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Intra-household Resource Allocation and Familial Ties*

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Abstract

In this paper, we investigate the link between intra-household resource allocation and familial ties between household members. We show that, within the same geographic, economic and social environments, households where members have 'stronger' familial ties (e.g. a nuclear family household) achieve near Pareto efficient allocation of productive resources and Pareto efficient allocation of consumption while households with 'weaker' familial ties (e.g. an extended family household) do not. We propose a theoretical model of the household based on the idea that altruism between household members vary with familial ties which generates predictions consistent with the observed empirical patterns.

Keywords: Intra-household Allocation, Social Norms, Extended Families, Altruism, Household Farms, Income Shocks, Risk-sharing, Consumption Smoothing
JEL Codes: O12, D13, Q1

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1 Introduction

The question as to how resources are allocated within households has long been of interest to economists. Particularly in societies where state support and market institutions are weak, the household remains an important unit of production, and investment in the human capital of children. The unitary household model, which assumes that the household acts as a single decision unit maximizing a common utility function, has been consistently rejected by empirical evidence (reviewed by Haddad, Hoddinott and Alderman 1997, Doss 2013). In contrast to the unitary household model, the collective household models allow the representation of individual behavior within the household. Chiappori (1988, 1992) has shown that simply assuming Pareto efficient allocations implies a set of testable restrictions. The basic model has been extended in several directions, including household production (e.g. Udry, 1996) and children (e.g. Thomas, 1990), among others.

The empirical tests of the collective household model, however, have been less consistent than those of the unitary household model. Attanasio and Lechene (2014), Bobonis (2009), Browning, Bourguignon, Chiappori and Lechene (1994), Browning and Chiappori (1998), Chiappori, Fortin and Lacroix (2002) and Rangel and Thomas (2005), among others, fail to reject Pareto efficiency of intrahousehold resource allocations in various contexts. On the other hand, Dercon and Krishnan (2000), Duflo and Udry (2004), Goldstein and Udry (2008), and Udry (1996) reject efficient intrahousehold resource allocations. A broad pattern emerges, however, from these seemingly conflicting empirical results. On the one hand, the studies that reject Pareto efficiency are concentrated in Africa and have tended to focus on household productive resources (e.g. Udry, 1996; Goldstein and Udry, 2008; Kazianga and Wahhaj, 2013; Guirkinger et al., 2015). On the other hand, studies that fail to reject efficiency tend to focus on consumption in developing countries (e.g. Bobonis, 2009; Attanasio and Lechene, 2014) or labor supply in developed countries.

It has been widely noted that a key element of interactions within a household is their repeated and regular nature. Game theoretic reasoning implies that individuals who expect to interact repeatedly into the future should be able to sustain greater levels of cooperation compared to those who interact sporadically. If household members care about future outcomes sufficiently, then they will be able to achieve efficiency in consumption and production decisions (Browning and Chiappori, 1988; Udry, 1996; Duflo and Udry 2004). This reasoning would apply to all individuals living under the 'same roof', whatever the nature of familial or kinship ties between them.

However, if cooperation between household members are sustained through altruism, or norms of familial rights and obligations, then households with different types of familial composition may well diverge in their behaviour. For example, while altruism may be stronger between nuclear family members, a patriarch overseeing a large household consisting of members of the extending family may be more effective in imposing rules of coordination and collaboration. Therefore, it is not clear which type of household would be more effective in the organisation of production and consumption within the household.

The role of extended families and kinship networks in economic interactions has received considerable attention from economists in recent years (see Cox and Fafchamps 2008 for a review; and di Falco and Bulte (2011, 2013), Baland et al. (2013) for recent work on sub-Saharan Africa). However, this literature generally focuses on extended family members who inhabit separate households and do not provide insights about the functioning of extended-family households as compared to nuclear family households. By contrast, there is scarce evidence on whether or how family ties affect intra-household allocation.

In this paper, we advance the literature on intra-household resource allocation and on human interactions in three ways. First, we explicitly link the household decision making process to the nature of familial ties within the household, an aspect that has been less researched in the literature. Second, we show that, within the same geographic, economic and social environments, households where members have 'stronger' familial ties achieve near Pareto efficient allocation of productive resources and Pareto efficient allocation of consumption while households with 'weaker' familial ties do not. Thus, we are able to reconcile two strands of empirical evidence in the literature that have either failed to reject or have rejected Pareto efficient allocation of household resources. This is in line with early research by Lundberg (1988) who attempted to relate labour supply of husbands and wives in the US labour market to the household structure. She found evidence that husbands and wives without pre-school children behaved like separate individuals in determining their labour supply, while families with young children appeared to determine labour supply jointly. More recently, Angelucci and Garlick (2015) found evidence of Pareto efficient consumption allocation for households with relatively old heads but not for households with relatively young heads. Third, we propose a theoretical model which is able to account for the differences in efficiency between household with 'stronger' familial ties and those with 'weaker' familial ties. For the remaining of the paper we refer to households with 'stronger' familial ties as 'nuclear' family households; i.e. households consisting of the head, his spouse or spouses and their children, and we refer to households with 'weaker' familial ties as extended family households, i.e. households that include at least one member in addition to the nuclear unit.

The setting for the empirical analysis in this paper is rural Burkina Faso. Agricultural households in Burkina Faso provide an interesting setting for exploring the topic because of the diversity of family ties that exist within the same household (discussed in Section 4) and the practice of assigning farm plots, individually, to adult household members for which they control production choices, as well as the proceeds of farm output (Udry, 1996). Besides these 'private' plots, the household farms on one or more 'collective' plots, under the management of the household head (Kazianga and Wahhaj, 2013). According to a social norm, each able household member is expected to contribute some labour to the 'collective farm' and the head is expected to use its proceeds for expenditures on household public goods (Hammond 1966; Fiske 1991; Lallemand 1977).

We find that, controlling for plot characteristics and household-crop-year fixed-effects, collective plots use labour more intensively and achieve higher agricultural yields than private plots. Using the test of efficiency in agricultural production based on the approach pioneered by Udry (1996), we are able to reject the hypothesis of efficiency in production for both extended family households and nuclear family households. However, (i) yields achieved on private plots in nuclear family households are close to those achieved on collectively farmed plots while the corresponding gaps in extended family households are significantly larger. Using data on consumption expenditures by different household members, we implement the two tests of intra-household risk-sharing, based data on (ii) consumption expenditures and idiosyncratic shocks to income from specific farm plots, following Duflo and Udry (2004) and (iii) data on child anthropometrics and shocks to mothers' farm income. With both approaches, we are able to reject the hypothesis of efficient risk-sharing for extended family households but not for nuclear family households.

Our data-set on agricultural resource allocation allows us to examine which household member is providing labour on which farm plots, and therefore, the role of familial ties in labour allocation. We find that (iv) household members who share a nuclear family tie provide more labour on each other's private farm plots, as compared to household members who share an extended family tie, or no family ties; (v) for a given relation to the household head, household members provide more labour on collective farm plots in nuclear family households than in extended family households, controlling for individual and plot characteristics and household-year fixed-effects.

To explain these empirical patterns, we propose a model of household decision-making in which nuclear family members exhibit greater altruism towards each other, or a greater alignment of preferences, compared to a pair of individuals who are unrelated or are connected by extended-family ties. This assumption can be motivated by the evolutionary approach to altruism and familial ties, based on the work of Hamilton (1964), as discussed in Cox and Fafchamps (2008). Then, labour contributions and transfers that nuclear family members make to each other voluntarily (i.e. in a Nash equilibrium) may be sufficient to achieve efficiency in production and consumption decisions within a nuclear family household. In the case of the extended family household, such voluntary contributions may be insufficient to achieve the first-best. But the existence of the social norm described above enables the household head to commit to using the output of the collective farm for the well-being of the entire household. This leads to a distortion of productive resources in favour of the collective farm but enables the household to achieve a second-best allocation.

If nuclear family households are able to allocate resources more efficiently, it raises the question why extended family households exist at all. To this question, we are able to provide two types of answers based on the available data. First, in a setting where labour markets function poorly or are non-existent, co-habitation can provide the basis of labour exchange (Guyer 1993), allowing more effective monitoring of labour by the head, as well as the remuneration in the form of private plots and provision of household public goods. Second, in the absence of formal insurance and lack of effective risk-sharing arrangements *between* households, an additional member allows greater income diversification and improves the ability of the household to engage in consumption smoothing. The addition of a extended-family member or unrelated individual to the household may reduce efficiency but would nevertheless increase net welfare if these benefits are sufficiently high. Consistent with these hypotheses, we find that (vi) households where the head has more inherited land, and consequently the marginal product of labour is higher, is more likely to include the co-residence of extended family members and unrelated individuals; (vii) household heads exposed to greater income volatility due to the characteristics of their inherited land and local rainfall conditions are more likely to end up with extended-family households; (viii) household food consumption is more sensitive to shocks to agricultural income in the case of nuclear family households than in the case of extended family households.

Extended family households, on average, have more members; and a head who is more likely to by polygynous and, on average, older. To investigate whether the differences in resource allocation between the two groups of households are due to these observed differences, we replicate the tests of efficiency in production and consumption for subsamples in which nuclear and extended family households are identical or similar along these dimensions. The pattern of results described above persists for these subsamples. It is important to recognise that the nuclear family households in our data-set are self-selected and, consequently, may differ from the extended family households along unobservable dimensions as well. However, we are unable to provide a simple story based on selection which would explain the combined evidence regarding labour use across farm plots, plot yields and consumption risk-sharing as described in (i)-(v) above. By contrast, the assumption of stronger ties across nuclear family members provides a parsimonious explanation for all these patterns and, therefore, suggests that family ties play an important role in intra-household resource allocation.

Foster and Rosenzweig (2002) develop and test a theory of household division using Indian village data, in which preference heterogeneity among household members also plays an important role. Specifically, since household public goods must, by definition, be consumed in the same quantity by families residing in 'joint households', those who have different preferences regarding private and household public goods have incentives to break away and form a household unit on its own. However, Foster and Rosenzweig (2002) assume that the allocation of resources within the joint household is efficient, and do not investigate whether and how family ties affect resource allocation *within* the joint household. By contrast, given the large body of evidence pointing to an inefficient allocation of resources within agricultural households in sub-Saharan Africa, we posit that the intra-household allocation of resources is a Nash equilibrium and estimate the level of altruism (or alignment of preferences) between household members using data on labour allocation across farm plots.

Guirkinger and Platteau (2014) develop a theory to explain both household division and individualisation of farm plots for agricultural households in West Africa, using the idea of 'moral hazard in teams' in collective farm work. While a similar mechanism may be at work for our sample of households in Burkina Faso, it would not explain why collective farms achieve higher yields than private farm plots. In particular, the distribution of plot yields across farm plots within the same household correspond closely to the distribution of labour for our sample; and therefore, we analyse the data within a theoretical framework which can account for the labour allocation choices.

The remainder of the paper is organised as follows. In the next section, we attempt to describe the evolution of household structure in West Africa during the last twenty years using household-level data and discuss possible reasons for these changes. The theoretical framework is developed in Section 3. The data used in our analysis is described in Section 4. Section 5 investigates plot yields and allocation of labour across different types of farm plots managed by the same household and compares the dispersion in yields across different types of households. We analyse how the proceeds from different types of farm plots affect consumption expenditures in Section 6, and examine risk-sharing within households using child anthropometric data in Section 6.2, making comparisons between nuclear family and extended family households. Alternative hypotheses for the pattern of results are explored in Section 7. In Section 8, we discuss possible explanations for the presence extended-family households in West Africa, and provide evidence regarding this explanations. Section 9 concludes.

2 Evolution of Household Composition in West Africa

We define a nuclear family household as one that consists only of the household head, his wife or wives and their children. Extended family households would include at least one individual who does not belong to the household head's nuclear family. In the African context, a household may be composed of one or more 'cooking units', embedded within a 'farming group' (i.e. a group of individuals who farm together) and a dwelling group (Goody, 1989).

Extended family households can arise from married sons or siblings who decide to raise their own families within their father's or brother's household and from other adult relatives who decide to join the households. (e.g. Adepoju, 2005; Akresh, 2009; Coulson, 1962; Young and Ansell, 2008). Child-fostering, a practice which is widely observed in sub-Saharan Africa, would also lead to extended family households according to our definition (Akresh 2009).

Widespread market failure in rural labour markets means that family or household members are, commonly, the main source of farm labour for small-holder agricultural households in sub-Saharan Africa. This has historically provided an impetus for the cohabitation of individuals who do not belong to the same nuclear family (Guyer 1993).

It has been argued in the literature that rising land pressures are one of the key drivers behind the individualisation of land tenure which, in turn, can cause agricultural households to split up into smaller farming units (see, for example, Guirkinger and Platteau 2014 and the references within). The same pressures, coupled with the growth of income-earning opportunities outside of agriculture would make it more difficult for agricultural households to hold on to its working members with the promise of land assets or future claims on the earnings generated by these assets. To the extent that there are stronger ties between members of a nuclear family than between members of the extended family and unrelated individuals, these pressures can lead to an evolution of agricultural households towards the nuclear family model.

The Demographic and Health Surveys (DHS), which provides data on household composition across countries and over time using consistent definitions, allow us to examine how the prevalence of nuclear family households is evolving over time. Table 1 reports the proportion of nuclear family households for 9 countries in West Africa using DHS surveys conducted in the region during the period 1993-2013. In 5 out of 9 countries, the share of nuclear family households has risen over this period. It has remained stable in 3 countries and has declined in one country (Ghana). The multiplication of urban households, by itself, cannot account for these changes; the pattern persists when we restrict the analysis to the rural subsample.

It is important to recognise that the evolution towards the nuclear family model does not imply a weakening of the extended family network or kinship-based ties. Indeed, there is a large literature emphasizing the important role that these networks continue to play in economic affairs in sub-Saharan Africa (for recent studies on the subject, see, for example, di Falco and Bulte (2011, 2013); Baland et al. (2013)). But evolution in the composition of the household raises the question whether nuclear family households, in any fundamental way, operates differently from extended family households. That is the question we address in this paper within the context of agricultural households in Burkina Faso.

3 Theoretical Framework: Intra-household Allocation of Land, Labour and Consumption Expenditures

Consider a household consisting of n adult members labelled $i = 1, .., n$. The household has total farm land of area A which is to be allocated among the different household members and a 'common' plot. Each household member i has a labour endowment of E^i which he or she would allocate across the different farm plots after the land has been divided up. There is no agricultural labour market and therefore all plots must be farmed using household labour.

We denote by A_j the size, and by L_{mj} and L_{fj} the total amount of male and female labour allocated to household plot $j \in \{1,..,n,c\}$. Here, $j = c$ denotes the common plot, and $j \in \{1,..,n\}$ represents the private plot assigned to household member j. We assume, for simplicity, that the crop grown and the agricultural technology employed, is the same across all plots. Agricultural output from plot j is given by

$$y_j = F\left(A_j, L_{mj}, L_{fj}\right) \tag{1}$$

where $F(.)$, the production function is increasing and concave in each argument. Let $\mathbf{y} = (y_1, .., y_n, y_c)$ denote the income levels of the household from its different agricultural plots.

The proceeds from the farms can be spent on either private goods or a household public good. Person i's utility from consumption is given by the function $u^i(\mathbf{x}, z)$ where $\mathbf{x} = (x_1, x_2, .., x_n)$, x^i is total expenditures on person i's private good and z denotes total expenditures by the household on household public goods.

3.1 Collective Household Model

Given reservation utilities $(\underline{u}^1, .., \underline{u}^n)$, the following optimisation problem yields a Pareto-efficient allocation of land and labour across different types of farm plots, and consumption expenditures on different goods:

$$\max_{\mathbf{A},\mathbf{L}^1,..,\mathbf{L}^n,\mathbf{x},z} u^1(\mathbf{x}, z) \tag{2}$$

subject to

$$\begin{aligned}
u^i\left(x^i, z\right) &\geq \underline{u}^i \text{ for } i = 2,..,n &(3)\\
y_j &= F\left(A_j, L_{mj}, L_{fj}\right) \text{ for } j = 1,..,n,c &(4)\\
A_c + \sum_{i=1}^{n} A_i &= A &(5)\\
L_c^i + \sum\nolimits_{j=1}^{n} L_j^i &\leq E^i \text{ for } i = 1,..,n &(6)\\
z + \sum\nolimits_{i=1}^{n} x^i &\leq y_c + \sum\nolimits_{j=1}^{n} y_j &(7)\\
L_{mj} &= \sum_{i \in \mathcal{I}_m} L_j^i,\ L_{fj} = \sum_{i \in \mathcal{I}_f} L_j^i &(8)
\end{aligned}$$

where $\mathbf{A} = (A_c, A_1, .., A_n)$ is a vector describing the intra-household allocation of land – and $\mathbf{L}^i = (L^i_c, L^i_1, .., L^i_n)$ the allocation of labour by household member i – across the different household plots, $\mathbf{x} = (x_1, .., x_n)$ represents expenditures on private goods consumed by different household members and z captures expenditures on the household public good. We denote by $\mathcal{I}_m$,$\mathcal{I}_f \subset \{1, .., n\}$ the subset of household members who are male and female, respectively.

