Gender, Production and Consumption: Allocative Efficiency within Farm Households*

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Abstract

Seminal contributions to the literature have explored data on agricultural activities in West Africa to show that, within families, plots of land managed by women are less productive than those farmed by their husbands. This is interpreted as evidence that these farm households do not allocate resources Pareto efficiently. This research has been very influential in the development and broader literatures. We argue that failure of efficiency in production does not necessarily imply failure of efficiency in consumption. Using farm household data from three independent surveys collected in two West African countries, we explicitly test whether consumption decisions are consistent with Pareto efficient resource allocation. They are. This is the case even if, for the exact same households, we replicate the results of tests based on plot-level productivity differences. Adapting the latter tests to the presence of unobserved heterogeneity reveals fragilities of evidence based on production data, however. The balance of evidence is not consistent with rejecting the hypothesis that West African farm households allocate resources Pareto efficiently.

Keywords: Pareto-efficiency, farm households, agricultural production, consumption. **JEL codes:** D13, O12, O13.

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1 Introduction

The traditional characterization of households as groups of individuals who behave as if they shared the same preferences, the unitary model, has been rejected in a wide array of settings.[1] A number of alternative representations have been proposed but there is little consensus in the literature regarding the general applicability of a specific model. Among those, one important class is the one proposed by Chiappori (1988, 1992) and Browning and Chiappori (1998), and further generalized by Cherchye et al (2012). In their design households are characterized as collectively rational in the sense that resource allocations are Pareto efficient. Empirical evidence on the extent to which household behavior is consistent with this crucial assumption is mixed, however.

On the one hand, studies based on consumption choices of households in Canada (Browning and Chiappori, 1998), France (Bourguignon et al., 1993), Mexico (Bobonis, 2009), Taiwan (Thomas and Chen, 1994) and the United States (Chiappori et al, 2002) fail to reject the hypothesis that resources are allocated Pareto efficiently. On the other hand, very insightful contributions focusing on aspects of agricultural productivity and input usage among farm households in rural West Africa have reached the opposite conclusion. Akresh (2008), Owens (2001) and Udry (1996), for example, exploit the fact in some areas of Burkina Faso and Senegal, husbands and wives farm independent plots of land and report that these individuals fail to maximize farm profits at the household level.[2] They conclude that holding all other inputs constant, reallocating land away from wives to their husbands would result in very large increases in total agricultural output of the farm household. This is an important, widely cited and very influential result. It is also a remarkable finding as it indicates that, even in environments in which resources are extremely constrained with households eking out a subsistence and survival a paramount concern, husbands and wives systematically fail to allocate resources in a way that is Pareto efficient.

Our research is a theory-oriented re-examination of the evidence from rural West Africa. We exploit the fact that agricultural-households make decisions over both production and consumption and argue that tests for Pareto efficiency based on production alone are unlikely to be informative. Using three independent surveys of farm households conducted in two West African countries, Ghana and Senegal, the implications of Pareto-efficient resource allocations are tested on both production choices, exploiting plot-level data, and the

[1]See, for example, Schultz (1990); Thomas (1990); Lundberg et al (1997); Rubalcava and Thomas (2000); Rangel (2006); Martinez (*forthcoming*) and many others.

[2]See also Akresh et al (2011, 2012), Ahsraf (2009), Duflo and Udry (2004), Jones (1983) and Von Braun and Webb (1989).

allocation of household consumption expenditures. We replicate the finding that, controlling observed characteristics of plots, those farmed by wives are substantially less productive than those farmed by their husbands. However, on the consumption side, for *exactly the same* households, our findings based on a demand system with food and non-food goods fail to reject efficient resource allocations. We argue that, in the absence of a model that explains how plots are allocated between husbands and wives, relying on production-based tests for efficiency is, at best, a weak test. This point is illustrated using the same data from Burkina Faso as Udry (1996) and highlights the potential role that unobserved heterogeneity plays in tests based on plot-level data. In particular, when employing novel empirical tests robust to a reasonable source of unobserved heterogeneity, we find no evidence of productivity differences between husbands and wives' plots. The same biases do not arise in consumption-based tests and we conclude that the balance of evidence is not consistent with rejecting the hypothesis that farm households in West Africa allocate resources Pareto efficiently.

Understanding decision-making within households is an important scientific and policy issue. It has been argued that the empowerment of women is key for economic development (see review by Duflo, 2012); without a clear understanding of intra-household dynamics, policies that are intended to improve the status of women may be ineffective or, worse, backfire. While our conclusion that the behavior of West African households is consistent with Pareto efficiency is in keeping with the recent empirical literature on household resource allocation in other countries across the entire globe, it does not imply that improving the status of women is either infeasible or undesirable. Rather, it suggests that thinking about these issues in the context of a model of collective rationality is likely to be profitable.[3]

The remainder of the paper is organized as follows. In Section 2 the model of general collective rationality is applied to the case of agricultural-households, while empirical implications of the Pareto-efficiency hypothesis are discussed in Section 3. Section 4 presents the data sets used in the analysis. The econometric evidence on the efficient allocation of resources within West African farm households is presented in Section 5. Section 6 concludes.

2 Conceptual framework

A distinguishing feature of farm households is that production and consumption decisions are intimately connected because they produce agricultural goods both for sale and for their

[3]Advances on the computation of equivalence scales to models of the household that allow for preference heterogeneity can be seen in Bowning et al (2008).

own consumption. In addition, many farm households allocate labor both on and off the farm. Models of farm households have been used to investigate a wide array of important issues in development including the functioning of markets, the relationship between health and productivity, the welfare impacts of changes in prices, of technological innovation and of public policies (Jayachandran, 2006; Singh et al., 1986; and Strauss, 1986).

Relatively few studies have explored decision-making *within the farm-household* although the anthropological literature has documented many examples of farm household responses to policy and technological changes that suggest within households dynamics are extremely important (Guyer, 1997). A well-known example involves a government intervention in the Gambia that sought to improve the economic status of women by introducing technology to raise the productivity of rice which had traditionally been cultivated by women. As rice turned from subsistence to a cash crop, males took over cultivation and marketing (Dey, 1993). Clearly, the program did not have the intended direct impact on the status of women although the net effect on the well-being of women and other family members has not been established. Similarly, potential benefits of public-policy-induced innovation in cotton production in Tanzania, a crop controlled by men, were not fully realized as women did not tend the cotton plants but continued to cultivate maize (Fortman, 1986). These types of studies have been interpreted as providing *prima facie* evidence that the dynamics of the allocation of time and financial resources within farm households is not consistent with the unitary model and unlikely to be efficient. This argument has particular force in the African context where it is not uncommon for a farm household to be headed by a male with many wives, all of whom manage their own plots. Moreover a large number of ethnographic studies conducted in West Africa indicate that it is neither the custom nor the practice for husbands and wives to pool their resources. Many of these studies indicate that husbands and wives take responsibility for different domains of decision-making and resource allocation, although the precise domains vary across cultures and societies (See Guyer, 1980; Mook, 1986 and Orubuloye et al., 1991).

In this section we extend the standard model of the farm household to allow heterogeneity in the preferences of individual members and permit these members to have agency in decision-making. We restrict attention to models that assume collective rationality of all household members and draw out testable empirical implications of the assumption that resource allocations are Pareto efficient. This lays the foundation for the empirical analyses presented in the following section.

A general model of a farm household can be characterized as an aggregation over the felicity functions of different members, or sub-groups of members such as generations, gender, blood ties and so on. Without loss of generality, consider a household formed by two groups:[4]

$$W = W[U^m(C^m, C^f, l^m, l^f; X, \epsilon), U^f(C^m, C^f, l^m, l^f; X, \epsilon); \Lambda] \tag{1}$$

where the superscripts m and f index the group. They may be male and female adults in the household, for example. C represents the consumption vector, l stands for leisure, while X and ϵ represent observed and unobserved characteristics of the farm households and/or its members, respectively. The consumption vector includes market goods (non-food consumption and food purchased in the market) and agricultural commodities produced by the household. The discussion of Λ, a vector of parameters, is deferred to the next sub-section.

Household units are limited in their choices by their time and money budget with total expenditure given by:

$$P_c' \cdot \left(C^m + C^f\right) = E = \left[w(T - l^m) + w(T - l^f)\right] + \left(\overline{\pi}^m + \overline{\pi}^f\right) + \left(y^m + y^f + y^0\right) \tag{2}$$

where P_c represents the vector of consumption prices. The income generating process consists of returns to labor supplied to the market, profits from production on all plots (which includes rents to fixed inputs), and non-labor/non-business income (transfers, gifts). In the absence of specific information on how income from productive activities are divided, it is assumed that profits derived from agricultural activity on a plot accrue to the person responsible for management of production in that area.

Farm production is assumed to consist of both food (partially consumed by the household, and partially sold) and non-food cash crops (which are sold in the market place). Technology is embedded in the production function:

$$F(\underline{Q_a}, \underline{Q_k}, \underline{L_a}, \underline{L_k}, \underline{V_a}, \underline{V_k}; A, \underline{Z}, \underline{\Phi}) = 0 \tag{3}$$

Where sub-scripts (a) and (k) represent food and non-food crops, respectively; Q represents output, L is labor input (which may be vector-valued), V is a vector containing any other variable inputs. Observed and unobserved characteristics of each plot are reflected

[4]Decision-making by extended households is an important issue in itself, but it is put to the side in this paper. See Rangel (2011), Witoelar (2012), LaFave and Thomas (2012), for example.

in Z and Φ, respectively. Finally, A indicates the total amount of land to which the household has access for farming. The function F is a characteristic production function, concave, decreasing in outputs and increasing in inputs. The variables are defined in terms of vectors to capture production based on multiple plots. All household members are assumed to be subject to the same technological parameters that govern the optimal combination of inputs within each plot.

Farm profits are given by the solution to:

$$\overline{\pi}^m + \overline{\pi}^f \equiv \max_{\left\{\underline{Q_j},\underline{L_j},\underline{V_j}\right\}_{j=a,k}} \sum_j \sum_{n=1}^{N_j} \left(p_j Q_{jn} - w L_{jn} - \overrightarrow{\rho} \cdot \underline{V_{jn}} \right) \tag{4}$$

which can be expressed as the sum of (short run) profit functions (conditional on fixed factors) across all plots managed by household members:

$$\overline{\pi}^m + \overline{\pi}^f \equiv \sum_j \sum_{n=1}^{N_j} R^*_{jn} \left(A_{jn}, p_a, p_k, \overrightarrow{\rho_a}, \overrightarrow{\rho_k}, Z_{jn}, \phi_{jn} \right) \tag{5}$$

Each household maximizes both profits and welfare which yields demands for inputs and consumption goods, off farm labor supply and farm output. Under the assumption that markets are complete in the sense that all prices are treated as parametric, own labor and the labor of hired workers are perfect substitutes and there is no uninsurable uncertainty, then the farm household optimization program can be treated as recursive (Singh, Squire and Strauss, 1986). This is a strong assumption that has powerful implications for behavior in the model; to wit, behavioral choices can be treated as if all farm production decisions are delegated to a profit maximizing third party with the household retaining all profits. Thus, although household members all make production and consumption decisions simultaneously, the process can be modeled as if the decisions are made sequentially. In the first stage, each household members maximizes profits on the plots they manage, conditional on technology. In the second stage, the household maximizes utility subject to time and budget constraints which take as given time allocated to labor on the farm and the sum of profits from all the plots.

The assumption that decisions are recursive is not innocuous. It rules out the possibility that the marginal value of labor supplied by those who have control over a plot (own the plot) is different from that of labor supplied by others − be they household members, hired laborers or exchange workers. That is, there is no scope for managerial skill (of the plot owner), monitoring costs or shirking (by others). Farm gate and market prices are assumed to be the same and thus there are no market externalities, no scope for bargaining or transactions costs and no indivisibilities. All household members have access to a complete set of futures markets including markets for insurance. Despite the wide reach of such assumption, evidence in its support is mixed; see, for example, Pitt and Rosenzweig (1986), Benjamin (1998), Lafave et al. (2012).

The key point for this research is that if decisions are not recursive, then production decisions by individual household members reflect the combined influence of not only technology, the characteristics of their plots and their own characteristics (such as farming skill) but also their own preferences (including altruism towards other household members), all prices and exogenous income. Moreover, consumption choices depend not only on preferences, prices and total income but also on the sources of income (i.e. profits from own plots) and thus technology, fixed inputs and plot characteristics. For the purposes of our research it is important to keep an eye for the potential effects of market incompleteness over tests regarding the efficiency of intra-household allocations.

3 Empirical implications of collective rationality

The assumption that decisions are Pareto efficient applies to both profit maximization in farm production, and to resource allocation with respect to consumption. Specifically, the assumption implies and embodies:

i) optimal allocation of available goods across individual members - given the aggregate amounts of income available so that the distribution of consumption maximizes each individual's well-being while meeting (minimum) utility requirements for all other members, and;

ii) efficient production across plots given plot characteristics and technologies. That is, it should not be possible to reassign production plans across production sets (plots) so as to produce, in the aggregate, more of a particular output (or use less of a particular input) without producing less (using more) of another.

Empirical tests for efficiency in each domain are discussed separately in the next two sub-sections because each class of tests calls for different data and are subject to distinct sources of limitations. We begin with tests for efficiency in consumption.

3.1 Preference-heterogeneity and efficiency in consumption

Farm households have traditionally been characterized by the unitary model. In this formulation, either by the power of consensus (Samuelson, 1956) or by the emergence of a dictator (Becker, 1991), the decision process is summarized by a representative individual's utility function. This means that either the household agrees on the utility derived from each choice to be made (therefore, the felicity functions in W are identical), or the choices are based on the dictators' view of the world (the non-dictator's felicity gets zero weight in W). In practice, these two alternatives are observationally equivalent. In the theoretical language described above, the unitary model assumptions correspond to the following (reduced-form) demand functions:

$$C = C\left(P, Y; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right) \tag{6}$$

where P includes production prices, wages and consumption prices, and Y is the aggregated non-labor/non-business income.

Alternatively, households can be considered as composed of individuals with heterogeneous preferences. A theoretically appealing class of models proposed and developed by Chiappori (1988, 1992) and Browning and Chiappori (1998) assumes that household behavior is collectively rational. The motivation is similar to other contributions to the literature based on bargaining concepts, but collective rationality abstracts from specifying the bargaining process.[5] This model axiomatically requires an efficient result for the negotiations regarding the allocation of resources within the household. Even though the model is set up as a static framework, its justification is almost invariably based on the repeated nature of the interaction between family members, which would promote the exhaustion of efficiency enhancement possibilities.

In the basic form of the collective model (with production), as presented in Chiappori (1997), the decision process can be interpreted as follows: members agree on some efficient production plan, on the level of public-goods consumption and on some distribution of household resources (net of expenditures on public goods); then each member freely chooses the bundles of private goods that maximize their utility subject to an individual budget constraint.[6] More generally, the efficiency assumption is equivalent to the following implicit structure for the household maximization problem:

[5] See Manser and Brown (1980), McElroy and Horney (1981), and Ulph (1988) for structural modeling of bargaining processes.

