0.0218**	−0.1021**
brothers	0.0511	0.0557	0.0531	0.0264	0.0586	0.0291
IP_past	0.2639***	0.2753***	0.2590***	0.1023***	0.2718***	0.1073***
age_hh	0.0013	0.0014	0.0013	0.0185	0.0014	0.0198
village FE	yes	yes	yes	yes	yes	yes

***, **, *: parameter estimate significant at 1%, 5% and 10%, respectively

Table 3: Share of land in individual production

	S5	marg eff S5	S6	marg eff S6	S7	marg eff S7
ha_tot_pc	−0.1687	−0.0025				
ha_rain_pc			−0.2536**	−0.0066***	−0.2933**	−0.0102***
bottom	0.9808***	0.0144***				
ha_btom_pc			0.9077***	0.0235***	1.0474***	0.0364***
married men	0.1054*	0.0015	0.1262**	0.0033***	0.1197**	0.0042***
oth memb	0.0110	0.0002	0.0057	0.0001	0.0147	0.0005
brothers	0.7062***	0.0104**	0.7935***	0.0205***	0.6041***	0.0210***
IP_past	1.2092***	0.0178***	1.2661***	0.0328***	1.2139***	0.0422***
age_hh	0.0055	0.0001	0.0080	0.0002	0.0015	0.0001
K1	−0.5251**	−0.0077	−0.6071***	−0.0157***	−0.6246***	−0.0217***

***, **, *: parameter estimate significant at 1%, 5% and 10%, respectively

District dummies are included in all specifications

Marginal effects are computed at the mean value of continuous variables, for a household with bottom=0, IP_past=0, K1=0

Table 4: Robustness checks: LMP without village FE, logit and probit models

Variable	S1'	S2'	S3'	S4'	S1 logit	S2 logit	S3 logit	S4 logit	S1 probit	S2 probit	S3 probit	S4 probit
IP_past	0.3052***	0.3123***	0.3006***	0.3093***	1.6291***	1.6200***	1.6269***	1.6336***	0.9771***	0.9757***	0.9761***	0.9788***
brothers	0.049	0.0564	0.0514	0.0598	0.3436	0.3733	0.3665	0.4044	0.2057	0.2201	0.2192	0.2376
age_hh	0.0013	0.0016	0.0013	0.0017	0.0087	0.0108	0.0086	0.0109	0.0051	0.0064	0.0054	0.0067
married men (v1)	0.0289*	0.0324**	0.0725***	0.0755***	0.1414	0.1667*	0.4134**	0.4202***	0.0842	0.0973*	0.2390***	0.2442***
others	0.0086	0.0086	0.0079	0.0078	0.0514	0.0469	0.046	0.042	0.0306	0.0295	0.0278	0.0267
ha_tot_pc (v2)	−0.0188		0.0184		−0.1118		0.1227		−0.0677		0.0669	
ha_rain_pc (v3)		−0.0325**		0.0075		−0.1927*		0.051		−0.1161**		0.023
bottom	0.1902***		0.1867***		1.1473***		1.1475***		0.6616***		0.6602***	
ha btom pcap		0.1641**		0.1607**		0.9770**		0.9842**		0.5756**		0.5776**
v1 * v2			−0.0198**				−0.1215*				−0.0703**	
v1 * v3				−0.0213**				−0.1251**				−0.0732**
village FE	no	no	no	no	no	no	no	no	no	no	no	no

***, **, *: parameter estimate significant at 1%, 5% and 10%, respectively

Table 5: Linear Probability Models of the determinants of the granting of individual plots to members (including migrants in the land availability measures)

Variable	S1mig	S2mig	S3mig	S3mig (std X)	S4mig	S4mig (std X)
IP_past	0.2871***	0.2995***	0.2813***	0.1111***	0.2954***	0.1166***
brothers	0.0783	0.079	0.0805	0.040	0.0823	0.0409
age_hh	0.0015	0.0017	0.0015	0.0219	0.0017	0.0236
married men (v1)	0.0244	0.0286*	0.0724***	0.1327***	0.0770***	0.1410***
others	0.0096	0.0104*	0.0088	0.0408	0.0095	0.0439
ha_tot_pcm (v2)	−0.0089		0.0314	0.0378		
ha_rain_pcm (v3)		−0.0181			0.0254	0.0312
bottom	0.2216***		0.2244***	0.1122***		
ha_btom_pc		0.1713**			0.1794**	0.0504**
v1 * v2					−0.0257**	−0.1100**
v1 * v3			−0.0235**	−0.1058**		
village FE	yes	yes	yes	yes	yes	yes