It is well-known that the optimisation problem in (2)-(7) implies efficiency in household production choices. In particular, it implies that farm yields and labour intensity across plots owned by the same household should be independent of the household member to whom the plot is assigned, and forms the basis of the test of the Collective Household Model used by Udry (1996), and subsequently by Goldstein and Udry (2008), Kazianga and Wahhaj (2013), and Guirkinger et al. (2015).

3.2 Non-Cooperative Decision-Making between Altruistic Household Members

In this section, we develop an alternative model where decisions are made in a non-cooperative manner – i.e. there is no binding agreement regarding intra-household allocation. In the next sub-section how the degree of atruism affects intra-household allocation.

The household head decides how to divide up the available land between different household members and, potentially, a common plot. Each household member i has a reservation utility $\underline{u}^i$ which they can obtain if they exit the household. Therefore, to ensure that other members remain within the household, the head has to ensure that each is able to attain at least his or her reservation utility from the intra-household allocation of land, and subsequent labour and consumption choices within the household. The head cannot commit ex-ante (i.e. before production takes place) to making private transfers from any farm plots over which he retains control. However, following the ethnographic literature, we assume that there is a social norm that prescribes that the proceeds from the common plot be spent on household public goods.[1] The norm can potentially incentivise other household members to provide labour on the common plot (in the knowledge that they wil derive some utility from its proceeds). Modelling the social norm is not essential for deriving the key predictions of the model but it simplifies the analysis. and, provides a rationale for the presence of common plots, which are widely prevalent in the study area (see Section 4).

We assume that violating the social norm can have costly social consequences and, therefore, the head always acts according to the norm. Thus, we have $z \geq y_c$. We focus on the case where, given the level of expenditures on household public goods by the head, all other household members make zero contribution to household public goods from their own

[1] See references in the introduction and the discussion in Kazianga and Wahhaj (2013).

private plots and they make zero contribution to private expenditures pertaining to other household members. Thus, we have $z = y_c$ and $x^i = y_i$. We denote by $z(\mathbf{y})$ and $x^i(\mathbf{y})$, $i = 1, .., n$ the household's expenditures on different goods as a function of its income from the different household plots.

Given the functions $z(\mathbf{y})$ and $x^i(\mathbf{y})$, $i = 1, .., n$, we can analyse the labour decisions by the household members. Besides their own plot and the common plot, they may contribute labour to each other's private plots if they have altruistic preferences. Each household member i allocates labour according to the following optimisation problem:

$$\max_{L_c, L_1^i, .., L_n^i} u^i \left(x^1(\mathbf{y}), .., x^n(\mathbf{y}), z(\mathbf{y}) \right) \tag{9}$$

subject to

$$\begin{aligned} y_j &= F(A_j, L_{mj}, L_{fj}) \text{ for } j = 1, .., n, c \\ L_{mj} &= \sum_{k \in \mathcal{I}_m} L_j^k, \; L_{fj} = \sum_{k \in \mathcal{I}_f} L_j^k \text{ for } j = 1, .., n, c \\ E^i &\geq L_c + L_1^i + ... + L_n^i \end{aligned}$$

From the optimisation problem, we obtain the following first-order conditions:

$$\begin{aligned} u_j^i \frac{\partial F(A_i, L_{mj}, L_{fj})}{\partial L_{mj}} &= u_z^i \frac{\partial F(A_c, L_{mc}, L_{fc})}{\partial L_{mc}} \text{ for each } j \in \{1, .., n\} \\ \text{such that } L_j^i &> 0 \text{ if } i \in \mathcal{I}_m \end{aligned} \tag{10}$$

$$\begin{aligned} u_j^i \frac{\partial F(A_i, L_{mj}, L_{fj})}{\partial L_{fj}} &= u_z^i \frac{\partial F(A_c, L_{mc}, L_{fc})}{\partial L_{fc}} \text{ for each } j \in \{1, .., n\} \\ \text{such that } L_j^i &> 0 \text{ if } i \in \mathcal{I}_f \end{aligned} \tag{11}$$

Given $\mathbf{A}$ and $\overline{\mathbf{L}}^1(\mathbf{A}), .., \overline{\mathbf{L}}^n(\mathbf{A})$, we can determine the farm income from each plot $\mathbf{y}$, and thus household spending on each good $x_1, .., x_n, z$. Therefore, we can write consumption expenditures directly as a function of intra-household land allocation: $\bar{x}_1(\mathbf{A}), .., \bar{x}_n(\mathbf{A}), \bar{z}(\mathbf{A})$.

The head of the household allocates land between the common plot and the private plots of the other household members to maximise his own utility (which can depend on the private consumption of other family members). However, he also has to ensure that the private plots awarded to the other household members are large enough that they would choose to remain within the household. His optimisation problem can be written as follows (we choose the index 1 to represent the household head):

$$\max_{\mathbf{A}} u^1 \left(\overline{x}_1(\mathbf{A}), .., \overline{x}_n(\mathbf{A}), \overline{z}(\mathbf{A}) \right) \tag{12}$$

$$\text{subject to } u^i \left(\overline{x}_1(\mathbf{A}), .., \overline{x}_n(\mathbf{A}), \overline{z}(\mathbf{A}) \right) \geq \underline{u}^i \text{ for } i = 2, .., n \tag{13}$$

$$A_c + \sum_{i=1}^{n} A_i = A \tag{14}$$

The optimisation problem described in (12)-(14) determines the size of each farm plot within the household, including the common plot.

Guirkinger and Platteau (2015) develop an alternative but closely related theory on the intrahousehold allocation of farm land to explain the existence of mixed farms. The key difference in their work is that the household head is able to assign not only private plots to other household members but also transfers that can be made contingent on the total output on a 'collective' plot. These transfers provide household members incentives to work on the 'collective' plot but the labour allocation is inefficient because of the problem of 'moral hazard in teams'. By contrast, we assume that the household head cannot commit to making such transfers at all but the social norm – which obliges him to spend the proceeds of the common plot on household public goods – provides an alternative source of incentives for other household members to contribute labour to the common plot.

3.2.1 The Effect of Stronger Ties within the Household

To investigate how, given the framework outlined in Section 3.2, altruism or familial ties affect the intra-household allocation of resources, we introduce specific parametric forms for the production and utility functions. We represent the farming technology using a Cobb-Douglas production function and preferences using constant-elasticity-of-substitution utility functions as follows

$$F\left(A_k, L_{mk}, L_{fk}\right) = \left(A_k\right)^{\alpha}\left(L_{mk}\right)^{\beta_1}\left(L_{fk}\right)^{\beta_2} \text{ for } k = c \text{ or } k \in \{1,..,n\} \tag{15}$$

$$U_i\left(\mathbf{x}, z; \delta_i\right) = \left[\left(x_i\right)^{\rho} + \delta_{ic}\left(z\right)^{\rho} + \sum_{j \neq i} \delta_{ij}\left(x_j\right)^{\rho}\right]^{\frac{1}{\rho}}, \ i \in \{1,..,n\} \tag{16}$$

where $\delta_{ij}, \delta_{ji} \in [0,1]$ capture the level of altruism between household members i and j and δ_{ic}, δ_{jc} their relative preferences for household public goods. If $\delta_{ij} = \delta_{ji} = 0$, then household members i and j do not care at all about each other's private consumption. On the other hand, if If $\delta_{ij} = \delta_{ji} = 1$ and $\delta_{ic} = \delta_{jc}$, then their preferences are perfectly aligned.

Labour Use Intensity: Consider a male household member i and a female household member j who both contribute labour to the common plot and each other's private plots. From the first-order conditions in (10) and (11), we obtain

$$\delta_{ic}\frac{(z)^{\rho}}{L_{mc}} = \frac{(x_i)^{\rho}}{L_{mi}} = \delta_{ij}\frac{(x_j)^{\rho}}{L_{mj}} \tag{17}$$

$$\delta_{jc}\frac{(z)^{\rho}}{L_{fc}} = \delta_{ji}\frac{(x_i)^{\rho}}{L_{fi}} = \frac{(x_j)^{\rho}}{L_{fj}} \tag{18}$$

Then we obtain a relationship between the labour use intensity on the common plot and each private plot (the derivation is shown in the Theoretical Appendix):

$$\begin{aligned}
\ln\left(\frac{L_{mc}}{A_c}\right)-\ln\left(\frac{L_{mi}}{A_i}\right) &= \left[\frac{\rho\left(\alpha+\beta_1+\beta_2\right)-1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\frac{A_c}{A_i}\right)+\left[\frac{1-\rho\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\delta_{ic}\right) \\
&+ \left[\frac{\rho\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\left[\ln\left(\delta_{jc}\right)-\ln\left(\delta_{ji}\right)\right] \qquad (19) \\
\ln\left(\frac{L_{mc}}{A_c}\right)-\ln\left(\frac{L_{mj}}{A_j}\right) &= \left[\frac{\rho\left(\alpha+\beta_1+\beta_2\right)-1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\frac{A_c}{A_j}\right)+\left[\frac{\rho\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\delta_{jc}\right) \\
&+ \left[\frac{1-\rho\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\left[\ln\left(\delta_{ic}\right)-\ln\left(\delta_{ij}\right)\right] \qquad (20)
\end{aligned}$$

According to equations (19) and (20), any differences in the use of male labour (per unit area) is due to differences in plot characteristics (as represented by A_c, A_i and A_j), relative preferences for household public goods versus private goods, and (lack of) altruism between household members (as represented by δ_{ij} and δ_{ji}). If $\delta_{ij} = \delta_{ji} = 1$ and $\delta_{ic} = \delta_{jc}$, then preferences across household members are identical and we obtain an efficient allocation of labour across farm plots as in the Collective Model and the Unitary Model of the household. We can represent lower levels of altruism by using smaller values of δ_{ij} or δ_{ji} and this would lead to a widening gap in the intensity of labour use between the private plots and the common plot, in favour of the common plot. Equivalent results for female labour use intensities are shown in the Theoretical Appendix.

Plot Yields: Using (19) and (20), we can also compute the gap in yields between the common plots and the private plots (the derivation is shown in the Theoretical Appendix):

$$\begin{aligned}
\ln\left(\frac{y_c}{A_c}\right)-\ln\left(\frac{y_i}{A_i}\right) &= \Gamma\ln\left(\frac{A_c}{A_i}\right)+\left[\frac{\beta_1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\delta_{ic}\right) \\
&+ \left[\frac{\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\left[\ln\left(\delta_{jc}\right)-\ln\left(\delta_{ji}\right)\right] \qquad (21) \\
\ln\left(\frac{y_c}{A_c}\right)-\ln\left(\frac{y_j}{A_j}\right) &= \Gamma\ln\left(\frac{A_c}{A_j}\right)+\left[\frac{\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\delta_{jc}\right) \\
&+ \left[\frac{\beta_1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\left[\ln\left(\delta_{ic}\right)-\ln\left(\delta_{ij}\right)\right] \qquad (22)
\end{aligned}$$

where $\Gamma = (\alpha-1)+(\beta_1+\beta_2)\left[\frac{\alpha\rho}{1-\rho(\beta_1+\beta_2)}\right]$. From (21) and (22), we find that any differences in yields between the common plots and the private plots are, once again, due to differences in plot characteristics, relative preferences between household public goods and private goods, and divergent preferences between household members. If $\delta_{ij} = \delta_{ji} = 1$ then, allowing for differences due to plot size, and preferences for household public goods, the yields across common plots and private plots are identical as implied by efficiency in agricultural production. For lower values of δ_{ij} and δ_{ji}, a yield gap opens up in favour of the common plot.

Most importantly, equations (21) and (22) – and the corresponding equations for labour use intensities – provide a link between the allocation of productive resources within the household and the extent of altruism between household members, which can be investigated with plot-level data from agricultural households. We discuss and implement empirical tests implied by these equations in Section (5).

Individual Labour Contributions on Plots: Note that the first-order conditions on labour in (10) and (11) relate to *total* labour on farm plots. Therefore, they do not pin down *individual* labour contributions. However, if we assume that work is shared equally among all male/female household members who provide labour on a plot – as in a symmetric Nash equilibrium – we can derive a set of equations relating individual labour contributions across farm plots. Let us denote by $n_m(i)$ and $n_m(j)$ the total number of male workers on the farm plots of i and j respectively. Rearranging (36) and (37) and dividing by the log of number of workers on each plot, we obtain

$$\begin{aligned} \ln\left(\frac{1}{n_m(i)}\frac{L_{mi}}{A_i}\right) - \ln\left(\frac{1}{n_m(j)}\frac{L_{mj}}{A_j}\right) = & \left[\frac{\rho(\alpha+\beta_1+\beta_2)-1}{1-\rho(\beta_1+\beta_2)}\right]\ln\left(\frac{A_i}{A_j}\right) \\ & +\left[\frac{\rho\beta_2}{1-\rho(\beta_1+\beta_2)}\right]\ln(\delta_{ji}) \\ & -\left[\frac{1-\rho\beta_2}{1-\rho(\beta_1+\beta_2)}\right]\ln(\delta_{ij})+\ln\left[\frac{n_m(j)}{n_m(i)}\right] \end{aligned} \tag{23}$$

Using the equation above, we can compare labour contributions between household members who share different types of family ties. Suppose that for individuals belonging to the same nuclear family, we have $\delta_{ji} = \delta_{ij} = \delta_n > 0$ and δ_e is the corresponding parameter for individuals belonging to different nuclear families such that $1 > \delta_n > \delta_e > 0$.[2] Suppose that i and j share a nuclear family tie while j' is a cohabitating individual who belongs to a different nuclear family. If i contributes positive amounts of labour on the plots of both j

[2]The assumption that individuals sharing a nuclear family tie would exhibit higher levels of altruism towards each other than individuals sharing an extended family tie or no familial ties can be motivated by the evolutionary approach to familial ties and altruism, based on the work of Hamilton (1964), as discussed in Cox and Fafchamps (2008). In fact, this approach would yield more precise predictions regarding altruism between different households than what we are assuming here. Our simplified approach is due to the fact that the data provides limited information on the familial relations within the household.

and j', then we obtain

$$\begin{aligned}\ln\left(\frac{1}{n_m(i)}\frac{L_{mi}}{A_i}\right)-\ln\left(\frac{1}{n_m(j)}\frac{L_{mj}}{A_j}\right) &= \left[\frac{\rho(\alpha+\beta_1+\beta_2)-1}{1-\rho(\beta_1+\beta_2)}\right]\ln\left(\frac{A_i}{A_j}\right) \\ &- \left[\frac{1}{1-\rho(\beta_1+\beta_2)}\right]\ln(\delta_n)+\ln\left[\frac{n_m(j)}{n_m(i)}\right] \quad (24)\\ \ln\left(\frac{1}{n_m(i)}\frac{L_{mi}}{A_i}\right)-\ln\left(\frac{1}{n_m(j')}\frac{L_{mj'}}{A_{j'}}\right) &= \left[\frac{\rho(\alpha+\beta_1+\beta_2)-1}{1-\rho(\beta_1+\beta_2)}\right]\ln\left(\frac{A_i}{A_{j'}}\right) \\ &- \left[\frac{1}{1-\rho(\beta_1+\beta_2)}\right]\ln(\delta_e)+\ln\left[\frac{n_m(j')}{n_m(i)}\right] \quad (25)\end{aligned}$$

Equations (24) and (25) provide a link between i's (male) labour contribution on his private plot, the private plot of another household member, and the nature of the family tie between them. For example, if the private plots of i and j are identical (i.e. $A_i = A_j$), their preferences are perfectly aligned ($\delta_n = \delta_{ji} = \delta_{ij} = 1$) and equal numbers of men work on their respective plots ($n_m(i) = n(j)$), then i will work equal amounts of time on the two plots. If δ_n is below 1, he will spend relatively more time on his own plot. Following the same reasoning, we can derive parallel equations for individual female labour contributions across private plots.

To have a prediction about the amounts of time i works on the plots of nuclear and extended family members, we need to know the relative sizes of $n_m(j)$ and $n_m(j')$. It can be shown that if $\delta_n > \delta_e$ and all household members have the same preference parameter for the household public good (e.g. $\delta_{ic} = \delta_{jc} = \delta_{j'c} = \delta_c$), then for each private plot, only the owner's nuclear family relations will contribute positive amounts of labour. But if the plot owner has no cohabiting nuclear family members of a given gender, then all workers of that gender contribute positive amounts of labour. Typically, in extended-family households, by far the largest nuclear family unit is that of the household head.[3] and a cohabiting extended family member (of the head) is less likely to have a nuclear family member of a particular gender than would a member of the main nuclear family unit. Therefore, if i and j belong to the head's nuclear family, we would expect $n_m(j') > n_m(j)$. Then, it follows from (24) and (25) that, controlling for plot characteristics, i contributes more labour per unit area on the private plot of a nuclear family member than that of an extended family member (or an unrelated individual living within the same household). We test this hypothesis using data on individual labour contributions on farm plots in Section 5.3.