[6] See also Cherchye et al. (2012)

$$\max_{C,l^m,l^f} W = U^m(C^m, C^f, l^m, l^f; X, \epsilon) + \mu U^f(C^m, C^f, l^m, l^f; X, \epsilon) \tag{7}$$

$$s.t. \quad : \quad P_c'C = \left[w(T - l^m) + w(T - l^f)\right] + \left(\pi^m + \pi^f\right) + \left(y^m + y^f + y^0\right)$$

$$: \quad F(\underline{Q_a}, \underline{Q_k}, \underline{L_a}, \underline{L_k}, \underline{V_a}, \underline{V_k}; A, \underline{Z}, \underline{\Phi}) = 0$$

$$: \quad \pi^m + \pi^f = \sum_j \sum_{n=1}^{N_j} \left(p_j Q_{jn} - \overrightarrow{w} V_{jn} - \overrightarrow{\rho} \cdot \underline{V_{jn}}\right)$$

where μ can now be defined as the Pareto (distributional) weight, reflecting the relative importance of each individual member (or group) in the aggregated household utility (summarizing their "power"). Taking these weights as exogenously fixed and interior, the objective described above reproduces the consensus model *a la* Samuelson (1956). If exogenously set at zero, they reproduce the Beckerian dictator model. For the purpose of Chiappori's model, the weights correspond to functions of elements that influence the fall-back position of individual members. The idea is that each individual has specific preferences that are pursued while negotiations take place. As the welfare under the outside-option increases (decreases), individuals are able to appropriate a greater (smaller) share of the surplus derived from their interaction. Therefore, Pareto-weights can be defined as a function of, among other things, distribution factors which affect the choices without directly affecting the budget constraint or individual preferences. These are captured by elements of the vector Λ. In other words, $\mu = \mu\left(\lambda^m, \lambda^f; P, Y, X, \epsilon\right)$.

Reduced-form demand functions associated with such representation are as follows:

$$C = C\left(P, Y, \mu; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right)$$

or:

$$C = C\left(P, Y, \lambda^m, \lambda^f; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right) \tag{8}$$

Under the unitary model, distribution factors do not affect demands which suggests the following exclusion restrictions:

$$\frac{\partial c_s}{\partial \lambda^i} = 0 \quad \forall s, \quad i = m, f \tag{9}$$

Rejection of these restrictions says nothing about how decisions are made within a household. We turn next to the model of collective rationality which posits that if allocations are efficient then distribution factors only affect decisions by shifting the outside options (or "power") of each household decision-maker. It follows directly that the ratio of marginal propensities to consume a good with respect to different distribution factors should be the same across all goods. Specifically, the collective rationality model imposes a weak separability assumption between measures of bargaining power and other factors that affect demands. This condition can be expressed as a cross-equation restriction:

$$\frac{\frac{\partial c_1}{\partial \lambda^m}}{\frac{\partial c_1}{\partial \lambda^f}} = \frac{\frac{\partial c_1}{\partial \mu_1}\frac{\partial \mu}{\partial \lambda^m}}{\frac{\partial c_1}{\partial \mu_1}\frac{\partial \mu}{\partial \lambda^f}} = \frac{\frac{\partial \mu}{\partial \lambda^m}}{\frac{\partial \mu}{\partial \lambda^f}} = \frac{\frac{\partial c_s}{\partial \lambda^m}}{\frac{\partial c_s}{\partial \lambda^f}} \qquad \forall s \tag{10}$$

or simply:

$$\frac{\partial c_1}{\partial \lambda^m}\frac{\partial c_s}{\partial \lambda^f} = \frac{\partial c_s}{\partial \lambda^m}\frac{\partial c_1}{\partial \lambda^f} \qquad \forall s \tag{11}$$

Intuitively, if decisions about production and how households resources are distributed between members are made and then individuals decide their consumption choices, a redistribution of power within the household will have the same impact as a change in exogenous income on each individuals consumption choices. Thus, the effects of any two factors that affect bargaining power must be proportional under the assumptions of the model.

It is important to note that if there are more than two decision-makers then the equality of ratios does not needto hold. Demands in this case would have the structural representation:

$$C = C\left(P, Y, \mu_1, \mu_2; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right)$$

where μ_2 is the Pareto weight attached to the felicity function of the third decision-maker (the second wife, for example), with a reduced form:

$$C = C\left(P, Y, \lambda^m, \lambda^f; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right)$$

As a direct consequence of multiple Pareto-weights we have:

$$\frac{\partial c_1}{\partial \lambda^m} = \frac{\partial c_1}{\partial \mu_1}\frac{\partial \mu_1}{\partial \lambda^m} + \frac{\partial c_1}{\partial \mu_2}\frac{\partial \mu_2}{\partial \lambda^m}$$

Hence, the proportionality is broken:

$$\frac{\frac{\partial c_1}{\partial \lambda^m}}{\frac{\partial c_1}{\partial \lambda^f}} = \frac{\frac{\partial c_1}{\partial \mu_1}\frac{\partial \mu_1}{\partial \lambda^m} + \frac{\partial c_1}{\partial \mu_2}\frac{\partial \mu_2}{\partial \lambda^m}}{\frac{\partial c_1}{\partial \mu_1}\frac{\partial \mu_1}{\partial \lambda^f} + \frac{\partial c_1}{\partial \mu_2}\frac{\partial \mu_2}{\partial \lambda^f}} \neq \frac{\frac{\partial c_s}{\partial \lambda^m}}{\frac{\partial c_s}{\partial \lambda^f}}$$

In these circumstances, statistical tests based on equation (10) will tend to over reject efficiency even when household behavior is indeed consistent with absence of Pareto-improving trade opportunities.

3.2 Efficiency in production

Independent of assumptions about the preferences of individuals within the household, if markets are complete, farm households should maximize profits. Clearly, how those profits are distributed depends on distribution factors but that does not change the fundamental condition that the marginal return to each input should be the same on every plot. For example, the return to one unit of labor should be identical across plots and not depend on who has managerial control over each on of them. Similarly, the returns to land (plot yields) should be identical across plots with the same characteristics (such as area and land quality) or, put in another way, differences in plot yields should be fully explained by variation in plots' productive characteristics.

Following Udry (1996), a Taylor series can approximate the difference in yield functions (seen in equation 5, above) for plots n and m as follows:

$$R^*_{jn} - R^*_{jm} = \frac{\partial R^*}{\partial A} \cdot (A_{jn} - A_{jm}) + \frac{\partial R^*}{\partial Z} \cdot (Z_{jn} - Z_{jm}) + \frac{\partial R^*}{\partial \phi} \cdot (\phi_{jn} - \phi_{jm})$$

where, keeping with our notation, A is plot area, Z and ϕ are observed and unobserved characteristics of the land, respectively.

A test of efficiency in production within the household is an assessment of the statistical significance of differences in yields (or marginal product of inputs) between plots managed by different household members. In its simplest form, the scheme can be described by defining $R_n(1)$ and $R_n(0)$ as the yields (value of production per hectare) of plots managed by members of "Group 1" and "Group zero," respectively. In terms of realized plot yield:

$$R_n = R_n(1) \cdot D_n + R_n(0) \cdot (1 - D_n)$$

where D_n is an indicator function that determines the member (group of members) responsible for managing plot n. By decomposing the yield as a linear function of the plot characteristics (area, A, and observed quality, Z) and some unobserved characteristics — $R_n(1) = \alpha_1 + A\delta + Z\beta + \phi$ and $R_n(0) = \alpha_0 + A\delta + Z\beta + \phi$, the resulting relation is just:

$$R_n = \alpha_0 + D_n\left(\alpha_1 - \alpha_0\right) + A_n\delta + Z_n\beta + \phi_n$$

In this formulation, the efficiency test amounts to determining if the effect of re-assigning a plot of land between two household members could increase total output with no change in labor (or other factors) supplied to each individual's plot.[7] In other words, it corresponds to testing the null-hypothesis that there is no additional gain to the household production in the event of plot reallocation:

$$H_0 : \gamma = \alpha_1 - \alpha_0 = 0 \tag{12}$$

Some farm households will be more experienced or better farmers or possibly farm higher quality land in dimensions that are not observed (in the data). To assure that rejection of profit maximization is not driven by these (unobserved) characteristics, the models include household specific fixed effects. To the extent that unobserved household characteristics affect yields in a linear and additive way, the estimates can be interpreted as drawing comparisons between plots within the same household. Tests of the exclusion restriction ($\alpha_1 - \alpha_0 = 0$), lie at the heart of tests of efficiency in the allocation of resources by farm households in West Africa.

Central to this test is the assumption that there is no plot specific unobserved heterogeneity that is correlated with both the yield and control intrahousehold over the plot. If this assumption is violated, estimates of (γ) will not be zero and efficiency in production can be incorrectly rejected. This is substantively important. If markets are incomplete, then it may be optimal for a household to allocate inputs to a specific plot or set of plots because of explicit or implicit inter-linked contracts (and these can be correlated with the identity of the plot manager). The test for efficiency in production is predicated on the assumption that we have sufficient empirical controls for the effects of market incompleteness at the plot level. In the case of the thin land markets in rural West Africa, where studies have shown that continued rights to cultivate land that is held in common in the village depends on cultivating the land in every season, the issue gains prominence. Goldstein and Udry

[7] An alternative comparison would also examine if the effects of an additional unit of land in the hands of one group had the same effects than in the hands of the other – that is testing whether the interaction of group indicator with area of plot is significant. This strategy is not explored here but see Udry (1996) for some results (p. 1027).

(2002), for example, document that plots managed by women are more likely to be drawn from the common pool and are, therefore, less likely to be fallowed than plots owned by the household which tend to be cultivated by men. This poses a serious problem for tests based on plot-level productivity.

While a test that takes into account plot-specific unobserved heterogeneity of a general form is not feasible with cross-sectional data, we advance in the direction of empirical robustness by proposing a novel variant of Udry's (1996) specification. In this way we aim at deriving tests that are invariant to plausible forms of plot-specific unobserved heterogeneity. In particular, in additional empirical exercises below we base our test on the implicit assumption that unobserved plot characteristics affect production multiplicatively (i.e., impact total factor productivity). That is, with the production function represented by:

$$Q_{jn}\left(A_{jn}, L_{jn}, V_{jn}; Z_{jn}, \phi_{jn}\right) = G^1_{jn}\left(A_{jn}, L_{jn}, V_{jn}; Z_{jn}\right) \cdot G^2_{jn}\left(\phi_{jn}\right)$$

and under profits maximization, the marginal rate of transformation between two different variable inputs, v_1 and v_2, should be equivalent to the ratio of their prices :

$$\frac{\frac{\partial Q_{jn}}{\partial V_1}}{\frac{\partial Q_{jn}}{\partial V_2}} = \frac{\frac{\partial G^1_{jn}}{\partial V_1}}{\frac{\partial G^1_{jn}}{\partial V_2}} = \frac{\rho_1}{\rho_2}$$

which is a quantity that is independent of the plot (n) for which is being measured, and invariant with respect to unobserved plot characteristics, be they technical (ϕ) or result of different tenure/contract terms.[8] Therefore, a testable implication of profit maximization lends itself as ratios that are equal across plots:

$$\frac{\frac{\partial Q_{jn}}{\partial V_1}}{\frac{\partial Q_{jn}}{\partial V_2}} = \frac{\frac{\partial Q_{jm}}{\partial V_1}}{\frac{\partial Q_{jm}}{\partial V_2}} \quad \forall\, n \neq m \tag{13}$$

Alternatively, since both input usage per hectare ($v_{jn} = \frac{V_{jn}}{A_{jn}}$) and yields depend on the same set of plot characteristics, let the quantity of interest be redefined as an output-input ratio:

$$\widetilde{R}^*_{jn}\left(A_{jn}, p_a, p_k, \overrightarrow{\rho_a}, \overrightarrow{\rho_k}, Z_{jn}\right) = \frac{R^*_{jn}}{v^*_{jn}}$$

which is the revenue per unit of variable input. Applying a Taylor expansion reveals that our dependent variable:

$$\widetilde{R}^*_{jn} - \widetilde{R}^*_{jm} = \frac{\partial \widetilde{R}^*}{\partial A} \cdot \left(A_{jn} - A_{jm}\right) + \frac{\partial \widetilde{R}^*}{\partial Z} \cdot \left(Z_{jn} - Z_{jm}\right)$$

[8]See Shaban (1987)

does not depend on unobserved plot heterogeneity that operates as a multiplicative productivity shifter.

This alternative profit-maximization condition has not been explored by the literature. In the econometric exercises that follow, regressions using the ratio between yield and variable inputs as the dependent variable are employed to inspect the robustness of conditions derived from original tests based on productivity differences. This is a novel approach, and one we expect to be picked up by those interested in examining determinants of plot-level productivity differences.[9]

4 Data and descriptive statistics

A contribution of this research is the investigation of efficiency on production and consumption for the same farm households. To this end, extremely rich surveys of farm households conducted in Senegal and Ghana are the focus of our empirical analyses. The farm household surveys cover an enormous range of the respondents lives in great detail; the samples are relatively small. In order to assure that our conclusions are not driven by the sample sizes, we exploit a large consumption survey conducted in Ghana (the third round of the Ghanaian Living Standards Survey, GLSS3) and restrict attention to rural households. The fourth data set is the agricultural production survey of farm-households in Burkina Faso used by Udry (1996). Over and above reproducing Udrys results, we provide additional tests of efficiency and place our results from Senegal and Ghana in a fuller context.[10] We further detail these data sources in Appendix A.

Table A1 presents summary statistics on the demographics of the households and land holdings in the three countries studied here. The samples in Senegal and Ghana are restricted to households for which consumption information is available in order to guarantee consistency across the empirical exercises. The average household head is a male in his mid-late forties (or early fifties) and the senior wife is about ten years younger. Polygyny is higher among men in the French colonized areas (Burkina Faso and Senegal), corresponding

[9] Examples would be studies of tenancy and contractual arrangements' effects over productivity or of the inverse relation between productivity and plot size

[10] The Burkina Faso survey included a consumption module. Attempts to obtain those data have not borne fruit in spite of contacts with many researchers and institutions. Thomas Reardon (MSU), a principal investigator of the study told us the data had been lost. Kazianga and Udry (2006) *construct* consumption data for this sample using variation in inventories and farm production. These do not correspond to the original consumption data we refer to. Moreover, since Kazianga and Udry's data can only capture a small number of consumption categories, they are not amenable to the tests of collective rationality presented below.

to half or more of the households in each sample. For Ghana polygyny is observed between 5% and 13% of the households, depending on the survey used. The nuptiality patterns, and therefore fertility, explain most of the differences in household size across these countries.[11]

The bottom panel of Table A1 reports average food shares (except for Burkina Faso) and land holdings. The average Senegalese farm household allocates over 80% of the budget to food whereas in Ghana this average is about 60%. [12] In the three countries, all households sampled have at least one member who is a farmer (defined as controlling a plot of land). Total area in hectares is larger in Senegal, somewhat smaller in Burkina Faso, and significantly smaller among Ghanaian households. Per capita measures bring the countries closer together in terms of area holdings. Male heads hold most of the land. Participation of women in farming activities is higher in Burkina Faso. GLSS3, which does not restrict attention to households that own a farm, reports a similar rate of land ownership by males but a much lower rate among females. This likely reflects the structure and administration of the questionnaire (The household head was asked to list the plot holders who were asked about the number of plots and amount of land they owned. Land owned in common was not enumerated).