***, **, *: parameter estimate significant at 1%, 5% and 10%, respectively

Table 6: Share of land in individual production (land availability accounting for migrants)

Variable	share IP	share IP	weighted share IP
IP_past	1.2055***	1.2791***	1.2301***
brothers	−0.7152***	−0.8069***	−0.6223***
age_hh	0.0051	0.0075	0.0007
married men	0.1044	0.1228*	0.1167**
others	0.0128	0.0082	0.0167
ha_tot_pcm	−0.1535		
ha_rain_pcm		−0.2473*	−0.3074**
bottom	0.9942***		
ha_btom_pcm		1.0402***	1.1833***
_cons	−4.4119***	−3.9771***	−3.2664***

Table 7: Multinomial probit estimation of the joint participation in migration and distribution of individual plots (base category: no migrants & no individual plots, 256 obs)

Variable	S8		S9		S10	
	coef.	p value	coef.	p value	coef.	p value
Migrants & No individual plot (115)						
IP_past	0.141	0.571	0.213	0.408	0.228	0.373
brothers	−0.803***	0.001	−0.766***	0.001	−0.776***	0.001
age_hh	0.022***	0.005	0.018***	0.023	0.018***	0.025
married men	0.160***	0.044	0.179***	0.027	0.175***	0.030
others	0.057**	0.052	0.040	0.175	0.044	0.143
ha_tot_pc	0.012	0.832				
ha_tot_pcm			−0.340***	0.000		
bottom	0.016	0.934	−0.082	0.681		
ha_rain_pcm					−0.329***	0.000
ha_btom_pcm					−0.900***	0.035
district 2	0.208	0.351	0.306	0.178	0.239	0.297
district 3	−0.083	0.744	−0.064	0.804	−0.136	0.603
K1	−0.503***	0.009	−0.586***	0.003	−0.569***	0.004
Migrants & individual plots (57)						
IP_past	0.990***	0.000	1.053***	0.000	1.054***	0.000
brothers	−0.256	0.383	−0.194	0.516	−0.221	0.456
age_hh	0.025***	0.012	0.022***	0.029	0.022***	0.027
married men	0.277***	0.002	0.297***	0.001	0.310***	0.001
others	0.060*	0.080	0.048	0.168	0.052	0.129
ha_tot_pc	−0.171*	0.076				
ha_tot_pcm			−0.532***	0.000		
bottom	0.852***	0.000	0.782***	0.002		
ha_rain_pcm					−0.589***	0.000
ha_btom_pcm					−0.165	0.704
district 2	0.969***	0.000	1.064***	0.000	0.968***	0.001
district 3	0.372	0.254	0.405	0.225	0.352	0.288
K1	−0.680***	0.004	−0.739***	0.002	−0.777***	0.001
No migrant & individual plots (73)						
IP_past	1.260***	0.000	1.289***	0.000	1.319***	0.000
brothers	0.193	0.474	0.188	0.489	0.218	0.423
age_hh	0.009	0.317	0.008	0.401	0.008	0.349
married men	0.113	0.194	0.118	0.176	0.131	0.131
others	0.066***	0.038	0.066***	0.039	0.066***	0.039
ha_tot_pc	−0.108	0.129				
ha_tot_pcm			−0.138*	0.060		
bottom	0.712***	0.001	0.695***	0.002		
ha_rain_pcm					−0.173***	0.025
ha_btom_pcm					0.586***	0.065
district 2	0.690***	0.006	0.720***	0.004	0.718***	0.005
district 3	0.064	0.828	0.065	0.827	0.058	0.844
K1	−0.739***	0.001	−0.746***	0.001	−0.840***	0.000

***, **, *: parameter estimate significant at 1%, 5% and 10%, respectively

For brevity, the parameter estimates on the constant are not reported.