Intra-household Land Allocation: To summarise the preceding results, when household members have 'weaker ties' or lower levels of altruism (i.e. lower values of δ_{ij} and δ_{ji}) they provide less labour on each other's private plots, while increasing their labour on the common plot. The social norm requiring that the proceeds of the common plot be spent on

[3]As discussed in Section 4, for the sample of rural Burkinabe households used in this paper, the average household size is 11.78, and the average size of the head's nuclear family within the household is 7.19 members.

household public goods - discussed above - ensures that they always have the incentive to work on the common plot. These incentives provide a rationale for the existence of common plots, and for allocating a greater share of the household's farmland to the common plot when household members have 'weaker ties'. However, household members who have weaker ties to the head may also be more inclined to exit the household. Consequently, they would need to be assured a higher level of private consumption to be persuaded to remain part of the household. Therefore, how levels of altruism affect intra-household land allocation and, in particular, the share of the household's farmland allocated to the common plot is theoretically ambiguous.[4]

Risk-sharing Arrangements: We can show that it is easier to implement a consumption risk-sharing arrangement when δ_{ij}, δ_{ji} are large. To be precise, imagine that there is a stochastic component to output from each plot, such that

$$y_k = F\left(A_k, L_{mk}, L_{fk}\right) + \varepsilon_k \text{ for } k = i, j, c \tag{26}$$

where the ε_k's are identically and independantly distributed. A consumption risk-sharing arrangement can take the form of a set of state-contingent transfers $\{\tau_i(\mathbf{y}), \tau_j(\mathbf{y}), \tau_c(\mathbf{y})\}$ from each household member to a common fund satisfying the condition $\tau_i(\mathbf{y}) + \tau_j(\mathbf{y}) + \tau_c(\mathbf{y}) = 0$. For any given $\mathbf{y}$, the maximum transfer that i is willing to make in a self-enforcing agreement is increasing in δ_{ij}, because a larger value of δ_{ij} translates into a stronger preference for the expenditures made by j and the same applies to j.[5] Consequently, it can be shown that larger δ_{ij}, δ_{ji} values will lead to greater consumption smoothing. In the extreme, if $\delta_{ij} = \delta_{ji} = 1$ and $\delta_{ic} = \delta_{jc}$, we obtain efficient risk-sharing within the group. Even if such a self-enforcing agreement cannot be implemented, some degree of risk-sharing can be achieved through voluntary (stage-dependent) transfers by each household member. It is straightforward to show that these transfers are larger, and therefore the extent of risk-sharing greater, when δ_{ij}, δ_{ji} are larger.

4 Description of Survey and Descriptive Statistics

The dataset we use for the empirical exercise in this paper is composed of a panel of households surveyed by the Office of Agricultural Statistics of the Ministry of Agriculture in Burkina Faso. The sample consists of 747 villages and about 6 households per village and

[4]Since the empirical relationship between family ties and the share of the common plot would not constitute a test of any of the theoretical models of the household considered in this paper, we do not report on them. Estimates reported in Kazianga and Wahhaj (2015), based on the same data used in this paper, indicate that the share of land allocated to common plots in extended family households is 2 percentage points smaller that the share of land allocated to common plots in nuclear family households. Guirkinger and Platteau (2014) obtain similar results in the context of rural Mali.

[5]Ligon, Thomas and Worrall (2002) and Fafchamps (1992) investigate in detail how changes in preference parameters affect the scope of risk-sharing within a group in the absence of external enforcement.

is designed to be nationally representative. The survey rounds that we used were fielded in 2010, 2011 and 2012. The survey was mainly focused on collecting information related to farm activities. Hence it contains detailed information on household demographics and farm activities, but has very limited information on consumption. The collected information includes farm characteristics (farm size, topography and distance to the homestead), production technologies, agricultural inputs and outputs, and farm labour. Information relating to each farm plot was obtained from the individual in the household who had responsibility for it during that season. The survey distinguished between household plots managed collectively and plots managed individually. The enumerators lived in the sampled villages and were instructed to visit the sample households at the end of each farming activity, i.e. field preparation, planting, weeding and harvesting.

Information on farm labour was collected at the individual-plot level; i.e. the survey recorded how many days each household member laboured on each farm plot. We combine this detailed information on farm labour and plot ownership to provide a full description of labour and land exchange within the household, a feature which is unique to this survey.

Characteristics of Nuclear and Extended Family Households: We use the demographic information in each survey to distinguish between extended and nuclear family households. As per the definitions given in the preceding section, we have 8,080 observations of extended family households and 5,723 observations of nuclear family households from the Ministry of Agriculture survey, as shown in Table 2.[6] On average, extended family households are larger, consisting of 11.78 household members versus 7.30 for nuclear family households. But this difference is almost exactly accounted for by the average number of extended family members in the former households (4.59). Furthermore, extended family households have significantly more married men (1.76 versus 1.04) and the household head have significantly more wives (1.57 versus 1.47). The head in extended family households is also slightly older and marginally more likely to be literate. Turning to the farm characteristics in the table, we see that extended family households have significantly more land, and have, on average, more farm plots under cultivation in a specific year.

Table 3 provides descriptive statistics by farm plot, broken down by plot-type (i.e. private plots and common plots) and by household-type (nuclear family households and extended family households). Common plots managed by the household head are an order of magnitude larger than the other plots (average area of 4.21 hectares as compared to 0.50 hectares for male private plots) but labour use intensity and yields are broadly similar across all types of plots.

Common plots in extended family households are significantly larger than in nuclear family households, but nuclear family households allocate a slightly larger share of household

[6]Note that households may change status from one year to the next, an issue that we shall address in the subsequent discussions.

farm land to the common plots. Members of nuclear family households allocate a greater share of their labour to common plots, compared to members of extended family households (82 per cent versus 79 per cent for men and 67 per cent versus 64 per cent for women). Based on average yields, men's private plots are the most productive and women's private plots the least productive in nuclear family households. In extended family households, the head's common plots are the most productive and, as within nuclear households, women's private plots are the least productive. The yield gap between the most productive and the least productive type of plots is larger within extended family households[7]. This suggests that extended family households may be relatively less efficient than nuclear family households in allocating its productive resources. We will revisit these issues in the econometric analyses.

Table 4 shows the labour allocation of adult household members across different types of household plots. For both men (top panel) and women (bottom panel), the average amount of labour allocated to the household head's common plots is an order of magnitude higher than on any other type of plot. Men allocate about 69 percent of their time and women about 62 percent of their time on the head's common plots. Men allocate on average 4 days to female private plots which is almost as many days as they spend working on their own private plots (6 days). By contrast, women allocate 17 days to their own private plots and about 4 days on male private plots. Common plots that are not managed by the household head receive the least labour.

Shadow Price of Family Land and Labour: The data on labour and land allocation within the household allows us to calculate how much labour an adult household member contributes to the household's common plots per unit of land it receives for private farming. In the absence of labour contribution by household members, the head would have to hire workers to work on the collective plot; and in the absence of the land that these household members receive from the household head for private farming, they would, at least in theory, have to make use of land markets. Therefore, the ratio described above can be regarded as the "shadow price of land" within the household or the inverse of the "shadow price of labour".[8]

Table 5 summarizes the "shadow" prices of land and labour implied by the allocation of land and labour discussed above. On average, nuclear family household members contribute 263 days of labour on common plots per hectare of land (allocated for private farming) while extended household members contribute 209 days of labour on common plots for one hectare

[7]For nuclear households, the ratio of the least productive plots (female plots) to the most productive plots (male plots) is 0.89. In extended households the ratio of the least productive plots (female plots) to the most productive plots (head managed common plots) is 0.86.

[8]The previous literature has highlighted the practice of labour and land 'exchanges' within the family – albeit in the context of bequests – in the case of India and Israel (Rosenzweig 1985; Rosenzweig 1988; Kimhi 2004). A number of studies on West Africa have also emphasized that the contribution of labour to collective farm plots constitutes part of an intrahousehold exchange (see, for example, Von Braun and Webb 1989).

of land. Looking at the shadow price by gender, we find that men and women in extended family households contribute, respectively, 446 and 181 days of labour per hectare of land while the corresponding figures for nuclear family households are 320 and 159. Overall, the patterns are consistent with the hypothesis that household heads are able to extract more labour from nuclear family members. Another interpretation of these patterns is that the household head's commitment to allocate the proceeds from the common plots to household public goods is more credible (e.g. because of stronger altruism) in nuclear family households than for extended family households, and this induces household members to voluntarily contribute more labour on common plots.

5 Household Agricultural Production

Informational asymmetry and commitment problems can prevent household members from engaging in the exchange of productive resources – e.g. land, labour and other agricultural inputs – and therefore prevent efficiency in household production (Udry, 1996). In this context, altruism within the household can induce voluntary intra-household transfers and enable the household to achieve a more efficient allocation of resources in the spirit of the well-known 'Rotten Kid Theorem' (Becker 1993). One of the key distinguishing features between extended family households and nuclear family households, besides household size and the demographic composition, is, potentially, the level of altruism between household members. Therefore, we investigate whether these two types of households differ in terms of their efficiency in agricultural production.

For this purpose, we implement the test of efficiency in household production using the approach first adopted by Udry (1996). Since Udry's original work in Burkina Faso, a number of studies have found evidence of inefficiency in agricultural production in West African households including Goldstein and Udry (2008) for Ghana, and Guirkinger et al. (2015) for Mali.

Following Udry (1996) and Kazianga and Wahhaj (2013), we estimate a farm plot yield equation which includes household characteristics, physical characteristics of the plot and features of plot ownership, as follows:

$$Q_{htci} = \mathbf{X}_{hci}\boldsymbol{\beta} + \mathbf{G}_{hi}\boldsymbol{\gamma} + \lambda_{htc} + \varepsilon_{htci} \tag{27}$$

where Q_{htci} is the log of yield on plot i in year t, planted to crop c and belonging to household h; $\mathbf{X}_{hci}$ is a vector of physical characteristics of plot i including the plot area, topography and distance to the household; λ_{htc} is a household-crop-year fixed effect; and $\mathbf{G}_{hi}$ is a vector of characteristics of plot i in household h including, for example, the gender of the person responsible for the plot and whether the plot is classified as being 'common' or 'private'. In the previous literature, these ownership characteristics have been found to have a significant effect on plot yields within the same household (after controlling for plot characteristics and the crops planted): Udry (1996) and Goldstein and Udry (2008) in the case of gender, and Kazianga and Wahhaj (2013) and Guirkinger et al. (2015) in the case of the plot type ('private' versus 'common'/'collective'). Equation (27) can also be seen as an empirical equivalent of equations (21) and (22). In particular, from the theory of voluntary labour contributions and familial ties presented in Section 3.2.1, we can predict that that the coefficient of a categorical variable indicating private plots (as opposed to common plots) is negative and that it is more negative in households with weaker familial ties.

Table 6 shows the estimated results for equation (27), using agricultural data from the survey. In these regressions, we divide the farm plots into three categories: (i) household common plots, (ii) private plots managed by male household members, and (iii) private plots managed by female household members. We find that the yields achieved on private plots managed by men and women are lower than that achieved on household common plots (the omitted category) and the differences are statistically significant at the 1% level in each instance. This holds true for the full sample of households (regression results shown in column 1 of the table) as well as for the subsample of extended family households (shown in column 2) and nuclear family households (shown in column 3).

Pareto efficiency would imply that yields across all three plot categories are equal, after controlling for the crops planted, the physical characteristics of the plot and the skills of the plot owner. An F-test for the hypothesis that the yields are the same across all three plot categories is strongly rejected for both extended family households and nuclear family households (yielding an F-statistic of 244.8 in the first case, and 53.25 in the second case).

In words, these households are achieving significantly higher yields on common plots compared to private plots which have been planted with the same crops, controlling for observable physical characteristics of the plot and the plot owner. But the divergence in plot yields between common plots and private plots is higher for extended family households than for nuclear family households. The estimated coefficients imply that, relative to household common plots, private male plots achieve yields which are 24% lower in extended family households and 13% lower in nuclear family households; the corresponding figures for female plot yields are 42% and 29% respectively.

The gender difference in plot yields has been noted in the previous literature, with potential explanations provided by Goldstein and Udry (2008) and Kazianga and Wahhaj (2013). However, the gap between extended family and nuclear family households is just as striking. And, if we assume that nuclear family households exhibit stronger familial ties than extended family households, these patterns are consistent with the predictions derived from the theoretical model presented in Section 3.2.1.

5.1 Plot Yield Dispersions

We can also use the data on plot yields to see graphically the variation in plot yields across different plots within nuclear family households and within extended family households. In Figure 1, we plot the residuals from estimations of equation (27) without $\mathbf{G}_{hi}$ – i.e. without the male and female-plot dummies, and the age and education of the plot manager. The resulting graphs show the distribution of plot yields for farm plots belonging to the same household and planted to the same crop, in the same year, after controlling for physical characteristics of the plots.

For comparison, we also show the residuals from corresponding regressions for the pooled sample with (i) village-crop-year fixed effects, and (ii) individual-crop-year fixed effects. Greater dispersion in the residuals indicates greater inefficiency in the allocation of farm resources within the relevant group (and more scope for improving output through a reallocation of resources). The household-level distributions, for both subsamples, lie between the village-level and individual-level distributions. This is consistent with the findings by Udry (1996) and Kazianga and Wahhaj (2013) and implies that the household is more efficient than the village at allocating resources across farm plots that belong to the group, but not as efficient as the individual.

We also see from the figure that there is greater variation in plot yields across apparently identical plots for extended family households as compared to nuclear family households. The equality of the two distributions is rejected at any conventional level using a Kolmogorov-Smirnov test. The graphs for the nuclear and extended family households are consistent with our estimated coefficients in the previous section and suggests that nuclear family households are more efficient at allocating productive resources across farm plots than extended family households.

5.2 Explaining the Plot Yield Gaps across Different Household Types

Why are plot yield dispersions greater in the case of extended family households as compared to nuclear family households? Table 2 shows that, on average, extended family households have 11.78 members while nuclear family members have 7.30 members, with the difference being strongly statistically significant. The presence of extended family members in the former group largely accounts for this difference: on average, extended family household have 4.59 extended family members while nuclear family households, by definition, have none. The table also shows that, while there is little difference in the head's marital status between the two groups, the head in extended-family households, on average, have more spouses; i.e. they are more likely to be in polygamous relationships. They are also, on average, slightly older. Therefore, the difference in household sizes, the extent of polygyny and the presence of extended family members present themselves as natural candidates to account for the observed difference in plot yield dispersions. In this section, we investigate the hypothesis relating to the presence of extended-family members while the alternative hypotheses are investigated in section 7.

Extended Family Members: To investigate whether the presence of extended family members can account for the wider dispersion of plot yields across extended family households, we introduce a set of categorical variables to the plot yield regressions indicating the relation of the plot owner to the household head. The estimated results for the whole sample, the sample of extended family households and nuclear family households are shown in Table 7.

The omitted plot category in the table is 'common plots managed by the household head'. We introduce a single category for all other common plots, and separate categories for private plots farmed by different relations of the household head. The first point to note for this table is that, even putting aside the common plots, the household head achieves a higher yield on private plots compared to other household members, with the differences being statistically significant.

Being outside of the nuclear family does not, however, seem to be a disadvantage in itself: we cannot reject the hypotheses that (i) the yield coefficient for the household head's sons is the same as that for other male relatives and unrelated male household members; and that (ii) the yield coefficient for the household head's daughters is the same as that for other female relatives and unrelated female household members. This holds true for both the subsample of extended family households and for the full sample.

The wider dispersion in plot yields in extended family households can be traced to two sources. First, in nuclear family households, the household head achieves almost the same yield on his private plots as on the common plots under his control (the coefficient is not statistically significant) while in extended family households, the corresponding yield gap is about 19% (and statistically significant). Second, the yield gap between the head's common plots and the private plots farmed by members of the nuclear family (i.e. the son, daughter and spouse of the household head and the head himself) is smaller in the case of nuclear family households than for extended family households. A joint test of equality between the relevant coefficients for the two subsamples is strongly rejected.

In summary, the wider dispersion of plot yields in extended family households is not due to the presence of extended family members per se. Rather, it is because the plot yield gap (relative to the household's common plots) is larger for household members in extended family households than for household members in nuclear family households who hold the same 'position' (defined in terms of their relation to the household head). To better understand the source of these plot yield differences, we examine how agricultural inputs, in particular farm labour, is allocated across household plots. We discuss this in the following section.

5.3 Allocation of Labour Across Farm Plots

If the production technology used by agricultural households exhibits diminishing marginal product of labour, then productivity efficiency requires that farm plots with the same physical characteristics (including plot size, soil quality, etc.) and planted to the same crops, should make use of equal amounts of labour. If not, it would be possible to increase output by reallocating labour towards farm plots with lower labour use intensity.

Therefore, we can test for efficiency in labour allocation across farm plots belonging to the same household by using a specification similar to (27) (see Kazianga and Wahhaj 2013). Given the patterns in farm plot yields highlighted in the previous section, we would expect labour use intensity (total labour per unit area) across farm plots to be more uniform in the case of nuclear family households than for extended family households.