Table A2 presents plot characteristics for the sample of heads and spouses (senior wives and others in case of polygyny) that hold at least one plot. Relative to household heads plots, those held by spouses are much smaller about half the size in Ghana and Senegal and around 10% of the size of the heads plot in Burkina Faso. When plot size is missing, it has been imputed (using local area median plot sizes for similar plot owners).[13] Plot size is more likely to be missing if the land is owned by a female which suggests that total land holdings of females may be measured with more error than those of males. The same issue arises with information about decision-making for each plot, reported for the two Ghanaian surveys in Table A2. According to the 1991-92 farm household survey, males have greater control over decision-making regarding sales of crops produced on their plots and males also have more access to land in the event of a divorce. However, it is plausible that these differences reflect gender-specific differences in the extent of missing data. Indeed, in the 1991-92 consumption survey, there is no difference between males and females in

[11] Household structure is very fluid throughout the world, especially in Africa. That issue is put aside and we treat household structure as given. See Foster (1998) for a discussion.

[12] Consumption aggregates available for the Senegalese households are different from the ones constructed for Ghana. One reason is that, for the former, food consumption includes expenditures on beverages and tobacco. The data do not allow further disaggregation.

[13] See Appendix A for details. The regressions below include a control indicating whether plot size is imputed. For GLSS3, households with at least one plot with missing area data were excluded from the analytical sample.

decision-making with respect to crop sales or crop choice. Again, controls for missing data are included in the regressions below.

Budget shares based on consumption over the prior 12 months for seven food and six non-food sub-aggregates are reported in Table A3. The sub-aggregates have been selected to assure there are few households that report zero expenditures on an item (which side-steps the complexities associated with dealing with the decision to consume and also the amount consumed). Relative to the Senegalese, Ghanaian households spend less on food, particularly cereals but more on animal protein (meat and dish) and more on health and education. To some extent this reflects the fact that agricultural production in Ghana relies more heavily on cash crops (particularly pineapples for export). Differences between the two Ghanaian samples largely reflects differences in regional patterns of consumption − the 1997-1998 sample is drawn from the southern part of eastern Ghana.

Table A4 summarizes individual land holdings. These measures are later used as proxies for factors that influence bargaining power of individual household members. The aggregation of area reproduces the plot-level findings discussed above. It is important to note that for the case of GLSS3, zeros where assigned to males in single-female-headed households, and vice-versa. The aggregate measures indicate that the holdings of Senegalese women are one-ninth that of their husbands, while for Ghana this relation is between one-seventh and one-sixth. The patterns are reproduced in the case of land areas computed conditional on decision-power or after-divorce rights.

The next section turns to the econometric evaluation of these data in terms of efficiency in the allocation of resources.

5 Empirical evidence

5.1 Heterogeneity of preferences and the unitary model

Basic tests

As described above, the test of the unitary model assumptions consists of the verification of an exclusion restriction: factors affecting the attractiveness of household members' outside-option (alternative to the current joint household arrangement) should not influence the allocation of resources. One clear challenge in taking this theory to the data is that the empirical counterpart of distribution factors is not obvious. It is clear that household members may derive bargaining power from a myriad of sources, each reflecting a different aspect of the options a person would have outside the household.

The individual-specific distribution factors or relative bargaining power are also not straightforward to measure. They should reflect resources that will follow the individual out of the household and they should not be the outcome of negotiations between a husband and wife. In a farm household setting, these issues are potentially less complex and can be represented by *de facto* control over economic assets which, to a first order of approximation, is naturally given by control over land for cultivation.[14] Moreover, the Ghanaian surveys are uniquely well-suited for this research because it is possible to probe the empirical importance of concerns regarding land as a proxy for relative bargaining power. In the analyses reported below, we will address one potential source of endogeneity of assets by exploiting the value of asset holdings in the period preceding the one used as reference for expenditures (1997-1998 Survey) and we will exploit information on land holdings over which the holder has more decision power, as well as land holdings that will be retained in the event of divorce (1997-1998 Survey).

In order to operationalize this estimation, we employ Working-Leser Engel curves that are augmented by factors that influence bargaining power in the following form:

$$c_h = Y_h \alpha_1 + X_h \alpha_2 + \beta^m \lambda_h^m + \beta^f \lambda_h^f + \varepsilon_h \tag{14}$$

where the distribution factors are represented by measures we discuss below. This model is a linearized version of reduced-form demands derived from the collective-rationality model. The controls for household characteristics (X) include household size (in logs) and composition (shares for children, adult males and females, and senior males). It also controls for age of the head and the senior wife (education is also included in the Ghana case), and indicator functions for location (villages in Ghana and zones in Senegal) that subsume market prices. Total per-capita expenditures (in logs) were included in order to control for total resources available to the household (Y).

An effort was made to minimize the chances of misspecification that could blur the inferences. In order to sidestep potential non-linearities the estimations are based on budget shares (instead of levels), while total household expenditures are allowed to have a flexible influence over the consumption decisions (it was introduced in the form of quartile splines). Moreover, by using budget shares as a dependent variable, one allows a non-parametric interaction between total expenditures and each covariate included in the model.

[14]See Thomas (1990), Haddad and Hoddinot (1995), and Doss (1996), for example.

Notice that, due to the direct impact of asset holding over permanent household income, tests regarding the unitary model assumptions need to be adapted to represent a permanent-income-pooling condition. That is to say, if the unitary formulation is applicable to the settings we study, then:

$$\frac{\partial c_s}{\partial \lambda^f} = \frac{\partial c_s}{\partial \lambda^m} \qquad \forall s \tag{15}$$

or:

$$\beta_s^f - \beta_s^m = 0 \qquad \forall s \tag{16}$$

The model was estimated individually for a series of commodities and the standard errors reported are computed with the infinitesimal jackknife method. Table 1 reports the (infra- and extra-) marginal effect of the measures of power and tests the difference between the effects of male and female land holdings. The figures indicate, although not overwhelmingly, that the effects of redistributing land from male heads to their senior wives has significant impact on the allocation of expenditures. Most strongly impacted expenditures are cereals, meats and fish, housing, clothing, adult goods, and other non-food items. Very similar results are found in subsamples that restrict observations to monogamous couples and to households where both heads (male and female) manage a plot of land. [15]

Table 2 replicates the same tests restricting the land area measures to areas in which individuals have decision-power over important aspects of the production process. The idea is that these would be a better approximation to the amount of land actually assignable to that individual. The inference from this estimation does not change our previous conclusions. Meanwhile, Table 3 further explores additional measures of factors affecting bargaining power available in the 1997-1998 Ghanaian survey (areas that can be farmed in case of divorce and past total asset holdings). The unitary model is, once more, rejected.

Modified tests

It is important to keep in mind the limitations of this test even when the measures of power can be considered exogenous. First, the direction of the differential effects can be misleading if markets are incomplete at the village level. This is the case because the marginal effects of measures of power in a collective model are a composite of effects that operate through the Pareto weight and the effect of preferences over the shadow-prices (and then over demand):

$$\frac{\partial c_s\left(P, \mu(\lambda^m, \lambda^f)\right)}{\partial \lambda^i} = \left[\frac{\partial c_s}{\partial P}\frac{\partial P^*}{\partial \mu} + \frac{\partial c_s}{\partial \mu}\right]\frac{\partial \mu}{\partial \lambda^i}$$

[15] Results available upon request.

and,

$$\frac{\partial c_s}{\partial \lambda^f} - \frac{\partial c_s}{\partial \lambda^m} = \left[\frac{\partial c_s}{\partial P}\frac{\partial P^*}{\partial \mu} + \frac{\partial c_s}{\partial \mu}\right] \cdot \left[\frac{\partial \mu}{\partial \lambda^f} - \frac{\partial \mu}{\partial \lambda^m}\right]$$

Hence, even if the exclusion restriction still applies, the sign of the power effect might be uninformative. One should, therefore, refrain from interpreting the direction of effects as revealing stronger(weaker) preferences for a specific good by either husbands or wives.

A second concern is related to differential measurement error in the indicators of power used in the estimations. Take the measure of land area, for example. The investigation of the data sets indicate that there is higher probability of female plots (compared with the heads') being missed in the area measurement rounds. This implies that the land area holdings for wives is more likely exposed to mismeasurement than their husbands'. Assuming a simple modeling of the measurement error by assuming it unrelated to the actual measure of area, the estimation of β^f is downward biased:

$$\widehat{\beta}^f \xrightarrow{p} \beta^f \cdot B_\omega$$

and, therefore, the measure of the differential effect of power in the hands of women (versus men) is also biased (larger absolute-value differences).

This same biased result also applies in the case in which the quality of land differs for men and women (a key point in the production analysis). Nonetheless, in both cases, we can still employ a strategy designed to indirectly infer the relevance of the unitary model's assumptions. This is as follows: If power indicators are measured with error or the quality of female land is inferior, we can explore multiple equations of the demand system to bypass inconsistent estimations. In particular, notice that the ratio of marginal effects of power measures is insulated from the bias terms:

$$\frac{\widehat{\beta}_1^f}{\widehat{\beta}_s^f} \xrightarrow{p} \frac{\beta_1^f}{\beta_s^f}$$

hence, the unitary-model tests could be based on the difference of ratios (across goods) of the power effects for women and men:

$$H_0 : \frac{\beta_1^f}{\beta_s^f} - \frac{\beta_1^m}{\beta_s^m} = 0 \tag{17}$$

5.2 Collective rationality

Incidentally, the test of the unitary model under measurement error we just described corresponds exactly to a test of Pareto-efficiency in consumption. Importantly, this means that the test of efficiency in consumption we propose is invariant with respect both to classical measurement error in the power indicators and to differences in quality of land held by men and women.[16] By the same token, and employing the same reasoning, it is also the case that non-recursivity of farm-household decision-making does not affect the tests based on the proportionality of power effects. We see this as a relevant empirical strength of consumption-based tests derived from the collective rationality model. This is an advantage of utmost importance and is behind our conclusions regarding efficiency of West African households presented below.

In practice, the testing of Pareto-efficiency restrictions consists of reproducing the proportionality conditions derived from the model presented above. It, therefore, requires joint estimation of a system of demand equations and the examination of non-linear (cross-equations) restrictions over the parameters attached to the power measures. These tests of restrictions are using a Wald statistic:

$$Wald = h\left(\underline{\alpha}, \underline{\beta}\right)' \cdot \left[\frac{\partial h}{\partial\left(\underline{\alpha}, \underline{\beta}\right)} \cdot \Omega \cdot \frac{\partial h}{\partial\left(\underline{\alpha}, \underline{\beta}\right)'}\right]^{-1} \cdot h\left(\underline{\alpha}, \underline{\beta}\right)$$

where Ω is the variance-covariance matrix of the system of equations. Computations of this quantity are based on a $h(.)$ function that is altered to reflect ratio-restrictions in terms of cross-multiplications or, in other words:

$$H_0 : h\left(\underline{\alpha}, \underline{\beta}\right) = \beta_1^f \beta_s^m - \beta_1^m \beta_s^f = 0 \qquad \forall s \tag{18}$$

In principle, the restrictions could be tested jointly for all parameters in the system of equations. However, it is important to consider that the critical value derived from the Chi-squared distribution attached to the theoretical Wald statistics is a function of the number of goods in the system (so that the significance level is kept constant). In this case our results could be sensitive and distorted (in particular, towards under-rejection of Pareto-efficiency). That is: if a large enough set of goods is employed in the estimation, the power of the test can be made arbitrarily small. Therefore we complement our analysis by also presenting

[16] Black et al. (2000) shows that, under certain reasonable conditions, this is also valid under non-classical measurement error problems.

pairwise tests of efficiency and, based on a system of 10 demand equations, reporting results for 45 pairs of goods (food and non-food).

The results of the pair-wise test is presented in Tables 4 (Senegal), 5 (Ghana, 1997-1998) and 6 (Ghana, 1991-1992). Using total land holdings as the proxy for factors affecting bargaining power, results indicate that, independent of the measure of power adopted, it is not possible to reject the Pareto-efficiency restrictions. The results in the small samples (Senegal and Ghana, 1997-1998) and in the large sample for Ghana (1991-1992) are similar and lead to the same conclusion. No pair of commodities for Senegal and only a couple of pairs for Ghana indicate that the ratio of power effects is sufficiently different to allow a rejection of the null hypothesis. Although rejections are found in this pairwise exercise, they correspond to less than 5% of the pairs and can be considered irrelevant (a statistical artifact) in tests that have significance levels set at 10%. Tables 7 and 8 examine alternative measures of distribution factors that condition land holdings to the degree of a holder's decision power. Both Ghanaian surveys allow this estimation, and the results corroborate previous findings.[17]

Table 9 focus on a joint test of the Pareto-Efficiency hypothesis over the system of commodities. This hypothesis cannot be rejected in any of the cases (inframarginal, extramarginal or both), surveys studied, or proxies for distribution factors used. Based on this data, even though the heterogeneity in preferences cannot be rejected, *there is no sign* that families in Senegal and Ghana *fail to achieve* an efficient allocation of their resources towards consumption.

A caveat of the analysis using Wald statistics to test non-linear hypothesis is the widely discussed non-invariance of the test statistics to reformulations of the null hypothesis.[18] Critchley et al (1996) have shown that this undesirable property comes from the fact that the Wald statistic, when applied to non-linear hypothesis, loses its characteristic of a distance measure and ends up reflecting a hybrid of two different geometric quantities. Alternatives to the Wald test are somewhat more costly in terms of estimation burden, since they require estimation of the restricted version of the model.[19] Hansen (2000), for example, has shown the value of the GMM distance-statistics proposed by Newey and West (1987) in

[17]Results using after-divorce land rights and total assets (available upon request) also yield the same conclusion.

[18] See Gregory and Veall (1985), Lafontaine and White (1986), and Phillips and Park (1988). See also Dagenais and Dufour (1991).

[19]Aside from the classical Lagrange-multiplier and likelihood ratio tests, also the Neyman's C(α), the Lu and King (2004)'s expanded Wald-type test, and the Newey and West (1987)'s GMM-distance tests would be invariant to the formulation of the null.

terms of reducing Type I error. We recognize, however, that Type I errors are not incredibly damaging to the tests we propose here. This is the case to the extent that they make the inference more stringent and conclusions more conservative. However, Hansen (2000) has not explored the occurrence of Type II errors across alternative estimation procedures. This type of statistical error would imply that the tests performed in the present paper are likely to fail to reject the Pareto-Efficiency hypothesis in a large number of circumstances even when it is actually false. More econometric research is needed on the topic, but we indeed refrain from departing significantly from more standard techniques.[20]

Finally, it is important to emphasize that in order to close our argument we need to face the question of what would have been our conclusion if traditional tests solely based on production efficiency were employed. Do they point to the same interpretation? We now go about examining them.