We estimate the following equation separately for nuclear family and extended family households and different labour types:

$$l^j_{htci} = \mathbf{X}_{hci}\hat{\boldsymbol{\beta}} + \mathbf{G}_{hi}\hat{\boldsymbol{\gamma}} + \hat{\lambda}_{htc} + \hat{\varepsilon}_{htci} \tag{28}$$

where l^j_{htci} is the log of the amount of labour of type j applied to plot i per unit area, in year t, and plot i belongs to household h and is planted to crop c. The labour types include 'adult male', 'adult female', 'child' and 'total'. Equation (28) can be regarded as an empirical equivalent of equations (19) and (20) derived from the theoretical model of voluntary contributions and familial ties. In particular, we have the theoretical prediction that the coefficient of a categorical variable indicating private plots (as opposed to common plots) is negative and that it is more negative in households with weaker familial ties.

The results are shown in Table 8. First, we observe that the labour use intensity (for total labour) is significantly higher for the common plots managed by the household head than for all other types of plots owned by the household (controlling for plot characteristics and the planted crop); and this holds for both nuclear family and extended family households. For both sets of households, the differences are statistically significant which implies that they are not allocating labour efficiently across farm plots.

Second, the labour use intensity gap between the head's common plots and the private plots farmed by members of the nuclear family (i.e. the son, daughter and spouse of the household head and the head himself) is smaller in the case of nuclear family households than for extended family households. A joint test of equality between the relevant coefficients for the two subsamples is strongly rejected. This is exactly the pattern we obtained in the case of plot yields and is consistent with the theoretical predictions above.

Turning to extended family households, we cannot reject the hypothesis that the labour use intensity coefficient (for total labour) of the household head's sons is the same as that for other male relatives and unrelated male household members. The corresponding coefficients for the household head's daughter, other female relatives and unrelated female household members are very close (-0.65, -0.68 and -0.72) but estimated precisely enough that we can reject the hypothesis that they are equal. Nevertheless, the pattern is broadly similar to what we saw in the case of plot yields: private plots managed by household members who are not part of the head's nuclear family are not at a disadvantage relative to the head's own children (of the same gender) in terms of labour inputs.

In summary, the findings discussed in this section suggests that the wider dispersion of plot yields within extended family households can be accounted for by the wider dispersion of labour use intensity within these same households.

Individual Labour Contributions on Privately-Owned Plots

Estimates based on equation (28) reveal the pattern of labour use intensities across farm plots but they do not tell us how different household members are dividing their own labour across different plots maintained by the household. As discussed in Section 3.2.1, if individuals who share a nuclear family tie have more altruistic preferences towards each other, we would expect them to contribute more labour to each other's private plots in relation to labour on their own private plots than would individuals who don't share such ties. To explore this hypothesis we estimate the following equation using data on labour contributions by individual household members on each farm plot:

$$l_{jhtci} = \mathbf{X}_{htci}\tilde{\boldsymbol{\beta}} + \mathbf{W}_{jht}\tilde{\boldsymbol{\zeta}} + \tilde{\lambda}_{htc} + \tilde{\varepsilon}_{jhtci} \tag{29}$$

where l_{jhtci} is the log of total labour per unit area provided by individual j in household h on private plot i planted to crop c in period t. The vector $\mathbf{X}_{htci}$ includes the characteristics of plot i (as before) and $\mathbf{W}_{jht}$ includes the worker's characteristics including gender, age and education; $\tilde{\lambda}_{htc}$ includes household-crop-year fixed-effects and the error term $\tilde{\varepsilon}_{ihvt}$ is clustered at the village level in the estimation. The vectors $\tilde{\boldsymbol{\beta}}$ and $\tilde{\boldsymbol{\zeta}}$ are parameters to be estimated. Equation (29) can be regarded as the empirical equivalent of equations (24) and (25).

The estimated results are shown in Table 9. For extended-family households we estimate equation (29) separately for workers who belong to the head's nuclear family (column 2) and those who don't (column 1). In each case, we include explanatory variables to indicate the relation of the plot owner to the head. This allows us to compare labour provided within owner-worker pairs that have a nuclear family tie to pairs that do not. In column 3, we provide equivalent estimates for nuclear family households.

The estimated coefficients for plot ownership in column (2) indicate that nuclear family members allocate more labour on plots owned by the head, head's spouse, daughter and son than on plots owned by the head's non-nuclear relations. By contrast, the estimated coefficients in column (1) indicate that extended family members allocate less labour on plots owned by members of the head's nuclear family than on plots owned by the head's non-nuclear relations. These differences are all statistically significant at conventional levels.

Furthermore, comparing the estimated coefficients in columns (1) and (2), we find that - taking the individual's labour on his/her own private plot as a reference point - the nuclear family members allocate more labour on private plots owned by the head, head's spouse, daughter and son than do extended family members. On the other hand, extended family members allocate more significantly more labour on plots owned by the head's non-nuclear relations than do members of the nuclear family. Except in the case of the head's private plots, the null hypotheses that any of the plot ownership coefficients in columns (1) and (2) are equal is strongly rejected.

Turning to column (3), we find that the estimated plot ownership coefficients are close to zero and statistically significant. In other words, there are no statistically significant differences in the allocation of labour across private plots within nuclear family households once plot characteristics, worker characteristics and household-crop-year fixed effects are controlled for.

These patterns provide strong evidence that the allocation of labour across private plots are a function of family ties, and that levels of altruism are higher for nuclear family ties and within nuclear family households.

Individual Labour Contributions on the Household's Common Plots

In Table 10, we provide parallel estimates for the total labour contribution of each household member to the household's common plots. Explanatory variables include the total size of the individual's private plots and of the household's common plots, demographic characteristics of the household, and characteristics of the household member. In columns 1-3, we control for household fixed effects and observable household characteristics such as the area of the common plot and the demographic composition of the household. In columns 4-6, we control for household-year fixed effects. Including household-year fixed effects allows us to account for time-varying household and village-level unobservables. In particular, we account for annual variations in prices (crops, land and wages) that can influence labour supply and land allocation. It is reassuring that the point estimates and the statistical significance are stable across the two specifications.

The omitted relationship category is the 'household head'. Focusing on columns 1-3, we see that the estimated coefficient in all the other relationship categories is negative and statistically significant. In other words, the household head contributes the most amount of labour to the household's common plots. This is expected since the head has overall responsibility for the common plots. More significantly, for a given relationship with the household head (e.g. a spouse, son or daughter) the coefficient is more negative in the case of extended family households than for nuclear family households. For example, the estimates imply that, within extended family households, the head's son contribute 37% less labour on the common plots than the head himself (statistically significant at the 1% level) while, in nuclear family households, there is no statistically significant difference between their labour contributions. A test of the equality of the coefficients for nuclear family members in columns 2 and 3 is strongly rejected.

The point estimates also indicate that the son contributes more labour than other male relations and unrelated male individuals living within the same household, but the differences are small and we cannot reject the hypothesis that they are equal. We are able to reject the hypothesis that the daughter, other female relations and unrelated female individuals all contribute the same amount of labour to the common plots. We obtain similar patterns when we control for household-year fixed effects in columns 4-6.

In summary, the estimates reveal sharp differences, between nuclear and extended family households, in the head's spouse, son and daughter's labour on the common plots (taking the head's own labour as a reference point). On the other hand, the differences in labour contributions between nuclear and extended family members within the same household is less marked. This pattern suggests that individuals within nuclear family households – irrespective of their relation to the household head – have preferences for household public goods more closely aligned with that of the head than individuals within extended family households.

6 Intra-Household Risk-Sharing

As discussed in Section 3.2.1, in the absence of formal contracts, households where individuals have 'stronger ties' or higher levels of altruism among them should be more effective at sharing risk among its members. It follows that if one exhibits a higher level of altruism towards a nuclear family member, as compared to a cohabiting extended-family member or unrelated individual, then nuclear family households should serve as more effective risk-sharing units than extended family households. In this section, we use data on income from individual farm plots, rainfall shocks, consumption expenditures and child anthropometric data to test this hypothesis in two different ways. Rainfall data is drawn from the Climate Research Unit (CRU) at the University of East Anglia, which provides monthly precipitation data on a 0.5×0.5 degree grid. We have geographic coordinates of each of the sample villages. Hence, we are able to link each village to a CRU grid and the rainfall covering the period from 1940 to 2012.

6.1 Efficiency in Consumption Expenditures

Rainfall shocks can have a differential impact on the output and income generated from different farm plots owned by the same household, due to differences in skill of the plot managers, plot characteristics, crops planted and inputs applied. Therefore, variations in rainfall can be used to examine whether an income shock for one household member affects household consumption differently from an income shock to another household member. These comparisons can also provide the basis for testing efficiency in consumption decisions within the household. Before proceeding to discuss the empirical results, we briefly describe the methodology used to analyse consumption decisions. The methodology is adapted from Duflo and Udry (2004), where the the intuition and underlying theory are discussed in greater detail.

Following a common approach in the literature (e.g. Fafchamps, Udry and Czukas 1998, Kazianga and Wahhaj 2013, Paxson 1992), we assume the following log-linear relationship between rainfall and household farm income:

$$\log(y_{iht}) = (\mathbf{X}_{iht} \otimes \mathbf{R}'_{vt})\,\boldsymbol{\lambda}_i + \boldsymbol{\delta}_h + \boldsymbol{\delta}_{vt} + \xi_{iht} \tag{30}$$

where y_{iht} represents income from plot i, farmed by household h in period t, $\mathbf{X}_{iht}$ is a vector of physical characteristics of plot i, $\mathbf{R}_{vt}$ is a vector of rainfall measures in village v in period t, $\boldsymbol{\delta}_h$ and $\boldsymbol{\delta}_{vt}$ are, respectively household and village-year fixed effects and ξ_{iht} is an error term to capture other exogenous shocks that affect farm income in period t.[9]

The estimated coefficients from (30) are used to compute a linear combination of rainfall variables as follows: $\hat{y}_{iht} = (\mathbf{X}_{iht} \otimes \mathbf{R}'_{vt})\,\hat{\boldsymbol{\lambda}}_i$. These fitted values represent the (log of the) component of household farm income that is explained by rainfall variations. If we assume that the demand for each consumption good can be expressed as a log-linear function of total expenditures, household Pareto weights and other household and regional characteristics, then we can derive the following specifications relating household expenditures and income:

$$\log(e_{ht}) = \sum_{i=c,m,f} \pi_{ei}\hat{y}_{iht} + \mathbf{H}_{hvt}\boldsymbol{\zeta}_e + \delta_{eh} + \delta_{evt} + \nu_{eht} \tag{31}$$

$$\log(x_{ht}) = \sum_{i=c,m,f} \pi_{xi}\hat{y}_{iht} + \mathbf{H}_{hvt}\boldsymbol{\zeta}_x + \delta_{xh} + \delta_{xvt} + \nu_{xht} \tag{32}$$

where e_{ht} represents total expenditures, and x_{ht} represents expenditures on some specific consumption good, in household h in period t. The vector $\mathbf{H}_{hvt}$ includes, potentially time-varying, household characteristics including the demographic composition of the household. The terms δ_{eh} and δ_{xh} are household fixed-effects and δ_{evt} and δ_{xvt} denote village-year fixed years. This specification controls for village-level annual covariate shocks, and hence is frequently used in the village-level risk sharing literature (e.g. Townsend 1994, Ravallion and Chaudhuri 1997, and Kazianga and Udry 2006).

If there is indeed a social norm in practice which requires the household head to spend the proceeds of the common plot on household public goods, then $\pi_{xc} > 0$ if x is a household

[9]Note that measures of rainfall do not appear in the equation on their own as these effects are entirely subsumed in the village-year fixed-effects.

public good and $\pi_{xc} = 0$ for private goods.[10] In words, a rainfall shock which affects the income generated from the common plot would affect expenditures that benefit the entire household but not expenditures which are specific to an individual. To investigate whether the prevalence of the norm varies across different types of households, we estimate equation (32) separately for nuclear family households and extended family households.

The estimates from equations (31) and (32) also provides a test for the Collective Model of the household. Consumption efficiency requires that

$$\frac{\pi_{xi}}{\pi_{ei}} = \frac{\pi_{xj}}{\pi_{ej}} \tag{33}$$

Following Duflo and Udry (2004), we test for (33) using a non-linear Wald test, separately for nuclear family and extended family households.

6.1.1 Results

The consumption expenditures data in the Ministry of Agriculture Survey can be used to construct measures of food consumption, broken down into (i) home-grown cereal consumption, (ii) consumption of other home-grown foods, and (iii) food purchases. Therefore, the methodology outlined above can be used to investigate how rainfall shocks which impact upon farm income affects consumption in these food categories.

Table 11 shows the first-stage results for (i) household common plots, (ii) male private plots and (iii) female private plots using data. Categorical variables indicating the topography of the plot and the location of the plot are interacted with the level of annual rainfall in the village where the plot is located. The effect of rainfall on farm plots on flat ground ("*plaine/plateau*") and farm plots located in "*cases*" are subsumed in the village-year fixed-effects. Compared to plots on flat ground, we find that rainfall has a strong positive effect on farm output derived from plots on low ground ("*bas-fond*") across all three types of plot ownership (i.e. 'common', 'male' and 'female') as well as on farm output derived from plots on sloping ground ("*versant*") for 'female' plots. Compared to "*cases*" plots, we find that rainfall has a strong positive effect on farm output derived from "brousse" plots and "campement" plots across all three types of plot ownership.[11]

Table 11 also reports F-tests on joint significance of the estimated coefficients for all the interaction variables. The F-test indicate that the coefficients are jointly significant across all three types of plot ownership. We also report the F-statistics for equation-specific

[10] If the norm requires all the proceeds from the common plot to be spent on household public goods, then we would obtain $\pi_{xc} = 1$. It is more likely that part of the proceeds will be stored for future use, e.g. storage of grains in a granary, in which case we would expect $\pi_{xc} < 1$.

[11] We also find negative coefficients for rainfall interacted with junior male plot location characteristics in column (1) and for rainfall interacted with common plot location characteristics in column (2), which suggest that increased rainfall cause resources to be diverted from some "cases" plots towards "brousse" and "campement" plots.

instruments and for all other instruments. As we are instrumenting for 3 endogenous variables, we also report the F-tests on equation-specific 'relevant' excluded instrument variables. Equation-specific instruments are rainfall deviation interacted with common plots in column 2, rainfall deviation interacted with male plots in columns 3 and rainfall deviation interacted with female plots in column 4. 'Other excluded instruments' refer to rainfall deviation interacted with male and female plots in column 2, rainfall deviation interacted with common and female plots in column 3, and rainfall deviation interacted with common and male plots in column 4. The F-statistics for the equation-specific instruments are comfortably above 10 in each equation, which suggests that the interaction variables are suitable instruments to estimate the effects of plot income on household consumption.[12] Moreover, the F-statistics for the 'other instruments' are consistently smaller in all specifications suggesting that multicollinearity is not likely in the second stage.

The second-stage results are shown in Table 12. Columns (1)-(3) in Panel A provide the estimates of household farm income shocks on total food consumption for, respectively, all households, nuclear family households and extended family households. A 10% change in income induced by rainfall shocks leads to 2% change in consumption in the full sample. For nuclear and extended family households, the corresponding changes in consumption are 3.3% and 1.6%, respectively. A test of the equality of the two coefficients is rejected at the 5% level. Therefore, it is apparent that food consumption in extended households is less exposed to idiosyncratic shocks than food consumption in nuclear family households. In columns 4-6 of Panel B, we investigate the effects of each type of income on household total food consumption. Although we find statistically significant effects for each type of income for each sample, the effects are relatively small implying that the households are able to protect food consumption reasonably well against shocks to each type of farm incomes, taken separately. For example, the full sample estimates indicate that a 10% decline in income from the common plot leads to only 0.8% decline in food consumption expenditures, while the effect of shocks to private male and female plots are less than half that size. We also report an F-test of the null hypothesis that shocks on different type of income have equal effects on household food consumption. We reject this null hypothesis at the 5% level for the full sample (column 4) and for extended family households (column 6), but not for nuclear family households (column 5). These results indicate more risk pooling within nuclear family households than in extended family households.

The corresponding estimates for sub-categories of food consumption – home-grown cereals, other home-grown produce, and purchased food – are shown in columns (1)-(9), panel B. The overall pattern in the point estimates, albeit small, suggest that the proceeds from the common plots are relatively more important for the household's consumption of home-

[12] In the Appendix Table A1, we reproduce the estimates shown in Table 11 for nuclear family and extended family households separately and the results are broadly consistent with those shown in Table 11.

grown produce while the proceeds from the private plots are relatively more important for the consumption of purchased food. These disaggregated estimates enable us to test for consumption efficiency using a non-linear Wald test as described in (33). The χ_2-statistics for these tests are provided in Table 13. We are able to reject consumption efficiency for the full sample of households. In words, the responsiveness of home-grown food consumption to changes in total food consumption varies, depending on the type of income shock that causes the change in total food consumption. This contradicts one of the key implications of Collective Household model. Repeating the test with the two subsamples, we are able to reject consumption efficiency for extended family households but not for nuclear family households.[13]

6.2 Idiosyncratic Income Shocks and Child Anthropometrics

In this section, we provide direct evidence on whether co-resident household members share idiosyncratic income risk. Intuitively, household members who experience negative income draws may benefit from transfers from co-resident relatives so that, on average, controlling for household aggregate shocks, individual consumption is insulated from own shocks. Ideally, implementing such a test would require measures of individual level consumption or nutrition as used by Dercon and Krishnan (2000) to test risk sharing within household in Ethiopia. In this paper we use child-level anthropometric outcomes, namely standardised child mid-upper-arm-circumference (MUAC). MUAC is a simple method of assessing nutritional status in children aged 6 to 60 months (e.g. Emergency Nutrition Network, 2012).

If households are efficiently sharing risk, then exogenous shocks to a mother's income should not influence nutritional outcomes for her children, once household level aggregate shocks have been controlled for. Based on this intuition, we estimate the following equation for the full sample of households, and separately for nuclear and extended family households:

$$MUAC_{ijht} = \pi_m \hat{y}_{jht} + \mathbf{X}_{ijhvt}\boldsymbol{\zeta}_m + \delta_{ht} + \nu_{ijht}$$

where $MUAC_{ijht}$ is the z-score of the upper-arm circumference of child i with mother j in household h in period t; $\hat{y}_{jht}$ is a measure of j's individual farm income or food consumption expenditures as described below; the vector $\mathbf{X}_{ijhvt}$ includes the characteristics of the child including, age and gender; δ_{ht} denotes household-year fixed-effects; and ν_{ijht} is an error term. We include the household-year fixed effects in order to control for household level shocks. Note that, due to the inclusion of these fixed-effects, the sample can only include households which have multiple mothers. In the case of nuclear family households, this translates into

[13] It is important to note that the food consumption categories 'own produce' and 'purchased food' can be used to test for consumption efficiency if the commodities purchased are distinct from those which are produced for own consumption.

the sub-sample of households where the head is polygynous. Perfect risk-sharing within the household would mean that $\pi_m = 0$.

We report the estimation results in Table 14. Columns 1-3 investigate the effects of exogenous shocks to the mother's crop income and columns 4-6 focus on the effects of mother food consumption expenditures. Mother's food consumption expenditures are measured as the sum of mother's harvest used in auto-consumption and food purchases by the mother - the purchases are financed by crop sales and non-farm income. We use the mother's plot characteristics interacted with local rainfall deviations to instrument for the mother's income and food consumption expenditures. The F-statistics of excluded instruments shown in the penultimate row are all comfortably above the 10 with the exception of column 5. Therefore, it is unlikely that the results are driven by weak instruments.

The results in columns 1-3 indicate that controlling for household level-shocks, shocks to the mother's income are passed through to child nutritional outcomes in the full sample (column 1) and in extended family households (column 2), although the effects are relatively small. In nuclear family households, however, the point estimate is virtually zero (column 3) implying that child nutritional outcomes are unaffected by shocks to mother's income once household-level shocks are controlled for. We obtain a similar pattern in the rejection of intra-household insurance when we use mother's food expenditures in columns 4-6, expect that the point estimates are larger: the hypothesis of full insurance is rejected for the full sample and extended family households in columns 1 and 2, but not for nuclear family households in columns 3.

Overall, the results suggest that nuclear family households are pooling risk but extended family households are not with respect to the nutrition of children.

7 Robustness Checks

As noted in section 4, the characteristics of nuclear and extended-family households differ along a number of dimensions which can affect the pattern of resource allocation within them. Extended-family households, on average, have more members, the head is, on average, older and more likely to be polygynous. It is plausible that the source of observed inefficiency of extended-family households is not due to the nature of ties between the household members, per se, but due to their larger size, or the practice of polygyny or the natural life-cycle of the household. To explore these hypotheses, we replicate the basic test of efficiency in production and consumption, as described in sections 5 and 6, for sub-sets of the household sample which are identical or similar along these dimensions.

Specifically, we consider three subsamples: (i) the subset of monogamous households; (ii) a subset of households for which the size distribution is nearly identical for nuclear and extended-family households; (iii) a subset of households for which the distribution of the head's age is nearly identical for nuclear and extended-family households. For (ii) and (iii), we perform a logit regression of the binary variable 'nuclear family household' on household size and head's age, and then retain nuclear and extended family households with close predicted probabilities. In the resulting sub-sample for (ii), average household size is 7.67 for extended family households and 7.65 for nuclear family households and the two means are statistically indistinguishable. In the resulting sub-sample for (iii), average household head age is 45.48 years for extended family households and 45.60 years for nuclear family households and, again, the two means are statistically indistinguishable. Arguably, any differences we detect between the nuclear and extended family households within these subsamples are not due to differences in household size in (ii), or differences in the age of the household head in (iii).

In Table 15, we report estimates of the basic plot yield equation in (27) for the subset of monogamous households (columns 1-3), the age-based sub-sample (columns 4-6) and the size-based subsample (columns 7-9). We find that the estimated coefficients for male and female private plots in nuclear and extended-family households are close to those obtained using the full sample of households. In particular, the households achieve lower yields on private plots compared to common plots (the excluded plot category), and the yield gaps are higher for extended family households than for nuclear family households. For each subsample, we can reject a null hypothesis of equality in the female plot coefficients across nuclear and extended family households. Similarly, we can reject the null hypothesis of equality of the corresponding male plot coefficients. Therefore, we conclude that the wider dispersion of plot yields across extended family households cannot be attributed to the extent of polygyny, household size or the household life-cycle as captured by the age of the head.

To investigate the extent of consumption risk-sharing for these subsamples, we re-estimate equations (30)-(32) and replicate the non-linear Wald test for equation (33) using each set of estimates. The Wald statistic and p-values are reported in Table 16. The tests imply a rejection of efficient risk-sharing for the size-based subsample and the age-based subsample. Within these subsamples, we find, as before, that the extended family households are inefficient while the test fails to reject efficiency for the nuclear family households. In the case of monogamous households, we fail to reject efficiency for the entire subsample (p-value of 0.50) as well as for the subset of nuclear and extended family households within it (p-values of 0.22 and 0.12 respectively).

In summary, differences in household size and the age of the head does not account for the differences in consumption efficiency between nuclear and extended family households, but when we exclude polygynous households consumption inefficiency disappears. The finding for monogamous households is not inconsistent with our overall hypothesis relating to family ties because – to the extent that the head's children in polygynous households are half-siblings – these ties are stronger within monogamous households. Furthermore, as the estimates in Table 16 shows, even within monogamous households, nuclear family households are closer to being efficient in production than extended family households. Therefore, we conclude that the alternative hypotheses do not explain satisfactorily the observed differences between nuclear and extended family households in the data.

8 The Advantages of Extended-Family Households

In sections 5-6.2, we provide evidence that nuclear family households allocate resources more efficiently than extended family households, and that, within the same household, there is higher transfer of labour resources between individuals who share a nuclear family tie. Yet, more than half the households in our sample of rural Burkinabe households are extended-family households. As shown in Table 1, the data from the Demographic and Health Surveys indicates that between one-quarter and three-quarter of households in West African countries, are extended-family households. Given the advantages of nuclear family households, there is a need to explain why we see such a high prevalence of extended family households across West Africa and, in particular, in Burkina Faso.

We posit and present evidence on two broad explanations, both related to market failure. In the context of Burkina Faso, the household head does not have the freedom to sell the farmland that he inherits from the lineage. The presence of market failure in land rental and labour markets prevents him from renting out this land or hiring in labour to work on it (see, for example, Udry 1996, and the references within). However, the institution of a household allows him to commit to using the proceeds of the household collective plots on household public goods and, thus, incentivise farm labour effort from any individual who joins the household, as well as remunerate these extra working hands by awarding them individual farming plots to work on. A household head who starts off with a large quantity of inherited land in relation to the size of his nuclear family will calculate a higher marginal product of labour of an additional individual that he can persuade to join the household[14]. Therefore, controlling for the size of the nuclear family, a household head with a large quantity of inherited land should be more likely to have extended-family members or unrelated individuals living within his household.

To test this hypothesis, we estimate linear probability models where the dependent variable is the household structure (1 = nuclear, 0 = extended), and include the head's inherited land, and the demographic composition of his nuclear family as explanatory variables. The results are shown in Table 17. We also control for the household's other farmland (columns 1-3) or the household's total land per capita (columns 4-6). In columns 6-9, we include the

[14]It is important to note that the head's nuclear family size is also endogenous since this is determined by marriage decisions (monogamy versus polygyny) and fertility choice. However, these choices can only provide a long-term solution to the household's farm labour shortages. By contrast, the household's available labour can be adjusted relatively quickly by having extended-family members or unrelated individuals join or leave the household.

squared term of inherited land to check for non-linearity in the hypothesized relationship. The specifications also include year dummies (columns 1, 4 and 7), year dummies and village fixed-effects (columns 2,5 and 8), or village-year fixed-effects (columns 3,6 and 9). In each estimation, the probability of an extended-family household is increasing in the size of the head's inherited land (statistically significant at the 1% level), as implied by the hypothesis described above.

Our second explanation relates to financial market failure. The income volatility of agricultural households in developing countries, the challenges they face in obtaining credit and insurance from the market for the purpose of consumption smoothing, and the limited nature of informal insurance within villages have been well documented in the literature (e.g. Townsend, 1994; Dercon 2002; Kazianga and Udry, 2006). In this context, increasing the size of the household by having non-nuclear members join it can help the household to diversify its income sources and therefore improve consumption smoothing. The estimates in Table 13 – discussed in Section 6.1.1 – shows that household food consumption is more sensitive to shocks to agricultural income in the case of nuclear family households than in the case of extended family households, point estimate of 0.334 versus 0.158, and statistically different at the 5% level.

We provide an indirect test of this hypothesis relating to financial market failure using historical rainfall data to create a measure of a household's income volatility. Specifically, we use the estimated coefficients from the first-stage regressions in Table 11, information on the characteristics of the head's inherited land, and data on historical rainfall to calculate the household's predicted income shocks during the 20 year period prior to the survey. We take the variance of these income shocks to construct a measure of each household head's income volatility when he first inherited his land as a function of the farmland characteristics and local rainfall conditions. The hypothesis related to financial market failure would imply that household heads facing greater income volatility should be more likely to have extended-family members or unrelated individuals living within his household.

In Table 18, we present estimates of linear probability models of household structure similar to those in Table 16 but include the head's income volatility as an explanatory variable. Consistent with our reasoning, increased volatility increases the probability of an extended-family household, the relevant coefficient being statistically significant at the 1% level for each specification. In other words, household heads exposed to greater income volatility due to the characteristics of their inherited land and local rainfall conditions were more likely to end up with extended-family households.

9 Conclusion

In this paper, we investigated and compared how resources are allocated within nuclear and extended-family households in rural Burkina Faso. We found that nuclear family households are close to being efficient in household production, and could not reject the hypothesis that they engaged in efficient intra-household risk-sharing in consumption choices. By contrast, extended family households were found to be inefficient in both production and consumption choices.

We argued that these differences were due to the stronger familial ties that exist within the nuclear family. In support of this hypothesis we showed that labour contributions by household members on individually managed plots were significantly higher when the owner and worker shared a nuclear family tie, as compared to the situation where they shared an extended family tie or were unrelated.

These results are significant for the wider literature on intra-household allocation and household composition. First, we identify within the same geographic, economic and social environments two sets of households, one which achieves near Pareto efficiency in production and consumption decisions and another which does not. We developed a theory of intra-household allocation where we explicitly account for familial ties and account for both efficient and inefficient production and consumption choices. The empirical evidence, combined with the theory, provides a way of reconciling two strands of empirical evidence in the literature that have either failed to reject or have rejected Pareto efficient allocation of household resources.

The evidence on the more efficient nature of nuclear family households raises the question why extended family households exist at all. We presented two hypotheses related to (i) land and labour market failure and (ii) insurance market failure, and presented evidence consistent with these explanations. The implication is that the development of these markets in similar rural settings, combined with increasing land scarcity, will cause extended family households to give way to nuclear family households. In the context of small-holder agricultural households, the analysis suggests that the evolution of household composition from extended to nuclear family households will lead to more efficient allocation of productive resources within the household because of the ties that bind together members of the nuclear family.

10 Theoretical Appendix

Deriving Conditions for Labour Allocation: From the first-order conditions in (10) and (11), we obtain

$$\begin{aligned}
\delta_{ic}\frac{(z)^{\rho}}{L_{mc}} &= \frac{(x_i)^{\rho}}{L_{mi}} = \delta_{ij}\frac{(x_j)^{\rho}}{L_{mj}} \\
\delta_{jc}\frac{(z)^{\rho}}{L_{fc}} &= \delta_{ji}\frac{(x_i)^{\rho}}{L_{fi}} = \frac{(x_j)^{\rho}}{L_{fj}}
\end{aligned}$$

Dividing each term in the first set of equations by the corresponding term in the second set of equations, we obtain

$$\frac{\delta_{ic}}{\delta_{jc}}\frac{L_{fc}}{L_{mc}} = \frac{1}{\delta_{ji}}\frac{L_{fi}}{L_{mi}} = \delta_{ij}\frac{L_{fj}}{L_{mj}} \tag{34}$$

Let $\frac{L_{fc}}{L_{mc}} = R$. Then $\frac{L_{fi}}{L_{mi}} = \delta_j R$ and $\frac{L_{fj}}{L_{mj}} = \frac{1}{\delta_i}R$.
Let $\frac{\delta_{ic}}{\delta_{jc}}\frac{L_{fc}}{L_{mc}} = R$. Then $\frac{L_{fi}}{L_{mi}} = \delta_{ji} R$ and $\frac{L_{fj}}{L_{mj}} = \frac{1}{\delta_i}R$.
Then, we can write

$$\begin{aligned}
& (A_c)^{\alpha}(L_{mc})^{\beta_1}(L_{fc})^{\beta_2} \\
=\ & (A_c)^{\alpha}(L_{mc})^{\beta_1}\left(\frac{\delta_{jc}}{\delta_{ic}}RL_{mc}\right)^{\beta_2} \\
=\ & \left(\frac{\delta_{jc}}{\delta_{ic}}R\right)^{\beta_2}(A_c)^{\alpha}(L_{mc})^{\beta_1+\beta_2}
\end{aligned}$$

Therefore,

$$\frac{(z)^{\rho}}{L_{mc}} = \left(\frac{\delta_{jc}}{\delta_{ic}}R\right)^{\rho\beta_2}(A_c)^{\rho\alpha}(L_{mc})^{\rho(\beta_1+\beta_2)-1}$$

Similarly,

$$\begin{aligned}
\frac{(x_i)^{\rho}}{L_{mi}} &= (\delta_{ji}R)^{\rho\beta_2}(A_i)^{\rho\alpha}(L_{mi})^{\rho(\beta_1+\beta_2)-1} \\
\delta_{ij}\frac{(x_j)^{\rho}}{L_{mj}} &= \delta_{ij}\left(\frac{1}{\delta_{ij}}R\right)^{\rho\beta_2}(A_j)^{\rho\alpha}(L_{mj})^{\rho(\beta_1+\beta_2)-1}
\end{aligned}$$

Therefore,

$$\begin{aligned}
\delta_{ic}\left(\frac{\delta_{jc}}{\delta_{ic}}R\right)^{\rho\beta_2}(A_c)^{\rho\alpha}(L_{mc})^{\rho(\beta_1+\beta_2)-1} &= (\delta_{ji}R)^{\rho\beta_2}(A_i)^{\rho\alpha}(L_{mi})^{\rho(\beta_1+\beta_2)-1} \\
&= \delta_{ij}\left(\frac{1}{\delta_{ij}}R\right)^{\rho\beta_2}(A_j)^{\rho\alpha}(L_{mj})^{\rho(\beta_1+\beta_2)-1}
\end{aligned}$$

$$\Longrightarrow (\delta_{ic})^{1-\rho\beta_2} (\delta_{jc})^{\rho\beta_2} (A_c)^{\rho\alpha} (L_{mc})^{\rho(\beta_1+\beta_2)-1}$$
$$= (\delta_{ji})^{\rho\beta_2} (A_i)^{\rho\alpha} (L_{mi})^{\rho(\beta_1+\beta_2)-1}$$
$$= (\delta_{ij})^{1-\rho\beta_2} (A_j)^{\rho\alpha} (L_{mj})^{\rho(\beta_1+\beta_2)-1}$$

Taking logs and multiplying throughout by -1, we obtain

$$-(1-\rho\beta_2)\ln(\delta_{ic}) - \rho\beta_2\ln(\delta_{jc}) - \rho\alpha\ln A_c + [1-\rho(\beta_1+\beta_2)]\ln L_{mc} \tag{35}$$
$$= -\rho\beta_2\ln(\delta_{ji}) - \rho\alpha\ln(A_i) + [1-\rho(\beta_1+\beta_2)]\ln L_{mi} \tag{36}$$
$$= -(1-\rho\beta_2)\ln(\delta_{ij}) - \rho\alpha\ln(A_j) + [1-\rho(\beta_1+\beta_2)]\ln L_{mj} \tag{37}$$