5.3 Replication and further examination of production (in)efficiency results

As mentioned above, Pareto-efficiency also implies that factors of production should be allocated across plots controlled by different household members in way that agricultural profits were maximized. Fixed-effects regressions can be used to empirically verify the differences in yields across plots controlled by men and women in the same household after controlling for observable differences in the characteristics of each plot, as proposed by Udry (1996). Table 10 presents the results of this estimation after conditioning on the crop choice (combined with household and year fixed-effects), as in the following empirical specification (household h, year t, crop j, plot n):[21]

$$R_{htjn} = D_{htjn}\gamma + A_{htjn}\delta + Z_{htjn}\beta + \eta_{htj} + \phi_{htjn} \quad (19)$$

where D is one when the plot is managed by one of the household female heads, A measures plot area and Z represents observed plot-characteristics.[22]

The figures in columns [a] to [c] of Table 10 essentially reproduce the patterns found by Owens (2001) for Senegal, Goldstein and Udry (2002) for Ghana, and Udry (1996) and

[20] Aguero (2002) shows that the Type II error incidence is significant for tests based on the GMM distance-statistic. However, the author does not examine the relative gain(loss) with respect to the Wald test.

[21] In Ghana the maize and cassava production were combined to form the "maize and cassava system", being considered a unique crop-choice category.

[22] Results do not change if samples are restricted to senior wives in Senegal and Ghana. The Burkina Faso survey of plots does not include an identifier for individual holder, except for his/her relation with the head of the household.

Akresh (2008) for Burkina Faso.[23] In the estimations presented here, the dependent variable was transformed to reflect amounts relative to the average (real valued) yield across all plots, all individuals, and all years in each of the samples. The three columns reflect the inclusion of different controls, such as area (indicators for plot-area distribution deciles) and some limited information on other plot characteristics. The specifications comparable across countries (raw and with area controls only) are presented in columns [a] and [b], and indicate that yields in plots controlled by wives are *smaller* than the ones controlled by their husbands (γ is significantly negative). Holding area disparities constant, the differences in output per hectare amount to 58% of the average yield in Senegal, 69% of the average yield in Ghana and 39% of the average yield in Burkina Faso.

We detail the results a bit more in columns [d] to [g] by excluding households-years-crops triples for which only one gender was represented in the sample. We also focus on monocultures or particular crops. The results obtained in the more general model also apply to these sub-samples, with plots controlled by women always found to be less productive than the ones farmed by household heads.

At face value, these results cast serious doubts on the efficiency of intra-household resource allocation throughout West Africa. Yet, these are the same households we considered to be efficient when observing their allocation of resources towards consumption. We believe, at least in principle, that results from consumption-based tests raise (theoretically sound) reasonable doubt regarding the conclusion derived from production data. In need of reconciliation of results, we turn to relative empirical strength of alternative tests of efficiency. In order to gain some traction in this issue, we carefully consider the potential biases originated from systematic differences in the quality of the land farmed by wives and husbands.

Before delving into unobserved heterogeneity, however, we also consider if the nature of the surveys used for this estimation (and of plot-level surveys in general) may be another source of bias for the proposed estimation. This occurs because the plots observed and used in the estimation are the ones selected for cultivation in that period. This selection process is most likely related to the observed and unobserved characteristics of the plot, as well as to the gender of the plot holder. The result is, again, a possible bias on the measurement of differences in productivity. These selection issues surround our samples, and can be thought of in terms of endogenous plot size. This happens to be a reality according to Burkinabe survey's documentation. Matlon (1988), for example, indicates that "across years, plot boundaries tend to shift and whole plots are often combined and/or subdivided" (most

[23] In a slight departure from the literature, on the present article we restrict our sample to husbands and wives only, while also adding controls for the choice of secondary and tertiary crops in each field.

probably) among farmers within Burkinabe households. It is unlikely that these changes are unrelated to farmers' assessment of the land quality. In fact, ethnographic evidence indicates that, throughout West Africa, plots of land are allocated to each individual member by the household head.[24] Ultimately, women have rights to use land that are associated to their position toward men (as mothers, wives, sisters and daughters). If heads are better informed (than the econometrician) about the quality of land plots they allocate, gender differentials are expected to also be capturing the heterogeneity that is unaccounted for. This suggests that the process of allocation of plots corresponds to the bargaining process at the time of the marriage. Thus family status of the bride could have important implications for the quality of land she farms as a wife.[25]

This observation seem to suggest that the inclusion of family background variables could explain the gender differentials in plot yields. Incidentally, Goldstein and Udry (2002), focusing on family background indirect effects through the choice of fallow duration, actually indicate that the gender differentials for Ghanaian households are eliminated in a two-stage estimation. Our understanding is that in their case the predicted fallow duration provides a sufficient statistic for unobserved characteristics at the plot level.[26] The data sets from Burkina Faso (for 1981 to 1983) and Senegal do not contain family background variables that could be used to extend these findings.

Using original data from ICRISAT on the Burkinabe families that were followed beyond the original sampling period we were able to track information on the proportion of land cultivated by men and women that were inherited from their respective families/lineages, however. The documentation for these data codes an inherited plot as "permanent appropriation"by cultivator, as opposed to the alternative "temporary appropriation." We take these as indicators of property rights. From these data it is clear that wives in Burkinabe households have more tenuous rights over the land they farm. This may help explain differences in productivity across plots. Moreover, if husbands allocate worse land to their wives, we should expect household in which women have less control over their land to have the biggest gaps in productivity as measured by the models above. We merge these data at the household level to the plot level data that covers the 1981-1983 period. Among the 2,841 plots we were able to preserve in the sample, a partial interaction of the female dummy with

[24]Kevane and Gray (1999) cite the Burkinabe proverb stating that "women's fields are made at night", reflecting the intra-household bargaining process that husbands and wives undertake in order to allocate plots of land. See also Fall et al (1989) for a description of the Senegalese case.

[25]This possibility was also alluded by Udry (1996). See footnote 11 on page 1033.

[26]Family background variables were not made available by the researchers at the time they kindly shared their data (back in 2003) and, therefore, the results are not reproduced here.

the share of land a wife has property rights over (as of 1984-1985) suggests that differentials are likely to fall as women hold plots that were independently acquired and not allocated by their husbands. The differential productivity estimates range from -62.37 (standard-error of 18.64) to -25.07 (with standard-error of 12.20), a reduction of approximately 40%. Similar results can be found when exploring fully-interacted models (results in Table 11).

That unobserved heterogeneity may drive the gender differential in yields if women's plots are of lower quality than men's is well recognized and thoroughly discussed by Udry (1996). The author is quite clear about the issue and tries to address such concern exploring an indirect argument that proceeds as follows: if observed measures of quality were to be dropped from the equation, and observed and unobserved characteristics have the same relation with the outcome variable, changes in the gender differential would indicate the direction of the (unobserved heterogeneity) bias. Altonji et al. (2005) has formalized this idea, and indicates that for this strategy to work it has to be the case that: (i) the set of observables is chosen at random from the full set of variables that determine both the gender of the plot holder and the plot yields, and; (ii) the number of observed and unobserved quality characteristics is large enough that none of the elements dominates the distribution of land plots assignments across gender or the distribution of plot yields.[27] The comparison of columns in Table 10 that control for plot characteristics with the ones that do not indicates that, along the dimensions of plot quality that are observed and conditional on crop-choice, the quality of male and female plots seem quite similar.

In order to further investigate this issue we start by basing ourselves on the assumption that crop-choice conveys most of the information on characteristics of the plots in Burkina Faso. Since the empirical model is based on holding constant crop choice across male and female plots, our strategy involves exploring the idea that crop history for the plot conveys important information on the quality of land (as farming in Africa is marked by rotation of cultures and fallowing periods).[28] When fixed effects of household-year-crop choice models are estimated using stratified samples based either on distance to the household (closer fields should be older and less fertile) or on indicators of fallow or past crop choice we still find indication that yields and input usage are different for men and women. These results are presented in the Panel A of Table 12.

Of course, availability of plot-quality information poses a limit to the empirical verification of unobserved heterogeneity's role. Instead of hitting our head against this wall we

[27]Examining how stringent these assumptions are is beyond the scope of the present paper, however.

[28]Of course, these should be treated as endogenous variables in a dynamic context. In our static framework we treat them as state-variables.

resort to the theory. As discussed in the conceptual framework section above, we employ a test that is designed to be insulated from unobserved productivity shifters (total factor productivity associated to plot quality). We estimate models identical to the ones above, except that the dependent variable is the ratio between plot yield and variable input per hectare (labor hours and kilograms of seeds). These should be relatively insulated from unobserved heterogeneity effects as long as we can sustain its multiplicative effect on productivity.

The results of these tests are shown in Panel B of Table 12. They indicate, rather overwhelmingly, that productivity per labor hour is not different between female and male plots within a household in a given year (the point estimate is a positive 0.0051 thousand FCA's for the female dummy, not significantly different from zero). Moreover, for a subsample of monoculture plots the difference in returns per kilogram of seeds is ignorable, being 5.11 kilograms (0.5% of the average) of output smaller for females per year (with a standard-error of 9.68).[29] The same pattern of equality in outcomes and input use per unit of variable input across plots farmed by men and their wives is observed everywhere in the table. Therefore, using alternative measures of productivity differentials that are more resilient to the influence of unobserved heterogeneity and under a number of sample stratifications, we see *no evidence* that male and female farmers fail to maximize family profits.

It is important to keep in mind that, despite all the measurement problems raised, the difference in productivity could be correctly measured and still not reflect non-cooperation among household members. The non-convexities and indivisibilities to which agricultural production is subject can still be an alternative explanation for such findings. In any case, it is our opinion that measures of productivity that indicate cooperation (or its absence) beyond reasonable doubt are very hard to come up with. Instead of pursuing what we consider to be and unfruitful route (at least with the type of data available) we focus on the fact that, despite the production-based results, consumption decisions are judged to be efficient for the Senegalese and Ghanaian families studied. We, therefore, see reasons to believe they are *not* leaving anything on the table after intrahousehold bargaining takes place.

6 Conclusions

This paper provides statistical evidence that farm households in West Africa cannot be characterized as monolithic decision-units, as if they were unaffected by reallocation of re-

[29]The difference in kilogram of output per hectare of land that follows the original test proposed by Udry (1996) suggests a significant difference of 433.42 kilograms in favor of plots managed by males in this same sample (relative to a base of 933 kilograms).

sources controlled amongst their members. These findings are compatible with anthropological studies in the region and with empirical investigations into the nature of household decision-making based on other developing and developed countries.

We also provide theory-based evidence that despite heterogeneity in preferences West African households are able to achieve an efficient allocation of resources towards consumption. This is the case even for a subset of households for which a non-cooperative characterization would seem appropriate if only tests based on efficiency in production were employed. We reconcile these findings by extending the analysis presented in early contributions to the economics literature and providing further evidence on the bias-prone aspects of tests based on production decisions. The same issues do not arise in consumption-based tests. We conclude that the balance of evidence suggests that widely cited previous studies may have prematurely rejected Pareto-efficient characterizations of West African households.

Most importantly, the evidence uncovered here indicates that, in an environment where markets are hardly functional and survival (or food-security) is closely connected to agricultural productivity, families do allocate their resources in way that the well-being of one individual member cannot be improved without hurting another. These results inform us that cooperative models of intra-household allocations can be regarded as a proper description of agricultural-household decision-making in West Africa. This does not imply that improving the status of women in the region is either infeasible or undesirable. Rather, it suggests that thinking about these issues in the context of a model of collective rationality (Chiappori and Browning, 1998) is likely to be profitable for both science and policy making.

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7 Appendix A

7.1 The ICRISAT Burkina Faso Farm-Level Studies (1981-1985)

The survey was implemented by ICRISAT from May 1981 to December 1985, with the last two years of data collection being undertaken by researchers from the World Bank and IFPRI. Households in 3 agroclimatic zones spread throughout 6 villages were interviewed during that period, producing an initial data set of approximately 150 observations. Individuals were assigned to the same household according to production organization and consumption sharing. Individuals considered as ambiguous cases were classified by the household head as members or non-members.[30] The actual survey collected production, agronomic and consumption information. Data made available by ICRISAT and the Economic Growth Center at Yale University provides the sections regarding production and agronomic characteristics of plots managed by household members. The information on consumption is not part of the publicly available data set. The production data explored in this paper, as well as in Udry (1996), pertains to the first three years of the survey.

Plot characteristics and input-output information were collected, respectively, for all cultivated plots and for a non-random subset of plots managed by household members. Area measurement, location, soil type and cropping pattern (including short term history) is available for all plots under cultivation (but not the ones under fallow). Input-output surveys focused on plots for which the principal crop was a cereal, cotton or root crop. For legumes and minor garden crops at most one plot cultivated by the head and one cultivated by his senior wife were covered. Interviews were conducted with the household head for production issues related to the communal plots, his personal plots, and for plots of other members for which he was considered "well informed". Own controllers were interviewed only if the head was not able to provide the information. Characteristics of all plots were obtained from interviews with the household head, except for area, which was directly measured with compass and tap immediately after the harvest of each cropping season.

7.2 The IFPRI/ISRA Study of Consumption and Supply Impacts of Agricultural Price Policies in Senegal (1988-1990)

The survey in Senegal focused on 6 agroclimatic zones. In each of the rural zones, 3 villages were selected (one necessarily a "market-village," from where zone-prices were collected).

[30] See Matlon (1988).

Twelve households were randomly chosen in each village, and they were scheduled to be interviewed from Oct-1988 to Sep-1990 (2 harvest years). [31] Two rural zones ended up having limited reporting: one was not surveyed in the second season (Sagatta), and the information from the other was discarded due to bad performance of the surveyor.[32] Household were delimited by using a simple rule. They should correspond to an unit of production formed by members of a family group who shared a cooking pot and for which the eldest member was responsible for assigning each member labor tasks as counterpart of a share of the household production. Seasonal workers that had labor paid with lodging and food were included in the household (*navetanes*), as well as other more permanent non-family workers living in the same compound (*sourghas*). The temporary migration of members was also followed with quarterly updating of the roster.

Food consumption data was collected with 24-hours recall questionnaires used in bi-weekly interviews. The woman responsible for the preparation of the last 3 daily meals was asked to report the quantity and products consumed (either purchased or from own production). Data of two monthly interviews was then extrapolated to report monthly figures.[33] Non-food purchases were divided in two questionnaires, one focusing on frequent (also including condiments) and the other in less-frequent purchases. Each member responsible for a transaction was asked to report it. Frequent purchases were computed with quarterly interviews (fortnight recall), while less frequent purchases were captured with monthly interviews.

Area measures and agricultural activity were computed only for plots being cultivated at the time of the survey rounds (no land characteristics were entered in the data-set). Input and output data were collected by interviews with plot managers, after they were named by the head. Data on income from different sources was also collected at the individual level, from labor supplied to the market, from transfers, from livestock transactions, from self-employment and from non-farm businesses. No information on assets was collected at the individual level.