Therefore, using (35) and (36), we obtain

$$[1-\rho(\beta_1+\beta_2)]\ln L_{mc} - [1-\rho(\beta_1+\beta_2)]\ln L_{mi}$$
$$= \rho\alpha\ln\left(\frac{A_c}{A_i}\right) + (1-\rho\beta_2)\ln(\delta_{ic}) + \rho\beta_2[\ln(\delta_{jc}) - \ln(\delta_{ji})]$$

$$\Longrightarrow [1-\rho(\beta_1+\beta_2)]\ln\left(\frac{L_{mc}}{A_c}\right) - [1-\rho(\beta_1+\beta_2)]\ln\left(\frac{L_{mi}}{A_i}\right) = -[1-\rho(\beta_1+\beta_2)]\ln\left(\frac{A_c}{A_i}\right)$$
$$+ \rho\alpha\ln\left(\frac{A_c}{A_i}\right) + (1-\rho\beta_2)\ln(\delta_{ic}) + \rho\beta_2[\ln(\delta_{jc}) - \ln(\delta_{ji})]$$
$$\Longrightarrow [1-\rho(\beta_1+\beta_2)]\ln\left(\frac{L_{mc}}{A_c}\right) - [1-\rho(\beta_1+\beta_2)]\ln\left(\frac{L_{mi}}{A_i}\right) = [\rho(\alpha+\beta_1+\beta_2)-1]\ln\left(\frac{A_c}{A_i}\right)$$
$$+ (1-\rho\beta_2)\ln(\delta_{ic}) + \rho\beta_2[\ln(\delta_{jc}) - \ln(\delta_{ji})]$$

Therefore,

$$\ln\left(\frac{L_{mc}}{A_c}\right) - \ln\left(\frac{L_{mi}}{A_i}\right) = \left[\frac{\rho(\alpha+\beta_1+\beta_2)-1}{1-\rho(\beta_1+\beta_2)}\right]\ln\left(\frac{A_c}{A_i}\right) + \left[\frac{1-\rho\beta_2}{1-\rho(\beta_1+\beta_2)}\right]\ln(\delta_{ic}) + \left[\frac{\rho\beta_2}{1-\rho(\beta_1+\beta_2)}\right][\ln(\delta_{jc}) - \ln(\delta_{ji})] \tag{38}$$

Following a similar reasoning, we have

$$\ln\left(\frac{L_{mc}}{A_c}\right) - \ln\left(\frac{L_{mj}}{A_j}\right) = \left[\frac{\rho(\alpha+\beta_1+\beta_2)-1}{1-\rho(\beta_1+\beta_2)}\right]\ln\left(\frac{A_c}{A_j}\right) + \left[\frac{\rho\beta_2}{1-\rho(\beta_1+\beta_2)}\right]\ln(\delta_{jc}) + \left[\frac{1-\rho\beta_2}{1-\rho(\beta_1+\beta_2)}\right][\ln(\delta_{ic}) - \ln(\delta_{ij})] \tag{39}$$

$$\ln\left(\frac{L_{fc}}{A_c}\right) - \ln\left(\frac{L_{fj}}{A_j}\right) = \left[\frac{\rho(\alpha+\beta_1+\beta_2)-1}{1-\rho(\beta_1+\beta_2)}\right]\ln\left(\frac{A_c}{A_j}\right) + \left[\frac{1-\rho\beta_1}{1-\rho(\beta_1+\beta_2)}\right]\ln(\delta_{jc}) + \left[\frac{\rho\beta_1}{1-\rho(\beta_1+\beta_2)}\right][\ln(\delta_{ic}) - \ln(\delta_{ij})] \tag{40}$$

$$\ln\left(\frac{L_{fc}}{A_c}\right) - \ln\left(\frac{L_{fi}}{A_i}\right) = \left[\frac{\rho\left(\alpha+\beta_1+\beta_2\right)-1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\frac{A_c}{A_i}\right) + \left[\frac{\rho\beta_1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\delta_{ic}\right) + \left[\frac{1-\rho\beta_1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\left[\ln\left(\delta_{jc}\right)-\ln\left(\delta_{ji}\right)\right] \tag{41}$$

Deriving Conditions for Plot Yields: By construction, we have

$$\begin{aligned}
\ln\left(\frac{y_c}{A_c}\right) &= \left(\alpha+\beta_1+\beta_2-1\right)\ln\left(A_c\right)+\beta_1\ln\left(\frac{L_{mc}}{A_c}\right)+\beta_2\ln\left(\frac{L_{fc}}{A_c}\right) \\
\ln\left(\frac{y_i}{A_i}\right) &= \left(\alpha+\beta_1+\beta_2-1\right)\ln\left(A_i\right)+\beta_1\ln\left(\frac{L_{mi}}{A_i}\right)+\beta_2\ln\left(\frac{L_{fi}}{A_i}\right)
\end{aligned}$$

Therefore,

$$\begin{aligned}
\ln\left(\frac{y_c}{A_c}\right)-\ln\left(\frac{y_i}{A_i}\right) &= \left(\alpha+\beta_1+\beta_2-1\right)\ln\left(\frac{A_c}{A_i}\right) \\
&\quad +\beta_1\left[\ln\left(\frac{L_{mc}}{A_c}\right)-\ln\left(\frac{L_{mi}}{A_i}\right)\right] \\
&\quad +\beta_2\left[\ln\left(\frac{L_{fc}}{A_c}\right)-\ln\left(\frac{L_{fi}}{A_i}\right)\right]
\end{aligned} \tag{42}$$

Substituting into (42) using (38) and (41), we obtain

$$\ln\left(\frac{y_c}{A_c}\right)-\ln\left(\frac{y_i}{A_i}\right) = \Gamma\ln\left(\frac{A_c}{A_i}\right)+\left[\frac{\beta_1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\delta_{ic}\right) + \left[\frac{\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\left[\ln\left(\delta_{jc}\right)-\ln\left(\delta_{ji}\right)\right] \tag{43}$$

where where $\Gamma = (\alpha-1)+\left(\beta_1+\beta_2\right)\left[\frac{\alpha\rho}{1-\rho(\beta_1+\beta_2)}\right]$.

Similarly, we can show that

$$\ln\left(\frac{y_c}{A_c}\right)-\ln\left(\frac{y_j}{A_j}\right) = \Gamma\ln\left(\frac{A_c}{A_j}\right)+\left[\frac{\beta_2}{1-\rho\left(\beta_1+\beta_2\right)}\right]\ln\left(\delta_{jc}\right) + \left[\frac{\beta_1}{1-\rho\left(\beta_1+\beta_2\right)}\right]\left[\ln\left(\delta_{ic}\right)-\ln\left(\delta_{ij}\right)\right] \tag{44}$$

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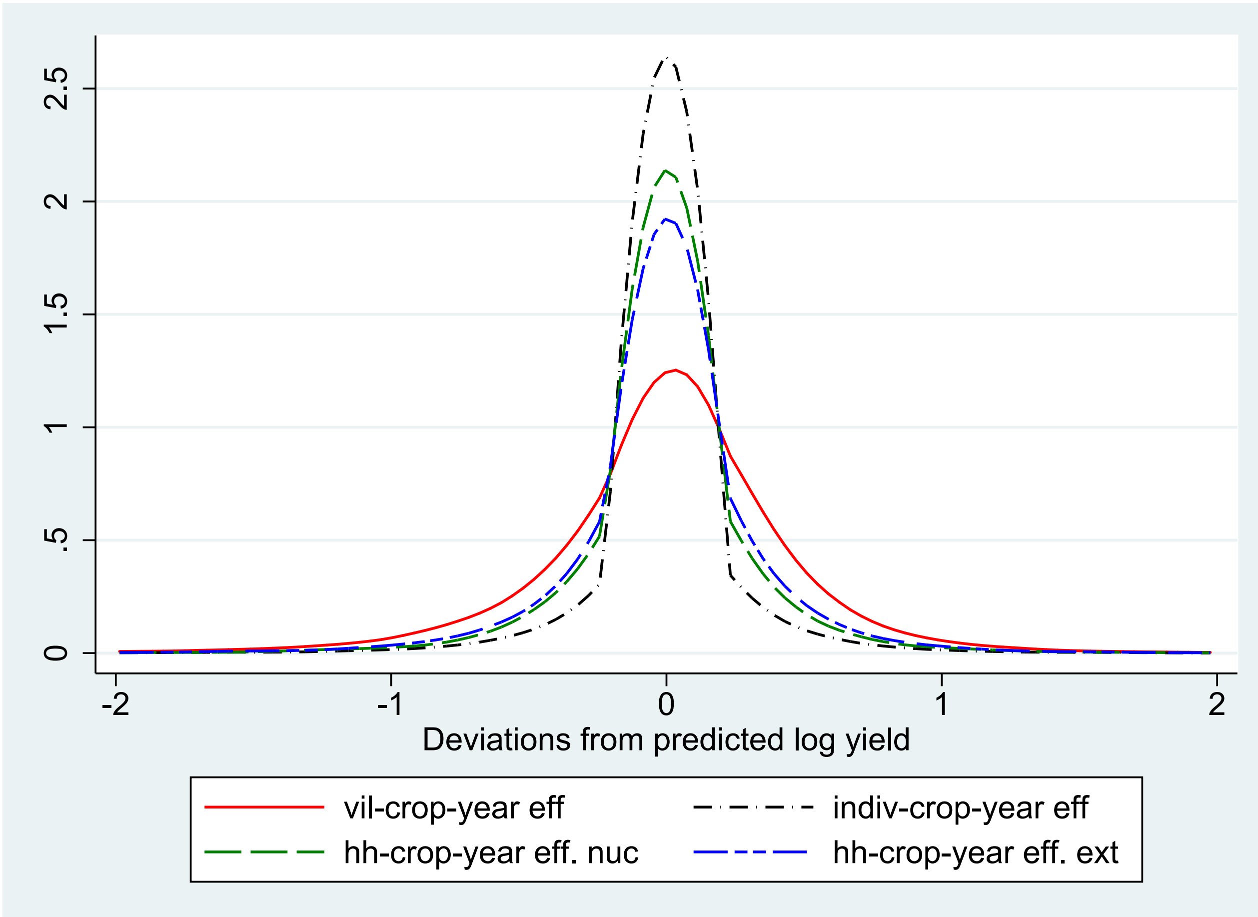

Figure 1: Plot yield dispersions

Tables

Table 1: Trends in household composition in West Africa

Country	Year	Share nuclear households		Country	Year	Share nuclear households	
		All	Rural			All	Rural
Benin				Mali			
	1996	0.51	0.54		1996	0.67	0.73
	2001	0.58	0.61		2001	0.70	0.75
	2006	0.65	0.68		2006	0.68	0.73
	2012	0.68	0.72	Niger			
Burkina Faso					1992	0.50	0.54
	1993	0.53	0.61		1998	0.56	0.58
	1999	0.57	0.61		2006	0.60	0.63
	2003	0.60	0.63		2012	0.72	0.74
	2010	0.69	0.74	Nigeria			
Ghana					1990	0.65	0.67
	1993	0.73	0.74		1999	0.71	0.72
	1998	0.71	0.71		2003	0.65	0.67
	1999	0.72	0.71		2008	0.72	0.74
	2003	0.63	0.64		2013	0.72	0.73
	2008	0.66	0.66	Senegal			
Guinea					1993	0.24	0.20
	1999	0.48	0.52		1997	0.26	0.25
	2005	0.53	0.57		2005	0.24	0.23
	2012	0.47	0.52		2011	0.24	0.24
Ivory Coast					2013	0.25	0.23
	1994	0.42	0.42				
	1999	0.39	0.39				
	2012	0.48	0.52				

Source: Data from the Demographic and Health Surveys (http://www.dhsprogram.com/).

Notes: The sample consists of the West African countries with more than DHS rounds by September 2014. Nuclear households are defined as households consisting of a spouses and their children. Extended households are defined as households consisting of spouses, their children and other household members whether related or non-related.

Table 2: Household composition and plot characteristics by extended and nuclear households

	Extended Family Households		Nuclear Family Households		Difference	t-stat
	mean	(sd)	mean	(sd)		
Household Head's Characteristics						
Gender (1 = Male, 0 = Female)	0.95	(0.22)	0.94	(0.24)	0.01	2.03
Age	50.75	(15.88)	48.79	(13.43)	1.96	7.84
Married? (1 = Yes, 0 = No)	0.92	(0.27)	0.93	(0.26)	-0.01	-1.88
# of Wives	1.57	(1.13)	1.47	(0.98)	0.10	5.56
Literate? (1 = Yes, 0 = No)	0.26	(0.44)	0.23	(0.42)	0.02	2.93
Household Size	11.78	(6.70)	7.30	(3.86)	4.48	49.60
# Married Men	1.76	(1.12)	1.04	(0.48)	0.72	51.79
# Extended Family Members	4.59	(5.00)	-	-	4.59	82.56
# Observations	8080		5723			
Household Plot Characteristics						
Total Plot Area (hectares)	7.14	(7.48)	4.50	(4.48)	2.65	25.90
Proportion of Common Plot	0.74	(0.30)	0.75	(0.33)	0.00	-0.55
# of Plots	7.54	(5.00)	5.64	(3.55)	1.90	26.11
# of Common Plots	4.29	(2.95)	3.52	(2.49)	0.76	16.39
# of Private Plots	3.17	(3.76)	2.06	(2.45)	1.11	21.07
# of Male Private Plots	2.39	(3.14)	1.62	(2.13)	0.77	17.17
# Observations	7516		5220			

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: Nuclear households are defined as households consisting of a spouses and their children. Extended households are defined as households consisting of spouses, their children and other household members whether related or non-related. Total area is the sum of the area of all plots farmed by the household in a given year. Common plots refer to plots managed by the household head (or occasionally by another household member) and proceeds from which are shared by all household members. Private plots refer to plot managed by individual household members who then make decisions on how to allocate the proceeds.

Table 3: Summary of men and women labor allocation across different household's plots

	mean	sd	min	max
Adult Males (N=24905)				
Labor on (number of days worked each year):				
own private plots	5.87	17.18	0	241
male private plots	2.34	10.23	0	252
female private plots	4.21	10.85	0	176
head common plots	29.7	44.45	0	291
junior males common plots	0.92	8	0	202
junior females common plots	0.11	1.65	0	62
Adult Females (N=31610)				
Labor on (number of days worked each year):				
own private plots	16.69	26.44	0	288
male private plots	4.07	13.25	0	237
female private plots	3.95	11.6	0	225
head common plots	42.26	42.21	0	281
junior males common plots	1.19	8.73	0	250
junior females common plots	0.18	2.92	0	162

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: labor is measured in number of days worked on a specific plots. For the purpose of the analysis, adult is defined as 15 year or older. "Junior male" common plots and "junior female" common plots are used to distinguish between common plots managed by the household head and common plots managed by other male of female household members.

Table 4: Labor and land allocation, and farm productivity within extended and nuclear households.

	Private plots		Common plots managed by:		Share allocated to Common Plots:	
	Men	Women	Household Head	Other Family Members	Managed by Household Head	All
All households						
Male Labor (days)	20.39	16.39	169.65	6.10	0.80	0.83
Female Labor (days)	11.39	55.29	137.24	6.18	0.65	0.68
Total Labor (days)	31.96	71.95	307.44	12.34	0.73	0.75
Area (ha)	0.50	0.87	4.21	0.16	0.73	0.76
Farming intensity (days/ha)	64.15	82.96	72.99	76.66		
Yield (CFA/ha)	88674.89	79641.86	89073.29	86037.14		
Nuclear households						
Male Labor (days)	13.90	13.70	139.05	2.46	0.82	0.84
Female Labor (days)	7.28	44.07	112.41	3.09	0.67	0.69
Total Labor (days)	21.22	57.86	251.92	5.64	0.75	0.77
Area (ha)	0.32	0.64	3.31	0.07	0.76	0.78
Farming intensity (days/ha)	66.93	90.53	76.15	84.00		
Yield (CFA/ha)	95487.73	85059.06	88304.52	81561.08		
Extended households						
Male Labor (days)	24.89	18.25	190.90	8.63	0.79	0.82
Female Labor (days)	14.24	63.09	154.48	8.33	0.64	0.68
Total Labor (days)	39.43	81.74	346.00	17.00	0.71	0.75
Area (ha)	0.62	1.03	4.84	0.23	0.72	0.75
Farming intensity (days/ha)	63.17	79.69	71.49	75.15		
Yield (CFA/ha)	86270.92	77297.68	89438.24	86959.95		

Source: Authors' calculations using data from the Ministry of Agriculture of Burkina Faso.

Notes: Nuclear households are defined as households consisting of a spouses and their children. Extended households are defined as households consisting of spouses, their children and other household members whether related or non-related. Total area is the sum of the area of all plots farmed by the household in a given year. Common plots refer to plots managed by the household and proceeds from which are shared by all household members. Private plots refer to plot managed by individual household members who then make decisions on how to allocate the proceeds. Yield is measured as the value of harvest divided by the size of the plot.

Table 5: Shadow Price of Land: Labour on common plots per unit of private farm (days/hectare)

	Extended households	Nuclear households
Men and women	263.47	209.71
Men	446.30	319.70
Women	180.73	158.71

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: The shadow price of land is measured as total labor allocated to common plots (in days) divided by the size of private plots in hectares.

Table 6: Estimates of yields for extended and nuclear households

VARIABLES	(1) lny	(2) lny	(3) lny
Male_Plot	-0.24***	-0.27***	-0.14***
	(0.02)	(0.03)	(0.05)
Female_Plot	-0.48***	-0.54***	-0.33***
	(0.02)	(0.02)	(0.03)
age	0.02***	0.02***	0.03***
	(0.00)	(0.00)	(0.00)
age2	-0.02***	-0.01***	-0.02***
	(0.00)	(0.00)	(0.00)
topo1	-0.03	-0.03	-0.01
	(0.02)	(0.03)	(0.05)
topo2	0.01	-0.01	0.04
	(0.03)	(0.04)	(0.06)
_Iplotdist_2	0.16***	0.16***	0.16***
	(0.02)	(0.02)	(0.03)
_Iplotdist_3	0.19***	0.22***	0.11
	(0.05)	(0.06)	(0.10)
Constant	12.42***	12.52***	12.05***
	(0.06)	(0.07)	(0.11)
Observations	81,485	53,366	28,119
R-squared	0.37	0.37	0.37
Number of hhcyrfe	49,750	30,813	18,937
household-crop-year fixed effects	Yes	Yes	Yes
households	all	extended	nuclear
plots	all	all	all
F-Stat. test Male_Plot = Female_Plot = 0	256.9	244.8	53.25
p value	0.00	0.00	0.00

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level.
The dependent variable is natural log of plot yield measured in the local currency per hectare. Column 1 includes all households. Columns 2 and 3 include extended and nuclear households, respectively. The regressions control for household-crop-year fixed effects. Dummy variables representing the plot manager education level and dummy variables representing plot size by deciles are included in the regressions but not shown.

Table 7: Estimates of yields differences between common plots and private plots within extended and nuclear households.

VARIABLES	(1) lny	(2) lny	(3) lny
comm_nhead	-0.27***	-0.25***	-0.41***
	(0.04)	(0.04)	(0.08)
head	-0.18***	-0.21***	-0.10
	(0.04)	(0.04)	(0.06)
spouse	-0.52***	-0.58***	-0.39***
	(0.02)	(0.03)	(0.04)
son	-0.36***	-0.36***	-0.32***
	(0.03)	(0.03)	(0.07)
daughter	-0.56***	-0.59***	-0.47***
	(0.05)	(0.07)	(0.08)
other_rel_male	-0.33***	-0.35***	
	(0.04)	(0.04)	
other_rel_female	-0.50***	-0.53***	
	(0.03)	(0.03)	
no_rel_male	-0.38***	-0.42***	
	(0.14)	(0.14)	
no_rel_female	-0.55***	-0.59***	
	(0.03)	(0.03)	
age	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)
age2	-0.01***	-0.01***	-0.02***
	(0.00)	(0.00)	(0.00)
topo1	-0.02	-0.03	-0.01
	(0.02)	(0.03)	(0.05)
topo2	0.01	-0.01	0.04
	(0.03)	(0.04)	(0.06)
_Iplotdist_2	0.16***	0.16***	0.17***
	(0.02)	(0.02)	(0.03)
_Iplotdist_3	0.19***	0.22***	0.11
	(0.05)	(0.06)	(0.10)

Table 7 (continued)

VARIABLES	(1) lny	(2) lny	(3) lny
Constant	12.53***	12.60***	12.27***
	(0.06)	(0.07)	(0.13)
Observations	81,485	53,366	28,119
R-squared	0.37	0.37	0.38
Number of hhcyrfe	49,750	30,813	18,937
household-crop-year fixed effects	Yes	Yes	Yes
households	all	all	all
plots	all	all	all
F-Stat. test son = other male	0.29	0.15	
p value	0.75	0.86	
F-Stat. test daughter = other female	1.42	1.54	
p value	0.24	0.22	
F-Stat. test all nuc. members and comm_nhead equal	23.95	30.33	1.71
p value	0.00	0.00	0.16
F-Stat. test all other plots equal	13.74	16.60	
p value	0.00	0.00	

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level.
The dependent variable is natural log of plot yield measured in the local currency per hectare. Column 1 includes all households. Columns 2 and 3 include extended and nuclear households, respectively. The regressions control for household-crop-year fixed effects. Dummy variables representing the plot manager education level and dummy variables representing plot size by deciles are included in the regressions but not shown.

Table 8: Labor supply and plot ownership within nuclear and extended households

	Nuclear households				Extended households			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnmale_labor	lnfemale_labor	lnchild_labor	lnTotLab	lnmale_labor	lnfemale_labor	lnchild_labor	lnTotLab
comm_nhead	-1.11***	-0.12	-0.00	-0.43***	-0.87***	-0.15*	-0.01	-0.34***
	(0.19)	(0.19)	(0.00)	(0.07)	(0.12)	(0.09)	(0.01)	(0.04)
head	-0.09	-0.93***	0.01	-0.27***	-0.43***	-0.73***	0.00	-0.44***
	(0.13)	(0.14)	(0.00)	(0.05)	(0.09)	(0.08)	(0.00)	(0.04)
spouse	-1.99***	0.15**	-0.00*	-0.53***	-2.22***	0.03	-0.00	-0.71***
	(0.10)	(0.07)	(0.00)	(0.03)	(0.07)	(0.06)	(0.00)	(0.02)
son	0.65***	-2.20***	0.00	-0.50***	-0.26***	-1.32***	-0.00	-0.57***
	(0.19)	(0.19)	(0.00)	(0.06)	(0.08)	(0.10)	(0.00)	(0.03)
daughter	-1.50***	0.05	-0.00	-0.43***	-2.20***	0.12	-0.00	-0.65***
	(0.24)	(0.15)	(0.00)	(0.08)	(0.15)	(0.10)	(0.00)	(0.05)
other_rel_male					-0.40***	-1.34***	-0.01*	-0.58***
					(0.08)	(0.11)	(0.01)	(0.04)
other_rel_female					-2.33***	0.16**	-0.00	-0.68***
					(0.10)	(0.08)	(0.00)	(0.03)
no_rel_male					-0.62*	-1.59***	-0.04	-0.74***
					(0.33)	(0.48)	(0.04)	(0.09)
no_rel_female					-2.22***	0.01	0.00	-0.72***
					(0.11)	(0.07)	(0.00)	(0.03)
age	0.08***	0.02***	-0.00	0.02***	0.03***	0.03***	-0.00	0.02***
	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
age2	-0.06***	-0.02**	0.00	-0.02***	-0.02***	-0.03***	0.00	-0.02***
	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
topo1	-0.09	-0.08	0.00	-0.05	-0.05	-0.06	-0.00	-0.02
	(0.07)	(0.07)	(0.00)	(0.04)	(0.05)	(0.04)	(0.00)	(0.02)
topo2	0.15	-0.07	-0.00	-0.04	-0.01	0.00	0.01	0.03
	(0.09)	(0.09)	(0.01)	(0.04)	(0.07)	(0.06)	(0.01)	(0.03)
_Iplotdist_2	0.00	0.15***	0.00	0.13***	0.07**	0.00	0.00	0.07***
	(0.05)	(0.04)	(0.00)	(0.02)	(0.04)	(0.03)	(0.00)	(0.02)

Table 8 (continued)

	Nuclear households				Extended households			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	lnmale_labor	lnfemale_labor	lnchild_labor	lnTotLab	lnmale_labor	lnfemale_labor	lnchild_labor	lnTotLab
_Iplotdist_3	-0.00	-0.01	-0.00	0.11	0.12	0.18*	0.00	0.14***
	(0.15)	(0.14)	(0.00)	(0.08)	(0.13)	(0.10)	(0.00)	(0.05)
Constant	3.49***	5.31***	0.02**	6.66***	5.02***	5.24***	0.03***	6.92***
	(0.34)	(0.23)	(0.01)	(0.10)	(0.16)	(0.12)	(0.01)	(0.06)
Observations	28,119	28,119	28,119	28,119	53,366	53,366	53,366	53,366
R-squared	0.41	0.44	0.01	0.76	0.36	0.41	0.01	0.74
hh-cr-yr fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-Stat. test-1	98.99	71.79	0.94	1.45	140.10	60.98	1.20	27.13
p value	0.00	0.00	0.42	0.23	0.19	0.00	0.31	0.00
F-Stat. test son = other male					1.65	0.16	1.07	1.92
p value					0.53	0.86	0.40	0.15
F-Stat. test daughter = other female					0.63	3.88	0.98	1.71
p value					0.00	0.00	0.38	0.00
F-Stat. test all other plots equal					77.74	37.31	1.05	13.57
p value					0.00	0.02	0.34	0.18

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.

Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level.

The dependent variable natural log of male, female, child and total labor. All regressions control for household-crop-year fixed effects. All regressions also control for household demographic composition, and age of the household head, not shown. F-Stat. test-1 is short for an F-test that the coefficients of all nuclear members (son, daughter, spouse, head) and that of comm_nhead (common plots managed by non-head members) are all equal.

Table 9: Household Members' Labour Contributions on Household's Private Plots

VARIABLES	(1) lnTotLab_ha	(2) lnTotLab_ha	(3) lnTotLab_ha
Head	-0.56***	-0.52***	0.08
	(0.06)	(0.06)	(0.07)
Spouse	-0.75***	-0.44***	0.01
	(0.04)	(0.06)	(0.04)
Son	-0.57***	-0.35***	0.07
	(0.05)	(0.06)	(0.04)
Daughter	-0.71***	-0.43***	
	(0.09)	(0.06)	
other_rel_male	-0.17***	-0.78***	
	(0.03)	(0.00)	
no_rel_male	-0.26**	-0.97***	
	(0.12)	(0.17)	
other_rel_female	-0.27***	-0.79***	
	(0.02)	(0.06)	
no_rel_female	-0.27***	-0.92***	
	(0.04)	(0.06)	
worker_female	0.24***	0.31***	0.28***
	(0.03)	(0.02)	(0.02)
worker_age	0.02***	0.02***	0.03***
	(0.00)	(0.00)	(0.00)
worker_age2	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
worker_Education	-0.01*	-0.01**	-0.02**
	(0.01)	(0.01)	(0.01)
Constant	5.20***	4.86***	5.29***
	(0.07)	(0.07)	(0.06)
Observations	25,237	48,087	30,026
R-squared	0.37	0.34	0.33
Number of hhycrfe	8,729	12,124	8,147
Fixed effects	household-crop-year	household-crop-year	household-crop-year
households	extended	extended	nuclear
Worker	extended member	nuclear member	nuclear member

Source: Authors' calculations using data from the Ministry of Agriculture of Burkina Faso.

Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level.

The dependent variable is natural log of a particular household member's contribution per hectare on a specific private plot.

Columns 1 and 2 show the estimates for extended-family households. Column 3 show the estimates for nuclear family households.

Each estimation includes controls for household-crop-year fixed-effects, plot size, location and topography (not shown).

Table 10: Household members' labour contribution on households' common plots

VARIABLES	(1) lnLab_com	(2) lnLab_com	(3) lnLab_com	(4) lnLab_com	(5) lnLab_com	(6) lnLab_com
spouse	-0.81***	-0.88***	-0.56***	-0.92***	-0.94***	-0.66***
	(0.08)	(0.09)	(0.11)	(0.08)	(0.09)	(0.10)
Son	-0.42***	-0.45***	-0.07	-0.47***	-0.47***	-0.08
	(0.09)	(0.10)	(0.18)	(0.08)	(0.10)	(0.15)
Daughter	-1.61***	-1.76***	-0.98***	-1.62***	-1.78***	-0.96***
	(0.12)	(0.13)	(0.21)	(0.11)	(0.13)	(0.19)
other_rel_male	-0.54***	-0.61***		-0.57***	-0.61***	
	(0.10)	(0.10)		(0.10)	(0.10)	
other_rel_female	-2.20***	-2.24***		-2.30***	-2.31***	
	(0.13)	(0.13)		(0.12)	(0.13)	
no_rel_male	-0.56**	-0.61**		-0.80***	-0.85***	
	(0.28)	(0.29)		(0.25)	(0.25)	
no_rel_female	-1.40***	-1.49***		-1.40***	-1.46***	
	(0.14)	(0.14)		(0.13)	(0.14)	
Constant	3.68***	4.73***	1.33	3.11***	3.20***	2.57***
	(0.62)	(0.74)	(1.01)	(0.16)	(0.19)	(0.31)
Observations	55,628	39,242	16,386	55,628	39,242	16,386
R-squared	0.06	0.07	0.04	0.06	0.07	0.03
Fixed effects	hh.	hh.	hh.	hh-year	hh.-year	hd-year
F-Stat. test1	0.95	1.57		1.42	2.10	
p value	0.39	0.21		0.00	0.12	
F-Stat. test2	21.17	18.35		30.69	25.05	
p value	0.00	0.00		0.24	0.00	
F-Stat. test3	83.81	72.04	27.01	87.16	77.15	29.22
p value	0.00	0.00	0.00	0.00	0.00	0.00
households	all	extended	nuclear	all	extended	nuclear

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.

Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level.

The dependent variable is natural log of each household member contribution on common plots. Columns 1 and 4 show the estimates for the pooled sample. Columns 2 and 5 show the estimates for extended households, and columns 4 and 6 show the estimates for nuclear households. Columns 1-3 control for household fixed effects, and columns 4-6 control for household-year fixed effects. All regressions control for age and age squared, education level and the individual's private plot size (not shown). In addition, columns 1-3 include the size of the common plot, household size and composition and time trend (not shown). F-Stat. test1 is short for an F-test that the coefficients on son and other male are equal. F-Stat. test2 is short for an F-test that the coefficients on daughter and other females are equal. F-Stat. test3 is short for an F-test that the coefficients on all nuclear members (spouse, son, daughter) are all equal.

Table 11: Rainfall effects on income from common and private plots

	(1)	(2)	(3)	(4)
		Natural log of crop income from:		
VARIABLES	All hh plots	Comm. plots	Male plots	Female plots
Rainfall deviation from long run average interacted with farm area of type:				
low ground-household plots	0.065***			
	(0.022)			
sloping ground-all household plots	0.024			
	(0.016)			
location “brousse”-all household plots	0.150***			
	(0.009)			
location “campement”-all household plots	0.115***			
	(0.017)			
low ground-common plots		*0.218***	-0.307**	-0.127
		(0.091)	(0.147)	(0.157)
sloping ground-common plots		*0.040*	0.071	-0.098
		(0.049)	(0.086)	(0.079)
location “brousse”-common plots		*0.423****	-0.111**	-0.042
		(0.040)	(0.052)	(0.043)
location “campement”-common plots		*0.335****	0.022	0.091
		(0.061)	(0.065)	(0.071)
low ground-male plots		-0.817	*3.394****	-0.322
		(0.602)	*(0.973)*	(0.444)
sloping ground-male plots		-0.077	*0.778*	0.086
		(0.398)	*(0.613)*	(0.183)
location “brousse”-male plots		-0.845***	*2.868****	-0.032
		(0.124)	*(0.253)*	(0.108)
location “campement”-male plots		-0.737***	*1.987****	-0.151
		(0.260)	*(0.376)*	(0.170)
low ground-female plots		0.075	-0.413	*1.127****
		(0.248)	(0.509)	*(0.416)*
sloping gound-female plots		0.018	-0.351	*2.370****
		(0.312)	(0.465)	*(0.520)*
location “brousse”-female plots		-0.022	-0.151	*2.864****
		(0.090)	(0.192)	*(0.223)*
location “campement”-female plots		-0.193	-0.207	*3.548****
		(0.301)	(0.594)	*(0.725)*
Observations	12,867	12,867	12,867	12,867
R-squared	0.124	0.124	0.177	0.123
household fixed effects	yes	yes	yes	yes
village-year fixed effects	yes	yes	yes	yes
households	all	all	all	all
F-Stat. test all excluded instruments	74.24	16.16	17.37	21.39
p value	0.00	0.00	0.00	0.54
F-Stat. test equation specific excluded instruments		31.82	45.00	61.49
p value		0.00	0.05	0.00
F-Stat. test other excluded instruments		8.39	1.97	0.87
p value		0.00	0.05	0.54

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level. The dependent variables are the natural log of household’s harvest value from all plots (column 1), common plots (column 2), male private plots (column 3) and female private plots (column 4). The regressions control

household fixed effects and village-year-fixed effects. Other covariates (not shown) are household demographic characteristics, age and gender of the household head. We reported the F-statistics for all excluded instruments for all columns. We also reports the F-statistics for equation-specific instruments and for all other instruments. Equation-specific instruments are rainfall deviation interacted with common plots in column 2, rainfall deviation interacted with male plots in columns 3 and rainfall deviation interacted with female plots in column 4. “Other excluded instruments” refer to rainfall deviation interacted with male and female plots in column 2, rainfall deviation interacted with common and female plots in column 3, and rainfall deviation interacted with common and male plots in column 4.