[31] The authors of the survey report that delays in the financing of the project made impossible the collection of production activities during the first season.

[32] See Fall et al (1989) and Dakono et al (1993).

[33] See Diagne (1994).

7.3 The Survey on Agricultural Innovation and Resource Management in Ghana (1996-1998)

This survey designed and undertaken by Christopher Udry (Yale University) and Markus Goldstein (LSE).[34] The research was conducted in 4 villages in the Eastern Region of Ghana. These four areas are considered important for the regional production of fruits and vegetables, as well as represent a variety of agronomic, market and geographic conditions. The survey targeted couple- and triple-headed households, with 60 of them being selected in each village. Interviews were conducted with each individual member of the couple/triple (by an enumerator of the same sex), and followed households for approximately two harvest seasons (in 15 rounds).[35] The presence or temporary migration household members was computed with seasonal updating of the household roster.

Interviews regarding consumption were conducted such that head and spouse(s) reported the purchases and consumption from own production of food and non-food products for the past 12 months (in 3 different rounds, Apr-May 1997, Sep-Oct 1997, and Apr-May 1998). Interestingly, individuals were asked to report their own purchases and consumption, but also the ones made by their marital partner(s) and other household members,[36] so that more than one report on expenditures is observed for each good.

A rich data set on assets owned by individuals was also collected in three opportunities (Nov 1996, Dec 1997, and Oct 1998). Head and spouse(s) were asked to list their personal holdings in liquid assets (bank accounts and cash, among others), in production assets (seeds and equipment), in livestock, and in terms of stored crops. The survey includes detailed data on the quality of soils and on the agricultural production for each plot cultivated by a household member.[37] A large set of questions on the plots' ownership history, related property rights (including after divorce rights) and current contracts were also taken to the field.

[34] The complete data set is not available. This paper explores some specific sections posted in the survey's web-page and kindly made available by Christopher Udry and Harsha Thirumurthy using e-mail communications. The data set with plot revenues and the data set containing the GPS measures of plot area were both received in April-18-2003.

[35] See Goldstein and Udry (1999).

[36] Goldstein (1999) reports two problems with such interviews: First, male enumerators encountered problem implementing the questions about spouses' purchases, so that "coverage is not complete"; Second, for rounds 4 (Apr-May, 1997) and 8 (Sep-Oct, 1997), Village 1's enumerator has consistently under-covered a set of expenditure groups.

[37] In the first year only the cultivated were tested. In the second, however, all plots (including the ones under fallow) were part of the quality checks.

7.4 The Ghana Living Standards Survey - GLSS3 (1991-1992)

The survey was implemented by the World Bank and the Government of Ghana from September 1991 to September 1992.[38] The sample size is of 4,552 households in urban and rural areas of the country. The survey collected detailed data on consumption patterns of food (purchased and produced) and non-food items aggregated to yearly figures by the survey designers. The expenditures include remittances and imputed values for rental costs of owned houses.

The survey also collected plot level information, including holder's identity (as reported by the head of the household). Each holder was interviewed and reported the area measure of each plot, the crops harvested in the last twelve months, and information about the decision-making at the plot level - the identity of member(s) with decision power over crops to be farmed, inputs to be used, and who keeps the revenue from the production. Unlike the small-scale surveys presented above, GLSS3 does not contain information on production and revenue at the plot level, so that the tests of efficiency in production suggested by the literature cannot be implemented. Assets ownership and non-labor income information was not collected at the individual level, except for assets attached to non-farm business activities and savings accounts.[39]

7.5 Imputation of land area measures

Imputation of land area at the plot level was implemented using simple rules.

a) Senegal

Plots without land area measurement held by individual i were assigned the median plot area prevailing in his/her village. The median was conditional on the relation with the household head. In this way, plots held by wives, when having missing area, were assigned the median size of a plot held by wives in the same village.

A second stage of imputation was made necessary, and this turn the missing areas were imputed by using the median area conditional on relation to the head (without the same village requirement).

b) Ghana, 1997-1998

[38]Dr. K.A. Twum-Baah (Acting Government Statistician, Ghana Statistical Service) authorized the use of the GLSS data.

[39]For a detailed description of GLSS3, see Ghana Statistical Service (1995).

Plots without GPS land area measurement held by individual i were assigned the measure projected from the following regression:

$$\widehat{GPS} = \widehat{\alpha} \cdot (SELF - REPORTS) + \widehat{\beta} \cdot (GENDER)$$

If area was still missing after this attempt, the median conditional on the relation with the household head and village was imputed. If a third stage of imputation was made necessary, missing areas were imputed by using the median area conditional on relation to the head (without the same village requirement).

Table 1 : Testing the Unitary Model - effects of individual land holdings (bargaining power proxy) on expenditure patterns

	Area		Non-zero area indicator		Area	Area indicator	
	Male (SE)	Female (SE)	Male (SE)	Female (SE)	Fem-Male Diff. (t-stats)	Fem-Male Diff. (t-stats)	Wald - Diff. Joint test [p-val]
PANEL A: Senegal, 1989							
Cereals	0.33 (0.18)	0.94 (1.23)	-6.06 (3.93)	-4.10 (3.23)	0.61 (0.49)	1.96 (0.40)	1.03 [0.597]
Pulses	-0.05 (0.08)	0.46 (0.70)	-0.13 (2.27)	-0.09 (1.84)	0.51 (0.71)	0.04 (0.02)	0.99 [0.608]
Vegetables	-0.11 (0.05)	-0.39 (0.51)	1.29 (1.30)	1.08 (1.29)	-0.27 (0.55)	-0.21 (0.11)	0.78 [0.677]
Meats and fish	-0.06 (0.09)	0.52 (0.51)	3.34 (1.74)	-3.24 (1.59)	0.59 (1.14)	**-6.57 (3.09) ** **	**10.26 [0.006]**
Fruits and milk	-0.13 (0.22)	-2.30 (1.71)	3.55 (4.16)	5.98 (4.65)	-2.17 (1.22)	2.43 (0.38)	2.35 [0.309]
Human capital	-0.17 (0.07)	1.06 (0.62)	1.97 (1.32)	-1.91 (1.59)	**1.22 (1.97) ** **	**-3.88 (1.92) * **	4.28 [0.118]
Housing	0.14 (0.13)	-0.47 (0.68)	-2.76 (2.46)	0.65 (1.91)	-0.61 (0.85)	3.41 (1.07)	1.15 [0.562]
Clothing	-0.05 (0.09)	0.07 (0.73)	1.53 (2.07)	0.73 (2.08)	0.12 (0.15)	-0.80 (0.29)	0.09 [0.956]
Transport	0.04 (0.03)	-0.66 (0.47)	-0.20 (0.62)	1.68 (1.24)	-0.70 (1.45)	1.89 (1.24)	2.11 [0.348]
Non-food other	0.01 (0.08)	0.42 (0.50)	-1.56 (1.53)	0.90 (1.46)	0.41 (0.83)	2.45 (1.24)	**7.14 [0.028]**
PANEL B: Ghana, 1997-1998							
Tubers	-0.76 (0.70)	6.07 (3.41)	1.50 (5.15)	-7.03 (5.02)	**6.82 (2.00) ** **	-8.53 (1.33)	4.00 [0.136]
Cereals	0.04 (0.49)	-2.23 (4.04)	-2.70 (3.40)	3.56 (4.62)	-2.27 (0.59)	6.26 (1.09)	1.44 [0.487]
Meats and fish	0.30 (0.66)	5.16 (2.25)	-1.41 (4.46)	-6.46 (3.30)	**4.87 (2.02) ** **	-5.05 (0.86)	**5.54 [0.063]**
Vegetables	0.29 (0.30)	-1.04 (1.60)	1.07 (2.42)	2.64 (2.19)	-1.33 (0.87)	1.57 (0.55)	0.76 [0.685]
Pulses	0.12 (0.23)	1.33 (1.78)	0.84 (1.32)	0.95 (2.46)	1.21 (0.71)	0.12 (0.05)	2.34 [0.311]
Human capital	0.67 (0.59)	0.34 (2.93)	-4.99 (4.01)	-6.33 (4.70)	-0.33 (0.11)	-1.34 (0.20)	0.37 [0.832]
Housing	0.76 (0.35)	-1.16 (1.87)	-2.37 (2.19)	4.76 (2.97)	-1.92 (1.03)	**7.13 (1.94) * **	**4.80 [0.091]**
Clothing	-0.31 (0.51)	-4.12 (2.64)	0.37 (3.38)	4.72 (3.55)	-3.81 (1.44)	4.35 (0.85)	2.30 [0.317]
Adult goods	-0.27 (0.20)	1.00 (0.97)	3.36 (1.51)	-2.23 (1.44)	1.26 (1.26)	**-5.60 (2.50) ** **	**9.38 [0.009]**
Non-food other	-0.60 (0.52)	-6.83 (2.74)	5.29 (3.50)	7.67 (3.54)	**-6.24 (2.43) ** **	2.39 (0.52)	**8.26 [0.016]**
PANEL C: Ghana, 1991-1992							
Tubers	0.11 (0.08)	-0.11 (0.25)	-0.43 (1.41)	-0.43 (1.03)	-0.22 (0.93)	0.00 (0.00)	1.16 [0.561]
Cereals	-0.04 (0.04)	-0.24 (0.14)	1.19 (0.82)	0.52 (0.63)	-0.21 (1.52)	-0.67 (0.90)	**5.64 [0.060]**
Meats and fish	-0.05 (0.05)	-0.15 (0.18)	-1.78 (1.25)	0.05 (0.81)	-0.10 (0.59)	1.83 (1.51)	2.30 [0.316]
Vegetables	0.02 (0.05)	0.05 (0.21)	-0.79 (1.21)	-0.10 (0.87)	0.02 (0.12)	0.70 (0.64)	0.54 [0.764]
Pulses	0.01 (0.03)	-0.09 (0.09)	0.94 (0.56)	0.70 (0.40)	-0.09 (1.06)	-0.24 (0.47)	2.24 [0.326]
Human capital	-0.10 (0.04)	-0.04 (0.15)	0.24 (1.01)	0.17 (0.57)	0.06 (0.41)	-0.08 (0.08)	0.17 [0.917]
Housing	0.02 (0.04)	0.02 (0.13)	0.14 (0.80)	0.79 (0.51)	0.01 (0.05)	0.65 (0.84)	0.88 [0.645]
Clothing	0.19 (0.05)	0.26 (0.14)	-0.71 (0.95)	0.89 (0.58)	0.07 (0.54)	**1.61 (1.82) * **	**5.25 [0.072]**
Adult goods	0.03 (0.05)	0.34 (0.13)	1.08 (0.95)	-1.37 (0.64)	**0.31 (2.31) ** **	**-2.44 (2.75) ** **	**9.05 [0.011]**
Non-food other	-0.09 (0.07)	0.17 (0.21)	-1.64 (1.59)	-2.03 (0.78)	0.25 (1.27)	-0.40 (0.24)	1.89 [0.388]

Notes: Standard errors and t-statistics in parentheses next to coeficients computed by method of infinitesimal jacknife (White robust). P-values in brackets next to join-tests of significance. Samples are restricted to household that have land holdings.

Samples are 162 households (Senegal), 227 households (Ghana, 1997-1998), and 2,508 households (Ghana, 1991-1992). Estimated models include:

a) Senegal: per-capita total expenditure (qurtile splines), log number of household members, share of members ages 0 to 5, share of members ages 6 to 14, share of females and males ages 15 to 39, share of females and males ages 40 to 55, share of males ages 56 and above, head's and snior wife's age (second-order polynomial), indicator for monogamous relationships, and zone fixed-effects.

b) Ghana, 1997-1998: same as Senegal except for village fixed-effects (instead of zones) and additional inclusion of head's and senior wife's education (second order polynomial)

c) Ghana, 1991-1992: same as Ghana (1997-1998) except for additional inclusion of indicators for single-female and single-male headed households.

Table 2 : Testing the Unitary Model - effects of bargaining power on expenditure patterns
Proxy for bargaining power: Land area interacted with decision-power

	Area		Non-zero area indicator		Area	Area indicator	
	Male (SE)	Female (SE)	Male (SE)	Female (SE)	Fem-Male Diff. (t-stats)	Fem-Male Diff. (t-stats)	Wald - Diff. Joint test [p-val]
PANEL A: Ghana, 1997-1998, Land holder decides crop sale							
Tubers	-0.59 (0.50)	2.88 (3.80)	-0.25 (4.11)	-2.67 (7.18)	3.48 (0.93)	-2.42 (0.30)	2.39 [0.303]
Cereals	-0.31 (0.36)	-0.04 (2.53)	2.42 (2.92)	-0.87 (4.16)	0.27 (0.11)	-3.29 (0.62)	0.87 [0.648]
Meats and fish	0.03 (0.50)	4.27 (2.27)	-0.60 (3.93)	-7.73 (4.43)	**4.24 (1.79) ***	-7.13 (1.10)	4.30 [0.116]
Vegetables	0.20 (0.25)	-1.19 (1.42)	0.70 (2.30)	2.61 (2.87)	-1.39 (0.95)	1.91 (0.46)	1.46 [0.482]
Pulses	0.12 (0.20)	1.35 (1.73)	0.49 (1.34)	-0.30 (3.08)	1.23 (0.74)	-0.79 (0.24)	2.05 [0.359]
Human capital	0.35 (0.47)	0.58 (3.08)	0.41 (3.71)	-4.82 (6.18)	0.23 (0.07)	-5.23 (0.66)	2.50 [0.286]
Housing	0.54 (0.28)	-2.65 (1.80)	-2.41 (2.38)	6.74 (3.56)	**-3.19 (1.73) ***	**9.14 (1.93) ***	3.71 [0.156]
Clothing	0.35 (0.44)	-4.18 (2.19)	-4.24 (3.93)	8.68 (4.13)	**-4.53 (1.95) ***	**12.92 (1.96) ****	4.03 [0.133]
Adult goods	-0.31 (0.14)	0.64 (1.05)	2.33 (1.47)	-1.80 (1.98)	0.95 (0.86)	-4.13 (1.36)	2.98 [0.225]
Non-food other	-0.43 (0.41)	-3.32 (1.92)	2.94 (3.65)	3.04 (3.87)	-2.90 (1.46)	0.10 (0.02)	**7.68 [0.021]**
PANEL B: Ghana, 1991-1992, Holder keeps the revenue from production							
Tubers	0.12 (0.09)	0.10 (0.30)	0.04 (0.77)	-0.99 (0.94)	-0.03 (0.09)	-1.03 (0.94)	1.89 [0.388]
Cereals	-0.01 (0.06)	-0.31 (0.18)	0.64 (0.56)	0.12 (0.58)	**-0.30 (1.74) ***	-0.52 (0.69)	**8.12 [0.017]**
Meats and fish	-0.02 (0.07)	-0.04 (0.24)	-0.66 (0.61)	0.77 (0.79)	-0.03 (0.11)	1.43 (1.54)	4.39 [0.112]
Vegetables	0.03 (0.07)	0.06 (0.24)	-0.08 (0.61)	-0.53 (0.75)	0.03 (0.13)	-0.44 (0.48)	0.32 [0.854]
Pulses	-0.02 (0.04)	-0.05 (0.12)	0.26 (0.33)	0.63 (0.36)	-0.04 (0.33)	0.38 (0.82)	0.73 [0.693]
Human capital	-0.16 (0.05)	-0.05 (0.21)	1.03 (0.41)	0.41 (0.61)	0.11 (0.51)	-0.62 (0.89)	0.84 [0.656]
Housing	0.00 (0.05)	0.08 (0.16)	-0.26 (0.43)	0.07 (0.50)	0.08 (0.50)	0.33 (0.57)	1.57 [0.455]
Clothing	0.18 (0.06)	0.09 (0.18)	-0.54 (0.49)	0.36 (0.51)	-0.09 (0.51)	0.90 (1.42)	2.20 [0.332]
Adult goods	0.06 (0.06)	0.51 (0.18)	-0.42 (0.59)	-1.53 (0.55)	**0.45 (2.59) ****	-1.10 (1.52)	**6.73 [0.035]**
Non-food other	-0.10 (0.09)	-0.27 (0.27)	-0.25 (0.81)	0.35 (0.94)	-0.18 (0.69)	0.60 (0.53)	0.48 [0.786]
PANEL C: Ghana, 1991-1992, Holder chooses crop to be farmed							
Tubers	0.09 (0.09)	-0.02 (0.30)	-0.80 (1.04)	-1.76 (0.98)	-0.11 (0.41)	-0.96 (0.76)	1.54 [0.462]
Cereals	0.01 (0.06)	-0.15 (0.17)	1.79 (0.77)	0.68 (0.63)	-0.16 (0.99)	-1.11 (1.38)	**5.39 [0.067]**
Meats and fish	-0.07 (0.07)	-0.14 (0.22)	-0.34 (0.87)	1.90 (0.88)	-0.07 (0.33)	**2.23 (2.00) ****	**4.76 [0.092]**
Vegetables	0.05 (0.07)	-0.16 (0.25)	-0.38 (0.95)	-0.66 (0.84)	-0.21 (0.87)	-0.29 (0.25)	1.43 [0.489]
Pulses	0.00 (0.03)	-0.03 (0.11)	0.29 (0.41)	0.52 (0.38)	-0.03 (0.27)	0.23 (0.49)	0.24 [0.888]
Human capital	-0.12 (0.05)	-0.05 (0.20)	0.26 (0.66)	0.32 (0.61)	0.08 (0.42)	0.05 (0.07)	0.32 [0.851]
Housing	0.01 (0.05)	0.00 (0.15)	-0.47 (0.61)	0.08 (0.54)	-0.01 (0.08)	0.55 (0.80)	0.78 [0.678]
Clothing	0.22 (0.06)	0.30 (0.17)	-1.21 (0.73)	0.42 (0.57)	0.08 (0.53)	**1.64 (2.07) ****	**6.46 [0.040]**
Adult goods	0.05 (0.06)	0.40 (0.16)	0.14 (0.76)	-1.27 (0.60)	**0.34 (2.16) ****	-1.41 (1.62)	**5.03 [0.081]**
Non-food other	-0.11 (0.09)	0.03 (0.24)	-0.54 (1.13)	-0.84 (0.87)	0.14 (0.60)	-0.31 (0.21)	0.37 [0.830]

Notes: Standard errors and t-statistics in parentheses next to coeficients computed by method of infinitesimal jacknife (White robust). P-values in brackets next to join-tests of significance. Samples are restricted to household that have land holdings.

Table 3 : Testing the Unitary Model - effects of bargaining power on expenditure patterns
Ghana 1997-1998

	Area		Non-zero area indicator		Area		Area indicator		
	Male (SE)	**Female (SE)**	**Male (SE)**	**Female (SE)**	**Fem-Male Diff. (t-stats)**		**Fem-Male Diff. (t-stats)**		**Wald - Diff. Joint test [p-val]**
PANEL A: Total area which land holder has right to farm after divorce									
Tubers	-0.54 (0.90)	-3.07 (8.52)	2.31 (4.03)	6.68 (9.69)	-2.53 (0.30)		4.38 (0.41)		0.22 [0.898]
Cereals	-0.33 (0.68)	-6.24 (4.49)	-1.71 (2.97)	5.53 (4.78)	-5.91 (1.32)		7.24 (1.32)		1.87 [0.392]
Meats and fish	0.81 (0.70)	6.29 (5.32)	-4.30 (3.45)	-5.99 (6.18)	5.48 (1.02)		-1.69 (0.25)		3.05 [0.218]
Vegetables	0.97 (0.36)	-0.77 (2.57)	-2.91 (1.69)	2.64 (2.99)	-1.73 (0.68)		**5.55 (1.66)**	*	**5.10 [0.078]**
Pulses	0.47 (0.43)	-0.05 (4.45)	-1.85 (1.67)	2.13 (5.06)	-0.52 (0.12)		3.97 (0.82)		4.19 [0.123]
Human capital	1.70 (0.78)	4.55 (5.59)	-6.34 (3.89)	-8.42 (6.97)	2.85 (0.51)		-2.09 (0.27)		0.54 [0.764]
Housing	0.40 (0.56)	-3.05 (3.28)	-0.44 (2.38)	3.89 (3.77)	-3.45 (1.06)		4.33 (0.99)		1.13 [0.567]
Clothing	-1.38 (0.74)	0.28 (5.07)	4.18 (3.41)	-0.78 (5.56)	1.65 (0.32)		-4.95 (0.73)		1.09 [0.580]
Adult goods	-0.90 (0.30)	1.67 (1.95)	4.67 (1.44)	-2.80 (2.31)	2.57 (1.26)		**-7.47 (2.35)**	**	**10.95 [0.004]**
Non-food other	-0.83 (0.77)	-4.52 (4.25)	7.07 (3.70)	5.14 (5.36)	-3.69 (0.87)		-1.93 (0.31)		**4.72 [0.094]**
	Total Assets		**Non-zero assets indicator**		**Total Assets**		**Non-zero assets indicator**		
	Male (SE)	**Female (SE)**	**Male (SE)**	**Female (SE)**	**Fem-Male Diff. (t-stats)**		**Fem-Male Diff. (t-stats)**		**Wald - Diff. Joint test [p-val]**
PANEL B: Total assets (1996)									
Tubers	-0.08 (0.07)	-0.34 (0.19)	3.59 (5.21)	12.42 (5.67)	-0.26 (1.27)		8.83 (1.05)		1.61 [0.448]
Cereals	-0.07 (0.06)	0.14 (0.19)	3.88 (4.15)	-7.43 (7.17)	0.20 (0.93)		-11.31 (1.24)		1.68 [0.431]
Meats and fish	-0.03 (0.07)	0.11 (0.16)	-0.04 (4.98)	-2.13 (5.10)	0.14 (0.72)		-2.09 (0.27)		1.21 [0.545]
Vegetables	0.09 (0.03)	-0.05 (0.08)	-4.44 (2.42)	0.80 (2.45)	-0.14 (1.50)		5.24 (1.40)		2.33 [0.311]
Pulses	0.00 (0.03)	-0.21 (0.10)	-0.84 (2.29)	7.64 (3.31)	**-0.21 (2.01)**	**	**8.49 (2.24)**	**	**5.00 [0.082]**
Human capital	-0.04 (0.06)	0.14 (0.17)	3.00 (4.65)	-5.37 (5.60)	0.17 (0.98)		-8.37 (1.08)		1.20 [0.549]
Housing	0.03 (0.04)	0.32 (0.12)	-0.51 (2.97)	-7.99 (4.04)	**0.29 (2.22)**	**	-7.48 (1.40)		**5.64 [0.060]**
Clothing	0.02 (0.06)	0.05 (0.16)	-0.77 (4.14)	2.39 (5.14)	0.03 (0.18)		3.17 (0.40)		2.45 [0.293]
Adult goods	-0.01 (0.02)	-0.11 (0.09)	1.36 (1.75)	2.20 (2.61)	-0.10 (0.97)		0.84 (0.23)		**6.56 [0.038]**
Non-food other	0.07 (0.06)	-0.03 (0.18)	-3.08 (4.40)	-2.02 (5.40)	-0.11 (0.55)		1.06 (0.16)		0.65 [0.722]

Notes: Standard errors and t-statistics in parentheses next to coeficients computed by method of infinitesimal jacknife (White robust). P-values in brackets next to join-tests of significance. Samples are restricted to household that have land holdings.

See notes in Table 4

Table 4 : Testing the Collective Model - proportionality of individual land holdings' effects on expenditure patterns Senegal, 1989

	Cereals	Pulses	Vegetables	Meats and fish	Fruits and milk	Human capital	Housing	Clothing	Transport
	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]
PANEL A: Inframarginal effect of land holdings									
Pulses	0.52 [0.472]								
Vegetables	0.01 [0.915]	0.56 [0.453]							
Meats and fish	1.01 [0.314]	0.00 [0.961]	1.03 [0.311]						
Fruits and milk	1.09 [0.296]	0.51 [0.473]	0.69 [0.407]	0.85 [0.358]					
Human capital	2.48 [0.115]	0.03 [0.859]	1.85 [0.174]	0.02 [0.882]	2.02 [0.156]				
Housing	0.68 [0.410]	0.11 [0.744]	0.70 [0.403]	0.13 [0.717]	0.65 [0.422]	0.14 [0.711]			
Clothing	0.06 [0.806]	0.10 [0.756]	0.06 [0.800]	0.11 [0.736]	0.18 [0.668]	0.07 [0.784]	0.02 [0.892]		
Transport	1.37 [0.241]	0.03 [0.855]	1.46 [0.226]	0.07 [0.791]	1.06 [0.303]	0.52 [0.469]	0.40 [0.530]	0.17 [0.677]	
Non-food other	0.48 [0.490]	0.14 [0.705]	0.45 [0.502]	0.17 [0.683]	0.03 [0.867]	0.39 [0.530]	0.38 [0.536]	0.17 [0.679]	0.16 [0.692]
PANEL B: Extramarginal effect of land holdings									
Pulses	0.00 [1.000]								
Vegetables	0.01 [0.905]	0.00 [0.993]							
Meats and fish	2.67 [0.102]	0.01 [0.942]	1.54 [0.215]						
Fruits and milk	0.47 [0.491]	0.00 [0.972]	0.11 [0.739]	2.09 [0.148]					
Human capital	1.87 [0.171]	0.01 [0.942]	1.13 [0.287]	0.00 [1.000]	1.42 [0.234]				
Housing	0.65 [0.420]	0.00 [0.951]	0.54 [0.461]	0.37 [0.544]	0.63 [0.429]	0.32 [0.570]			
Clothing	0.01 [0.904]	0.00 [0.989]	0.02 [0.879]	0.52 [0.473]	0.13 [0.717]	0.47 [0.493]	0.20 [0.653]		
Transport	1.00 [0.317]	0.00 [0.950]	0.64 [0.424]	1.09 [0.297]	0.54 [0.463]	0.89 [0.347]	0.76 [0.383]	0.44 [0.506]	
Non-food other	1.04 [0.309]	0.01 [0.943]	0.90 [0.343]	0.08 [0.773]	1.31 [0.252]	0.05 [0.816]	0.06 [0.810]	0.27 [0.606]	0.61 [0.436]
PANEL C: Infra and extramarginal effect of land holdings (joint test)									
Pulses	1.38 [0.503]								
Vegetables	0.02 [0.993]	1.10 [0.576]							
Meats and fish	2.70 [0.260]	0.01 [0.997]	1.64 [0.441]						
Fruits and milk	1.13 [0.568]	0.85 [0.654]	0.75 [0.686]	2.10 [0.351]					
Human capital	2.55 [0.280]	0.04 [0.983]	1.85 [0.396]	0.06 [0.973]	2.02 [0.363]				
Housing	0.70 [0.706]	0.17 [0.918]	0.70 [0.705]	0.42 [0.809]	0.66 [0.718]	0.44 [0.801]			
Clothing	0.09 [0.957]	0.11 [0.948]	0.07 [0.965]	0.72 [0.697]	0.18 [0.912]	0.71 [0.702]	0.38 [0.827]		
Transport	1.38 [0.501]	0.06 [0.969]	1.47 [0.481]	1.41 [0.494]	1.08 [0.583]	0.94 [0.626]	0.89 [0.639]	0.46 [0.794]	
Non-food other	3.13 [0.209]	0.16 [0.921]	2.32 [0.314]	0.17 [0.919]	1.62 [0.446]	0.45 [0.797]	0.73 [0.695]	0.49 [0.784]	0.61 [0.736]

Notes: Wald-statistics and p-values [in brackets] are presented. Samples are restricted to household that have land holdings - 162 households.

Variance-covariance of parameters estimated by method of infinitesimal jacknife (White robust)

Table 5 : Testing the Collective Model - proportionality of individual land holdings' effects on expenditure patterns Ghana, 1997-1998

	Tubers	Cereals	Meats and fish	Vegetables	Pulses	capital	Housing	Clothing	Adult goods
	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]
PANEL A: Inframarginal effect of land holdings									
Cereals	0.08 [0.779]								
Meats and fish	0.97 [0.326]	0.13 [0.721]							
Vegetables	0.12 [0.726]	0.13 [0.720]	1.08 [0.300]						
Pulses	0.49 [0.482]	0.14 [0.707]	0.02 [0.880]	0.45 [0.504]					
Human capital	0.90 [0.342]	0.26 [0.613]	0.89 [0.346]	0.26 [0.612]	0.31 [0.581]				
Housing	1.15 [0.284]	0.23 [0.635]	**2.99 [0.084]**	0.08 [0.779]	0.54 [0.462]	0.18 [0.675]			
Clothing	1.31 [0.253]	0.14 [0.709]	0.01 [0.909]	0.87 [0.351]	0.00 [0.951]	0.75 [0.388]	1.92 [0.166]		
Adult goods	0.20 [0.653]	0.15 [0.701]	1.45 [0.228]	0.00 [0.981]	0.47 [0.492]	0.50 [0.479]	0.22 [0.642]	1.32 [0.250]	
Non-food other	2.22 [0.136]	0.22 [0.640]	0.04 [0.832]	1.21 [0.271]	0.00 [0.992]	0.83 [0.362]	**2.83 [0.093]**	0.01 [0.935]	1.73 [0.188]
PANEL B: Extramarginal effect of land holdings									
Cereals	0.18 [0.669]								
Meats and fish	0.17 [0.678]	0.71 [0.399]							
Vegetables	0.26 [0.609]	0.51 [0.474]	0.02 [0.876]						
Pulses	0.38 [0.537]	0.28 [0.595]	0.15 [0.697]	0.07 [0.793]					
Human capital	0.75 [0.386]	0.84 [0.360]	0.23 [0.631]	0.12 [0.733]	0.00 [0.966]				
Housing	0.09 [0.759]	0.04 [0.847]	1.03 [0.311]	0.53 [0.467]	0.39 [0.530]	1.55 [0.213]			
Clothing	0.10 [0.748]	0.34 [0.558]	0.02 [0.880]	0.07 [0.799]	0.29 [0.592]	0.41 [0.522]	0.44 [0.506]		
Adult goods	0.60 [0.439]	0.10 [0.753]	1.90 [0.168]	1.05 [0.306]	0.28 [0.595]	2.54 [0.111]	0.69 [0.405]	1.22 [0.269]	
Non-food other	1.15 [0.284]	1.01 [0.315]	0.34 [0.563]	0.06 [0.807]	0.01 [0.930]	0.01 [0.921]	2.13 [0.144]	0.39 [0.535]	**2.90 [0.089]**
PANEL C: Infra and extramarginal effect of land holdings (joint test)									
Cereals	0.49 [0.782]								
Meats and fish	1.43 [0.489]	0.90 [0.639]							
Vegetables	1.14 [0.565]	0.73 [0.696]	2.20 [0.333]						
Pulses	1.71 [0.426]	0.47 [0.792]	0.20 [0.906]	0.45 [0.799]					
Human capital	1.03 [0.597]	0.88 [0.643]	1.02 [0.600]	0.31 [0.857]	0.37 [0.832]				
Housing	1.35 [0.508]	0.58 [0.747]	3.03 [0.219]	0.56 [0.757]	2.19 [0.335]	1.66 [0.436]			
Clothing	1.73 [0.422]	0.35 [0.841]	0.18 [0.915]	1.73 [0.422]	0.31 [0.855]	0.75 [0.687]	1.94 [0.380]		
Adult goods	0.65 [0.724]	0.15 [0.928]	1.91 [0.384]	2.29 [0.319]	3.21 [0.200]	3.54 [0.170]	1.94 [0.379]	1.42 [0.491]	
Non-food other	2.27 [0.322]	1.19 [0.552]	0.70 [0.705]	1.72 [0.423]	0.01 [0.994]	1.51 [0.469]	2.97 [0.227]	0.95 [0.623]	2.93 [0.231]

Notes: Wald-statistics and p-values [in brackets] are presented. Samples are restricted to household that have land holdings - 227 households.