Table 12: Household consumption response to shocks in income from common plots, male private plots and female private plots (table continues on next page)

Panel A: Effects of plot specific income shocks on total household food consumption

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln_Cons	ln_Cons	ln_Cons	ln_Cons	ln_Cons	ln_Cons
log crop income	0.220***	0.334***	0.158***			
	(0.050)	(0.072)	(0.057)			
log crop income-common plots				0.078***	0.072**	0.077***
				(0.022)	(0.028)	(0.027)
log crop income-private plots				0.036***	0.047***	0.026**
				(0.011)	(0.015)	(0.011)
log crop income-male plots				0.030***	0.025**	0.031***
				(0.009)	(0.012)	(0.011)
Observations	12,867	5,315	7,552	12,867	5,315	7,552
households	all	nuclear	extended	all	nuclear	extended
Chi-2			4.50			
p value			0.03			
F-Stat.				4.121	1.207	3.338
p value				0.0166	0.300	0.0360

Panel B: Effects of plot specific income shocks on different categories of household food consumption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ln_cereals	ln_cereals	ln_cereals	ln_otherown	ln_otherown	ln_otherown	ln_cons1	ln_cons1	ln_cons1
log crop income-common plots	0.097**	0.082**	0.090*	0.129***	0.088	0.143***	0.154	0.140	0.179
	(0.040)	(0.036)	(0.052)	(0.047)	(0.069)	(0.054)	(0.119)	(0.134)	(0.157)
log crop income-private plots	0.058**	0.058**	0.050**	0.082***	0.092**	0.067***	0.129**	0.118	0.136**
	(0.024)	(0.029)	(0.022)	(0.025)	(0.039)	(0.023)	(0.053)	(0.076)	(0.062)
log crop income-male plots	-0.012	-0.029	-0.003	0.051***	0.064***	0.039**	0.117**	0.106*	0.119**
	(0.020)	(0.032)	(0.016)	(0.016)	(0.019)	(0.019)	(0.046)	(0.057)	(0.058)
Observations	12,867	5,315	7,552	12,867	5,315	7,552	12,867	5,315	7,552
households	all	nuclear	extended	all	nuclear	extended	all	nuclear	extended

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level.
In Panel A, the dependent variable is the natural log of all food consumption including own consumption and food purchases. In Panel B, the dependent variables are the natural log of household own consumption of cereals (columns 1-3), the natural log of household own consumption of other food (columns 4-6) and the natural log of household food purchases (columns 7-9). The regressions control household fixed effects and village-year-fixed effects. Other covariates (not shown) are household demographic characteristics, age and gender of the household head. In Panel A, in columns 3, we report a chi-2 test of the null hypothesis that the coefficients of nuclear and extended family households are equal. In columns 4-6, we report the F-Statistic of the null hypothesis that rainfall induced shocks on common plots, male private plots and female plots have the same effects on household total food consumption.

Table 13: Tests for unitary and collective household models

		Type of households:		
		All	Nuclear	Extended
Unitary household				
	Wald			
	stat	23.62	12.11	33.46
	prob	0.00	0.06	0.00
Efficient household				
	Wald			
	stat	17.36	5.67	18.05
	prob	0.01	0.46	0.01

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: The tests use the coefficients reported in Table 13.

Table 14: intra-household risk-sharing based on child anthropometrics

VARIABLES	(1) z-muac	(2) z-muac	(3) z-muac	(4) z-muac	(5) z-muac	(6) z-muac
log mother crop income	0.009*	0.002	0.013***			
	(0.005)	(0.013)	(0.005)			
log mother cons. Expenditures				0.019*	0.010	0.028***
				(0.011)	(0.030)	(0.011)
girl	0.072***	0.115***	0.057***	0.072***	0.115***	0.057***
	(0.015)	(0.028)	(0.018)	(0.015)	(0.028)	(0.018)
Observations	38,777	12,037	25,902	38,777	12,037	25,902
R-squared	0.048	0.035	0.055	0.046	0.034	0.049
household-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
households	all	nuclear	extended	all	nuclear	extended
Child age dummies	yes	yes	yes	yes	yes	yes

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level. The dependent variable is standardized (z-score) child mid-upper-arm-circumference (MUAC). The regressions control for household-year fixed effects, and child age dummies.

Table 15: Estimates of yields for extended and nuclear households with homogenous sub-samples

VARIABLES	(1) lny	(2) lny	(3) lny	(4) lny	(5) lny	(6) lny	(7) lny	(8) lny	(9) lny
Male_Plot	-0.24***	-0.27***	-0.10	-0.24***	-0.26***	-0.18***	-0.22***	-0.27***	-0.15***
	(0.04)	(0.04)	(0.08)	(0.03)	(0.03)	(0.05)	(0.04)	(0.05)	(0.05)
Fema_Plot	-0.42***	-0.47***	-0.29***	-0.47***	-0.53***	-0.36***	-0.41***	-0.47***	-0.34***
	(0.03)	(0.04)	(0.05)	(0.02)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
age	0.02***	0.02***	0.02**	0.02***	0.02***	0.04***	0.02***	0.02***	0.03***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
age2	-0.02***	-0.02***	-0.01	-0.02***	-0.02***	-0.04***	-0.02***	-0.02***	-0.02***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Constant	12.31***	12.36***	12.12***	12.34***	12.47***	11.95***	12.29***	12.46***	12.11***
	(0.10)	(0.11)	(0.23)	(0.07)	(0.08)	(0.15)	(0.09)	(0.12)	(0.12)
Observations	35,873	22,344	13,529	68,293	43,260	25,033	47,835	20,380	27,455
R-squared	0.36	0.37	0.36	0.38	0.38	0.38	0.37	0.36	0.38
household-crop-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
households	all	extended	nuclear	all	extended	nuclear	all	extended	nuclear
plots	all	all	all	all	all	all	all	all	all
specification robust to	monogamy	monogamy	monogamy	head age	head age	head age	hh size	hhsize	hh size
F-St. test Male_Plot = Female_Plot = 0	96.56	82.95	18.08	225.8	220.6	49.07	122.1	79.11	55.70
p value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level. The dependent variable is natural log of plot yield measured in the local currency per hectare. Columns 1-3 show estimates for monogamous household heads. In columns 4-6, age of household head is the same on average for nuclear and extended family households. In columns 7-9, nuclear and extended family household have the same size on average. Columns 1, 4 and 7 include all households. Columns 2, 5, and 8 include extended family households. Columns 3, 6 and 9 include nuclear family households. The regressions control for household-crop-year fixed effects. Dummy variables representing the plot manager education level and dummy variables representing plot size by deciles are included in the regressions but not shown.

Table 16: Tests for unitary and collective household models using homogenous subsamples

	Monogamous households			Similar household size			Similar hh. head age		
	Type of households:			Type of households:			Type of households:		
	All	Nuclear	Extended	All	Nuclear	Extended	All	Nuclear	Extended
Unitary household									
Wald									
stat	5.4	8.30	10.20	10.81	4.73	15.61	13.81	7.08	59.29
prob	0.50	0.22	0.12	0.09	0.58	0.02	0.03	0.31	0.00
Efficient household									
Wald									
stat	5.4	8.30	10.20	10.81	4.73	15.61	13.81	7.08	13.35
prob	0.50	0.22	0.12	0.09	0.58	0.02	0.03	0.31	0.04

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: The tests use the coefficients on regressions similar to those reported in Table 13, but estimated for each sample.
Regressions results are available from the authors.

Table 17: Land inherited by household head and household structure

VARIABLES	(1) nuc_bin	(2) nuc_bin	(3) nuc_bin	(4) nuc_bin	(5) nuc_bin	(6) nuc_bin	(7) nuc_bin	(8) nuc_bin	(9) nuc_bin	(10) nuc_bin	(11) nuc_bin	(12) nuc_bin	(13) nuc_bin
land inherited by hh head	-0.024***	-0.024***	-0.024***	-0.038***	-0.034***	-0.034***	-0.043***	-0.046***	-0.047***	-0.023***	-0.039***	-0.021***	-0.040***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
land inh. by head squared							0.001***	0.001***	0.001***		0.001***		0.001***
							(0.000)	(0.000)	(0.000)		(0.000)		(0.000)
Other hh farm land	-0.035***	-0.037***	-0.039***				-0.037***	-0.040***	-0.042***				
	(0.003)	(0.004)	(0.004)				(0.003)	(0.004)	(0.004)				
land per capita				0.286***	0.272***	0.279***							
				(0.025)	(0.024)	(0.025)							
head is female	-0.010***	-0.009***	-0.009***	-0.011***	-0.010***	-0.011***	-0.010***	-0.009***	-0.010***	-0.011***	-0.010***	-0.011***	-0.011***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
year 2011	0.037***	0.040***		0.057***	0.060***		0.029***	0.031***		0.049***	0.046***		
	(0.010)	(0.010)		(0.010)	(0.010)		(0.010)	(0.010)		(0.010)	(0.010)		
year 2012	0.024*	0.011		0.041***	0.032**		0.019	0.004		0.033**	0.017		
	(0.014)	(0.014)		(0.014)	(0.013)		(0.014)	(0.014)		(0.014)	(0.014)		
Constant	0.522***	0.318**	0.552***	0.176	0.180	0.446***	0.679***	0.398***	0.593***	0.403***	0.333**	0.526***	0.559***
	(0.138)	(0.142)	(0.012)	(0.134)	(0.142)	(0.012)	(0.135)	(0.140)	(0.011)	(0.137)	(0.141)	(0.010)	(0.010)
Observations	13,176	13,176	13,176	13,176	13,176	13,176	13,176	13,176	13,176	13,176	13,176	13,176	13,176
R-squared	0.086	0.067	0.066	0.089	0.067	0.066	0.097	0.080	0.079	0.069	0.059	0.048	0.058
Village fixed effects	No	yes	yes	No	yes	yes	No	yes	yes	No	yes	yes	yes
Village-year fixed effects	No	no	yes	No	no	yes	No	no	yes	No	no	yes	yes
household fixed effects	no	no	no	no	no	no	no	no	no	no	no	no	no

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.

Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level. The dependent variable is one for nuclear family households and zero for extended family households. The regressions also control for household demographic characteristics (based on the nuclear family members) and head age and gender. Columns 1-2, 4-5, 7-8 and 10-11 also control for village level prices.

Table 18: Variance of long run income shocks and household structure

VARIABLES	(1) nuc_bin	(2) nuc_bin	(3) nuc_bin	(4) nuc_bin	(5) nuc_bin	(6) nuc_bin
variance of income shocks	-0.115***	-0.116***	-0.115***	-0.116***	-0.115***	-0.116***
	(0.016)	(0.018)	(0.017)	(0.019)	(0.016)	(0.017)
current rainfall deviation					0.010	0.010
					(0.007)	(0.007)
head is female	-0.056**	-0.054*	-0.056**	-0.055*	-0.056**	-0.056**
	(0.027)	(0.029)	(0.027)	(0.029)	(0.027)	(0.027)
year 2011	0.059***		0.059***		0.070***	0.070***
	(0.010)		(0.010)		(0.012)	(0.012)
year 2012	0.028**		0.028**		0.022	0.021
	(0.014)		(0.014)		(0.015)	(0.015)
Constant	0.259*	0.510***	0.259*	0.509***	0.158	0.157
	(0.153)	(0.011)	(0.153)	(0.011)	(0.170)	(0.170)
Observations	12,568	12,568	12,568	12,568	12,568	12,568
R-squared	0.208	0.273	0.208	0.273	0.208	0.208
village fixed effects	yes	yes	yes	yes	yes	yes
village-year fixed effects	no	yes	no	yes	no	no
households fixed effects in first stage	yes	yes	yes	yes	yes	yes
village-year fixed effects in first stage	no	no	yes	yes	no	yes
current rainfall	no	no	no	no	yes	yes

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level. The dependent variable is one for nuclear family households and zero for extended family households. The regressions also control for household demographic characteristics (based on the nuclear family members) and head age and gender. Columns 1-2, 4-5, 7-8 and 10-11 also control for village level prices.

Appendix

Table A1: Rainfall effects on crop income from common and private plots, and for nuclear family and extended family households

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Natural log of crop income from							
VARIABLES	All hh plots	Comm. Plots	Male Plots	Female Plots	All hh plots	Comm. Plots	Male Plots	Female Plots
Rainfall deviation from long run average interacted with farm area of type:								
low ground-household plots	0.102***				0.043*			
	(0.031)				(0.024)			
sloping ground-all household plots	0.032				0.020			
	(0.026)				(0.018)			
location “brousse”-all household plots	0.169***				0.142***			
	(0.015)				(0.009)			
location “campement”-all household plots	0.147***				0.103***			
	(0.023)				(0.018)			
low ground-common plots		0.455**	-0.359*	0.091		0.077	-0.241	-0.247
		(0.209)	(0.214)	(0.246)		(0.080)	(0.167)	(0.151)
sloping ground-common plots		0.093	-0.055	-0.371***		0.009	0.126	-0.004
		(0.090)	(0.138)	(0.138)		(0.051)	(0.110)	(0.096)
location “brousse”-common plots		0.582***	-0.169**	0.041		0.366***	-0.084	-0.067
		(0.065)	(0.079)	(0.071)		(0.040)	(0.058)	(0.045)
location “campement”-common plots		0.440***	0.124	-0.012		0.306***	-0.023	0.101
		(0.084)	(0.103)	(0.097)		(0.065)	(0.069)	(0.077)
low ground-male plots		-1.256	2.969**	-0.392		-0.489	3.471***	-0.236
		(1.014)	(1.242)	(0.518)		(0.484)	(0.862)	(0.470)
sloping ground-male plots		-0.300	0.606	-0.269		0.043	0.869	0.361
		(0.642)	(0.927)	(0.290)		(0.366)	(0.600)	(0.228)
location “brousse”-male plots		-1.244***	3.461***	-0.053		-0.688***	2.609***	-0.056
		(0.199)	(0.393)	(0.174)		(0.126)	(0.281)	(0.114)
location “campement”-male plots		-0.864**	2.289***	-0.247		-0.660***	1.860***	-0.172
		(0.368)	(0.461)	(0.279)		(0.229)	(0.391)	(0.196)
low ground-female plots		0.462	-0.474	1.451*		-0.002	-0.281	0.968**
		(0.401)	(0.707)	(0.815)		(0.288)	(0.588)	(0.389)
sloping ground-female plots		0.726	-0.674	3.477***		-0.335	-0.175	1.910***
		(0.709)	(0.853)	(0.906)		(0.268)	(0.576)	(0.585)
location “brousse”-female plots		-0.137	0.119	3.309***		0.004	-0.303	2.659***
		(0.154)	(0.280)	(0.309)		(0.105)	(0.231)	(0.238)
location “campement”-female plots		-0.315	-0.052	3.706***		-0.186	-0.237	3.506***
		(0.457)	(0.650)	(0.772)		(0.311)	(0.680)	(0.877)

Table A1 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Natural log of crop income from							
	All hh plots	Comm. Plots	Male Plots	Female Plots	All hh plots	Comm. Plots	Male Plots	Female Plots
Constant	-0.007***	-0.018**	-0.035**	-0.013	0.006***	0.013**	0.029***	0.012
	(0.002)	(0.008)	(0.015)	(0.012)	(0.002)	(0.006)	(0.011)	(0.009)
Observations	5,315	5,315	5,315	5,315	7,552	7,552	7,552	7,552
R-squared	0.115	0.156	0.203	0.130	0.134	0.121	0.164	0.126
village-year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
households	nuclear	nuclear	nuclear	nuclear	extended	extended	extended	extended
F-Stat. test all instruments	41.33	14.85	11.37	18.02	60.05	12.35	13.05	17.93
p value		0.00	0.00	0.00		0.00	0.00	0.00
F-Stat. test relevant instruments		23.15	26.59	41.00		23.79	36.25	50.00
p value		0.00	0.00	0.00		0.00	0.00	0.00
F-Stat. test other instruments		8.26	1.56	1.347		5.59	1.36	1.615
p value		0.00	0.13	0.22		0.00	0.21	0.12

Source: Authors calculations using data from the Ministry of Agriculture of Burkina Faso.
Notes: *** significant at the 1 percent level, ** significant at the 5 percent level and * significant at the 10 percent level. Robust standard errors, clustered at the village level. This Table reproduces the estimates from Table 11 for nuclear (columns 1-4) and extended (columns 5-8) households. The dependent variables are the natural log of household's harvest value from all plots (columns 1 and 5), common plots (columns 2 and 6), male private plots (columns 3 and 7) and female private plots (columns 4 and 8). The regressions control for household fixed effects and village-year-fixed effects. Other covariates (not shown) are household demographic characteristics, age and gender of the household head. We reported the F-statistics for all excluded instruments for all columns. We also reports the F-statistics for equation-specific instruments and for all other instruments. Equation-specific instruments are rainfall deviation interacted with common plots in columns 2 and 6, rainfall deviation interacted with male plots in columns 3 and 6 and rainfall deviation interacted with female plots in columns 4 and 8. "Other excluded instruments" refer to rainfall deviation interacted with male and female plots in columns 2 and 6, rainfall deviation interacted with common and female plots in columns 3 and 7, and rainfall deviation interacted with common and male plots in columns 4 and 8.