Variance-covariance of parameters estimated by method of infinitesimal jacknife (White robust)

Table 6 : Testing the Collective Model - proportionality of individual land holdings' effects on expenditure patterns
Ghana, 1991-1992

	Tubers	Cereals	Meats and fish	Vegetables	Pulses	Human capital	Housing	Clothing	Adult goods
	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]
PANEL A: Inframarginal effect of land holdings									
Cereals	1.52 [0.218]								
Meats and fish	0.76 [0.383]	0.17 [0.684]							
Vegetables	0.07 [0.785]	0.08 [0.782]	0.01 [0.934]						
Pulses	0.39 [0.532]	0.36 [0.546]	0.52 [0.469]	0.15 [0.702]					
Human capital	0.27 [0.606]	1.69 [0.194]	0.43 [0.514]	0.03 [0.859]	0.82 [0.366]				
Housing	0.07 [0.796]	0.15 [0.700]	0.04 [0.843]	0.00 [0.949]	0.20 [0.657]	0.02 [0.895]			
Clothing	0.96 [0.327]	1.69 [0.194]	0.22 [0.636]	0.01 [0.938]	1.07 [0.300]	0.37 [0.542]	0.00 [0.995]		
Adult goods	1.97 [0.161]	0.05 [0.818]	0.38 [0.539]	0.10 [0.747]	0.28 [0.596]	**2.97 [0.085]**	0.19 [0.666]	**3.17 [0.075]**	
Non-food other	0.06 [0.802]	1.40 [0.236]	0.84 [0.360]	0.11 [0.741]	0.30 [0.582]	0.50 [0.480]	0.12 [0.734]	1.74 [0.187]	1.33 [0.248]
PANEL B: Extramarginal effect of land holdings									
Cereals	0.07 [0.798]								
Meats and fish	0.16 [0.688]	0.53 [0.467]							
Vegetables	0.11 [0.737]	0.09 [0.762]	0.01 [0.906]						
Pulses	0.01 [0.916]	0.21 [0.643]	1.24 [0.265]	0.28 [0.597]					
Human capital	0.01 [0.943]	0.01 [0.921]	0.09 [0.768]	0.06 [0.813]	0.00 [0.984]				
Housing	0.07 [0.793]	1.08 [0.299]	1.12 [0.289]	0.39 [0.530]	0.74 [0.389]	0.05 [0.828]			
Clothing	0.16 [0.691]	1.44 [0.231]	0.76 [0.385]	0.23 [0.629]	2.00 [0.158]	0.09 [0.764]	0.34 [0.559]		
Adult goods	0.15 [0.694]	1.60 [0.206]	1.04 [0.308]	0.27 [0.605]	2.67 [0.102]	0.09 [0.761]	0.52 [0.473]	0.00 [0.994]	
Non-food other	0.00 [0.955]	0.85 [0.358]	1.73 [0.188]	0.40 [0.526]	0.27 [0.606]	0.01 [0.903]	0.27 [0.605]	1.68 [0.195]	2.05 [0.153]
PANEL C: Infra and extramarginal effect of land holdings (joint test)									
Cereals	1.80 [0.406]								
Meats and fish	0.96 [0.619]	0.75 [0.688]							
Vegetables	0.25 [0.881]	0.13 [0.938]	0.03 [0.984]						
Pulses	0.40 [0.819]	0.49 [0.783]	1.60 [0.450]	0.42 [0.810]					
Human capital	0.35 [0.839]	1.99 [0.370]	0.60 [0.740]	0.11 [0.945]	0.82 [0.663]				
Housing	0.14 [0.931]	1.10 [0.576]	1.15 [0.563]	0.40 [0.819]	0.97 [0.617]	0.07 [0.965]			
Clothing	1.38 [0.503]	2.50 [0.286]	1.07 [0.585]	0.25 [0.883]	2.67 [0.263]	0.55 [0.759]	0.36 [0.834]		
Adult goods	1.97 [0.373]	1.62 [0.445]	1.56 [0.459]	0.32 [0.850]	3.39 [0.184]	2.97 [0.226]	0.81 [0.667]	3.27 [0.195]	
Non-food other	0.07 [0.968]	2.06 [0.358]	2.09 [0.351]	0.54 [0.763]	0.60 [0.740]	0.54 [0.765]	0.44 [0.802]	3.41 [0.182]	4.09 [0.129]

Notes: Wald-statistics and p-values [in brackets] are presented. Samples are restricted to household that have land holdings - 2,508 households.

Variance-covariance of parameters estimated by method of infinitesimal jacknife (White robust)

Table 7 : Testing the Collective Model - proportionality of individual land holdings' effects on expenditure patterns Ghana, 1997-1998

	Tubers	Cereals	Meats and fish	Vegetables	Pulses	Human capital	Housing	Clothing	Adult goods
	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]
PANEL A: Inframarginal effect of land holdings - area over which individual has decision power over crop sales									
Cereals	0.09 [0.768]								
Meats and fish	0.73 [0.392]	0.72 [0.396]							
Vegetables	0.01 [0.927]	0.16 [0.691]	0.48 [0.487]						
Pulses	0.48 [0.490]	0.32 [0.570]	0.12 [0.731]	0.36 [0.549]					
Human capital	0.20 [0.651]	0.00 [0.979]	0.67 [0.412]	0.15 [0.700]	0.29 [0.592]				
Housing	0.03 [0.871]	0.21 [0.646]	0.99 [0.319]	0.00 [0.973]	0.49 [0.485]	0.28 [0.595]			
Clothing	0.36 [0.546]	0.50 [0.480]	0.49 [0.485]	0.13 [0.722]	0.43 [0.510]	0.56 [0.455]	0.26 [0.607]		
Adult goods	0.01 [0.940]	0.09 [0.767]	1.54 [0.215]	0.03 [0.859]	0.48 [0.487]	0.15 [0.697]	0.13 [0.719]	0.87 [0.351]	
Non-food other	1.18 [0.277]	0.57 [0.450]	0.40 [0.527]	0.67 [0.412]	0.06 [0.805]	0.38 [0.536]	1.19 [0.276]	1.26 [0.261]	1.23 [0.268]
PANEL B: Extramarginal effect of land holdings - area over which individual has decision power over crop sales									
Cereals	0.08 [0.772]								
Meats and fish	0.06 [0.809]	0.19 [0.660]							
Vegetables	0.00 [0.972]	0.13 [0.720]	0.05 [0.822]						
Pulses	0.07 [0.792]	0.01 [0.939]	0.27 [0.605]	0.15 [0.699]					
Human capital	0.02 [0.891]	0.14 [0.710]	0.00 [0.952]	0.02 [0.887]	0.18 [0.673]				
Housing	0.14 [0.713]	0.18 [0.669]	0.10 [0.757]	0.22 [0.639]	0.25 [0.617]	0.07 [0.793]			
Clothing	0.21 [0.649]	0.16 [0.692]	0.68 [0.411]	0.34 [0.560]	0.17 [0.684]	0.19 [0.664]	0.16 [0.688]		
Adult goods	0.21 [0.646]	0.07 [0.799]	0.93 [0.334]	0.66 [0.418]	0.08 [0.782]	0.32 [0.572]	0.92 [0.337]	0.46 [0.499]	
Non-food other	0.06 [0.812]	0.06 [0.805]	0.56 [0.453]	0.07 [0.797]	0.02 [0.887]	0.14 [0.713]	0.62 [0.430]	1.23 [0.267]	0.84 [0.360]
PANEL C: Infra and extramarginal effect of land holdings (joint test)									
Cereals	0.13 [0.936]								
Meats and fish	1.36 [0.507]	0.75 [0.686]							
Vegetables	0.01 [0.995]	0.23 [0.892]	1.45 [0.483]						
Pulses	0.48 [0.788]	0.45 [0.797]	0.59 [0.746]	0.42 [0.811]					
Human capital	0.23 [0.891]	0.17 [0.918]	1.55 [0.461]	0.17 [0.917]	0.61 [0.736]				
Housing	0.28 [0.869]	0.26 [0.879]	1.22 [0.544]	0.27 [0.873]	1.62 [0.444]	0.29 [0.867]			
Clothing	1.50 [0.472]	0.52 [0.769]	0.68 [0.712]	1.61 [0.448]	2.06 [0.357]	0.67 [0.717]	1.29 [0.523]		
Adult goods	0.35 [0.840]	0.09 [0.957]	1.56 [0.458]	0.84 [0.658]	2.35 [0.308]	0.36 [0.837]	0.95 [0.621]	0.88 [0.646]	
Non-food other	1.46 [0.482]	0.96 [0.619]	0.56 [0.754]	0.93 [0.629]	0.06 [0.969]	1.84 [0.399]	1.19 [0.552]	1.38 [0.502]	1.24 [0.537]

Notes: Wald-statistics and p-values [in brackets] are presented. Samples are restricted to household that have land holdings - 227 households.

Variance-covariance of parameters estimated by method of infinitesimal jacknife (White robust)

Table 8 : Testing the Collective Model - proportionality of individual land holdings' effects on expenditure patterns Ghana, 1991-1992

	Tubers	Cereals	Meats and fish	Vegetables	Pulses	Human capital	Housing	Clothing	Adult goods
	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]	Wald stats [p-val]
PANEL A: Inframarginal effect of land holdings - area over which individual has decision power crop choice									
Cereals	0.36 [0.548]								
Meats and fish	0.28 [0.599]	0.49 [0.484]							
Vegetables	0.15 [0.699]	0.09 [0.761]	0.55 [0.457]						
Pulses	0.07 [0.790]	0.01 [0.922]	0.05 [0.820]	0.04 [0.841]					
Human capital	0.03 [0.856]	0.76 [0.385]	0.20 [0.656]	0.46 [0.499]	0.08 [0.782]				
Housing	0.00 [0.973]	0.06 [0.806]	0.03 [0.873]	0.03 [0.863]	0.04 [0.840]	0.00 [0.987]			
Clothing	0.24 [0.622]	0.95 [0.331]	0.04 [0.834]	0.78 [0.376]	0.07 [0.793]	0.39 [0.534]	0.01 [0.911]		
Adult goods	0.95 [0.330]	0.27 [0.606]	0.44 [0.507]	0.84 [0.360]	0.00 [0.948]	**2.76 [0.097]**	0.08 [0.777]	2.59 [0.108]	
Non-food other	0.00 [0.993]	0.49 [0.484]	0.30 [0.582]	0.26 [0.610]	0.07 [0.785]	0.05 [0.823]	0.00 [0.968]	0.53 [0.468]	1.35 [0.244]
PANEL B: Extramarginal effect of land holdings - area over which individual has decision power crop choice									
Cereals	1.51 [0.219]								
Meats and fish	0.69 [0.407]	**2.82 [0.093]**							
Vegetables	0.00 [0.945]	0.36 [0.549]	0.24 [0.622]						
Pulses	0.01 [0.917]	0.94 [0.333]	0.57 [0.450]	0.00 [0.993]					
Human capital	0.03 [0.861]	0.12 [0.728]	0.20 [0.658]	0.01 [0.915]	0.01 [0.904]				
Housing	0.61 [0.435]	0.22 [0.640]	0.43 [0.513]	0.35 [0.552]	0.55 [0.459]	0.23 [0.633]			
Clothing	1.85 [0.173]	1.40 [0.236]	1.30 [0.254]	0.62 [0.430]	1.25 [0.264]	0.32 [0.574]	0.01 [0.903]		
Adult goods	0.38 [0.536]	2.61 [0.106]	0.01 [0.927]	0.17 [0.680]	0.44 [0.507]	0.19 [0.666]	0.49 [0.483]	1.47 [0.225]	
Non-food other	0.01 [0.913]	0.42 [0.515]	0.37 [0.546]	0.00 [0.976]	0.00 [0.956]	0.01 [0.936]	0.47 [0.491]	0.90 [0.343]	0.25 [0.620]
PANEL C: Infra and extramarginal effect of land holdings (joint test)									
Cereals	1.77 [0.412]								
Meats and fish	0.85 [0.653]	3.53 [0.171]							
Vegetables	0.15 [0.927]	0.41 [0.816]	0.79 [0.673]						
Pulses	0.09 [0.956]	0.94 [0.624]	0.67 [0.714]	0.04 [0.980]					
Human capital	0.08 [0.961]	0.91 [0.634]	0.35 [0.838]	0.52 [0.770]	0.08 [0.960]				
Housing	0.65 [0.722]	0.30 [0.861]	0.44 [0.804]	0.41 [0.814]	0.58 [0.750]	0.24 [0.887]			
Clothing	3.17 [0.205]	1.89 [0.389]	1.33 [0.515]	2.96 [0.228]	1.28 [0.527]	1.30 [0.522]	0.05 [0.974]		
Adult goods	1.03 [0.598]	3.35 [0.188]	0.54 [0.764]	0.87 [0.646]	0.53 [0.767]	2.79 [0.248]	0.49 [0.782]	3.04 [0.219]	
Non-food other	0.01 [0.994]	0.97 [0.615]	0.67 [0.716]	0.28 [0.870]	0.08 [0.962]	0.06 [0.972]	0.49 [0.783]	1.03 [0.597]	2.15 [0.342]

Notes: Wald-statistics and p-values [in brackets] are presented. Samples are restricted to household that have land holdings - 2,508 households.

Variance-covariance of parameters estimated by method of infinitesimal jacknife (White robust)

Table 9: Joint tests of the collective model - Wald statistics [p-values]

	Senegal Total Land 1989	Ghana Total Land 1997-1998	Ghana Total Land 1991-1992	Ghana Land with crop sales decision 1997-1998	Ghana Land for which revenue is holder's 1991-1992	Ghana Land in which crop choice is holder's 1991-1992	Ghana Land that is kept after divorce 1997-1998	Ghana Total assets 1997-1998
Inframarginal {$\chi^2(17)$}	6.32	7.49	8.67	4.79	7.52	5.46	6.85	9.80
	[0.991]	[0.976]	[0.950]	[0.998]	[0.976]	[0.996]	[0.985]	[0.912]
Extramarginal {$\chi^2(17)$}	7.56	8.38	11.08	4.07	5.63	7.76	8.41	7.21
	[0.975]	[0.958]	[0.852]	[0.999]	[0.995]	[0.971]	[0.957]	[0.981]
Infra-extramarginal {$\chi^2(34)$}	15.47	22.67	19.03	14.56	15.23	15.00	19.22	16.89
	[0.997]	[0.931]	[0.982]	[0.999]	[0.998]	[0.998]	[0.980]	[0.994]

Note: χ^2(d.o.f). Variance-covariance of parameters estimated by method of infinitesimal jacknife (White robust)

Table 10: Testing Production Efficiency - plot yield per hectare (in % of sample mean)
Household-year-crop fixed effects estimation

	Overall samples			Subsample of mixed gender household-year-crop			
	No controls	**Area controls**	**Area + plot characteristics**	**All crops**	**Monocrops**	**Millet**	**Maize**
	[a]	**[b]**	**[c]**	**[d]**	**[e]**	**[f]**	**[g]**
PANEL A: Senegal, 1989							
Female vs. male plots	**-35.16**	**-58.20**	-	**-44.64**	**-44.64**	**-86.71**	-
	(9.14)	**(11.00)**		**(8.52)**	**(8.52)**	**(24.46)**	
Sample		*956*		*401*	*401*	*112*	
PANEL B: Ghana, 1997-1998							
Female vs. male plots	-19.32	**-69.03**	**-63.10**	**-133.28**	**-133.28**	-	**-139.35**
	(22.81)	**(31.17)**	**(28.97)**	**(52.80)**	**(52.80)**		**(57.27)**
Sample		*1,549*		*506*	*506*		*470*
PANEL C: Burkina Faso, 1981-1983							
Female vs. male plots	-3.12	**-38.51**	**-37.26**	**-56.22**	**-62.71**	**-46.09**	**-70.13**
	(7.39)	**(10.70)**	**(10.99)**	**(13.96)**	**(28.46)**	**(23.47)**	**(29.33)**
Sample		*3,935*		*1,158*	*554*	*237*	*41*

Notes: Standard errors in parentheses under coeficients computed by method of infinitesimal jacknife (White robust). Samples are restricted to heads and spouses.
Sample mean used to normalize the yield measures is also restricted to the same subsample in the heading.
The regression specifications are:
a) Burkina Faso: excluded soil type is "other", excluded topography "swamp", and exluded location "bushes".
b) Senegal: indicator for inputed area (median inputation) is included. No plot characteristics aside from area are available.
c) Ghana: indicator for inputed area (self-reports and median inputation), indicator for missing quality information, indicator for missing soil type, and indicator for missing topography. Excluded soil type is "loam", excluded topography "mid-slope", and ph and organic mater are modeled as linear effects

Table 11: Burkina Faso (1981-1983) - Robustness of Female vs. Male Differences in Productivity
Plot Outcomes for subsamples, household-year-crop fixed-effects models

	Overall samples		Subsample of mixed gender household-year-crop	
	Above median	Below median	Above median	Below median
	[a]	[b]	[c]	[d]
PANEL A: Stratified by Ratio of Female/Male Inherited Area Cultivated (as of 1984 and 1985)				
Female vs. male - Yields per hectare (in % of mean)	**-33.69**	**-64.32**	**-46.33**	-118.36
	(10.15)	**(41.86)**	**(10.96)**	(96.28)
Sample	*2,368*	*1,473*	*971*	*187*
PANEL B: Stratified by Ratio of Female/Male Share Inherited Area over Cultivated Area (as of 1984 and 1985)				
Female vs. male - Yields per hectare (in % of mean)	**-37.55**	**-43.80**	**-43.64**	**-77.38**
	(12.30)	**(22.99)**	**(10.72)**	**(35.00)**
Sample	*2,181*	*1,660*	*740*	*418*

Notes: Standard errors in parentheses under coeficients computed by method of infinitesimal jacknife (White robust). Samples are restricted to heads and spouses.

Table 12: Burkina Faso (1981-1983) - Robustness of Female vs. Male Differences in Productivity and Input Usage
Plot Outcomes for subsamples, household-year-crop fixed-effects models

		Stratification by Plot's Distance from the Dwelling		Stratification by Plot's Last Season Fallowing Status		Stratification by Plot's Primary-Crop Rotation In Relation to Last Season	
	Overall Sample [a]	Far (above 650 meters) [b]	Near (under 650 meters) [c]	Was under fallow [d]	Was NOT under fallow [e]	Did rotate [f]	Did NOT rotate [g]
PANEL A: Outcomes as in Udry (1996)							
Yields per hectare (in 1,000 FCA)	**-58.09**	**-43.03**	**-106.21**	**-43.92**	**-31.94**	**-57.94**	-24.57
	(14.93)	**(15.93)**	**(38.26)**	**(14.89)**	**(8.57)**	**(23.21)**	(22.24)
Labor input per hectare (in hours)	**-503.56**	**-373.36**	**-543.90**	**-754.07**	**-534.23**	**-511.17**	**-582.28**
	(57.80)	**(115.57)**	**(96.71)**	**(155.29)**	**(71.93)**	**(91.88)**	**(177.54)**
Production per hectare (in kg, for monocultures only)	**-433.42**	**-359.53**	-706.04	-126.04	**-311.99**	**-446.36**	-125.92
	(174.20)	**(184.96)**	(586.32)	(117.41)	**(122.36)**	**(261.46)**	(324.68)
PANEL B: Ratios of yield and input usage							
Yields per hour of labor (in FCA)	5.18	-1.57	-21.48	20.86	**56.26**	11.20	**118.86**
	(23.19)	(21.38)	(57.03)	(22.77)	**(19.96)**	(17.96)	**(62.92)**
Hired work per hour of family labor (in minutes)	1.00	-1.26	1.11	-1.62	1.17	2.82	0.37
	(1.50)	(2.42)	(2.44)	(2.45)	(2.10)	(2.48)	(2.99)
Production per kg of seed (in kg, for monocultures only)	-5.11	-1.89	-15.63	8.51	-8.74	-6.04	-15.98
	(9.68)	(25.30)	(20.85)	(11.43)	(19.50)	(10.13)	(50.44)
Sample	*1,158*	*338*	*483*	*233*	*722*	*639*	*232*
Sample (single-crop plots)	*547*	*165*	*205*	*126*	*299*	*347*	*74*

Notes: Standard errors in parentheses under coeficients computed by method of infinitesimal jacknife (White robust). Samples are restricted to heads and spouses.

Table A1 : Descriptive Statistics - Demographics, Food-share and Land Holdings

	Senegal 1989	Ghana 1997-1998	Ghana 1991-1992	Burkina Faso 1981-1983
Individual characteristics				
Male head age	47.36	43.58	45.49	50.46
	(1.01)	(0.88)	(0.39)	(1.05)
Senior wife age	34.94	37.22	36.89	39.93
	(0.88)	(0.79)	(0.32)	(1.25)
Household demographics				
Monogamous head (%)	53.70	95.15	87.60	43.80
	(3.93)	(1.43)	(0.85)	(3.56)
Single head (%)	-	-	40.19	2.99
			(0.98)	(1.32)
Household members (#)	11.91	5.93	4.75	11.79
	(0.52)	(0.19)	(0.06)	(0.57)
Males	6.09	2.95	2.34	5.59
	(0.38)	(0.11)	(0.03)	(0.26)
Females	5.80	2.98	2.41	6.20
	(0.24)	(0.12)	(0.03)	(0.35)
Age-gender groups (%)				
Males 0 to 5	12.61	9.92	7.94	10.67
	(0.88)	(0.86)	(0.25)	(0.66)
6 to 14	14.45	11.96	12.69	12.91
	(0.96)	(0.94)	(0.32)	(0.78)
15 to 20	5.76	3.60	5.54	5.25
	(0.58)	(0.49)	(0.25)	(0.50)
21 to 39	8.85	13.53	13.31	10.27
	(0.68)	(0.90)	(0.48)	(0.64)
40 to 55	6.26	5.94	5.64	5.10
	(0.58)	(0.73)	(0.30)	(0.49)
56 and above	3.02	4.78	5.97	5.10
	(0.39)	(0.74)	(0.33)	(0.66)
Females 0 to 5	12.69	10.44	8.19	8.98
	(0.89)	(0.85)	(0.25)	(0.61)
6 to 14	10.68	11.98	11.47	11.68
	(0.78)	(0.86)	(0.30)	(0.72)
15 to 20	6.78	4.31	4.64	5.72
	(0.58)	(0.59)	(0.21)	(0.49)
21 to 39	10.25	11.58	11.44	13.93
	(0.57)	(0.83)	(0.28)	(0.65)
40 to 55	5.68	4.00	7.36	6.54
	(0.51)	(0.58)	(0.29)	(0.81)
56 and above	2.72	2.77	5.82	3.85
	(0.35)	(0.47)	(0.34)	(0.52)
Food-share and Land Holdings				
Food-share (%)	81.86	60.38	63.90	NA
	(0.76)	(0.97)	(0.26)	
Household land area (hectares)	7.84	1.75	2.22	5.45
	(0.56)	(0.13)	(0.11)	(0.26)
Household per capita land area (hec.)	0.66	0.35	0.58	0.51
	(0.03)	(0.03)	(0.03)	(0.02)
Male head's land area (hectares)	4.67	1.46	2.48	4.70
	(0.34)	(0.13)	(0.14)	(0.22)
Male head reporting land (%)	93.83	90.31	97.45	100.00
	(1.90)	(1.97)	(0.36)	
Senior wife land area (hectares)	0.50	0.27	0.36	0.16
	(0.04)	(0.02)	(0.03)	(0.01)
Senior wife reporting land (%)	78.40	71.37	38.74	92.22
	(3.24)	(3.01)	(1.06)	(2.08)
Sample size (# households)	162	227	2,508	167

Notes: Standard errors in parentheses under sample means. Senior wife's land holdings in Burkina Faso reflects per-spouse measure. For Senegal and Ghana, samples are restricted to households that have land holdings and consumption data available. For Ghana (1991-1992), monogamous heads and land holdings are conditional on couple-headed households and age conditional on presence.

Table A2 : Descriptive Statistics - Plot Level Data

	Senegal 1989			Ghana 1997-1998			Ghana 1991-1992			Burkina 1981-1983		
	Male	**Female**	**Fem-Male Diff.**	**Male**	**Female**	**Fem-Male Diff.**	**Male**	**Female**	**Fem-Male Diff.**	**Male**	**Female**	**Fem-Male Diff.**
Area												
Plot size (hectares)	1.19	0.40	-0.78	0.46	0.23	-0.23	1.53	0.62	-0.91	0.80	0.09	-0.71
	(0.05)	(0.02)	(0.05)	(0.01)	(0.01)	(0.01)	(0.06)	(0.03)	(0.06)	(0.02)	(0.004)	(0.03)
Plot size (log hectares)	-0.23	-1.32	-1.10	-1.09	-1.65	-0.56	-1.01	-2.03	-1.01	-1.33	-3.11	-1.78
	(0.04)	(0.06)	(0.07)	(0.02)	(0.03)	(0.04)	(0.04)	(0.07)	(0.08)	(0.03)	(0.04)	(0.05)
Imputed area - self-reports (%)				11.61	18.07	6.46						
				(0.99)	(1.73)	(1.99)						
Imputed area - local median (%)	4.23	10.69	6.46	15.89	36.95	21.06						
	(0.80)	(1.73)	(1.91)	(1.13)	(2.16)	(2.44)						
Farm Decision-Making												
Plots for which crop sale is holder's decision (%)				76.31	60.04	-16.27	68.89	68.82	-0.07			
				(1.31)	(2.20)	(2.56)	(0.84)	(1.33)	(1.57)			
Missing crop sale decision-maker (%)				22.74	37.75	15.01	15.69	11.78	-3.90			
				(1.29)	(2.17)	(2.53)	(0.66)	(0.92)	(1.13)			
Plots for which crop choice is holder's decision (%)							83.95	81.91	-2.04			
							(0.66)	(1.10)	(1.29)			
Missing crop choice decision-maker (%)							15.65	11.70	-3.95			
							(0.66)	(0.92)	(1.13)			
After-Divorce Rights												
Plots that can be farmed after divorce (%)				59.66	31.33	-28.33						
				(1.51)	(2.08)	(2.57)						
Missing after-divorce rights (%)				17.32	36.75	19.43						
				(1.17)	(2.16)	(2.46)						
Sample size (# plots)		956			1,549			4,282			3,935	

Notes: Standard errors in parentheses are heteroskedasticity robust (infinitesimal jacknife).

Table A3 : Descriptive Statistics - Expenditure Shares

	Senegal 1989		Ghana 1997-1998		Ghana 1991-1992	
	Share	Non-zero reports	Share	Non-zero reports	Share	Non-zero reports
Food*	81.86	100.00	60.38	100.00	63.90	100.00
	(0.76)		(0.97)		(0.26)	
Tubers			15.77	96.92	15.28	95.73
			(0.73)	(1.15)	(0.23)	(0.40)
Cereals	40.16	100.00	10.13	98.24	9.55	90.95
	(0.96)		(0.60)	(0.88)	(0.23)	(0.57)
Meats and Fish	5.85	96.30	14.51	96.04	15.60	97.73
	(0.34)	(1.49)	(0.61)	(1.30)	(0.17)	(0.30)
Vegetables, fruits and condiments*	5.25	83.95	6.60	98.24	12.78	99.60
	(0.40)	(2.89)	(0.34)	(0.88)	(0.14)	(0.13)
Pulses and Oils	11.29	100.00	4.76	96.48	5.79	92.54
	(0.36)		(0.29)	(1.23)	(0.11)	(0.52)
Milk, fruits and other beverages*	18.17	100.00				
	(0.84)					
Other food	1.15	42.59	8.61	99.56	4.89	91.55
	(0.20)	(3.90)	(0.41)	(0.44)	(0.09)	(0.56)
Non-food						
Human Capital (health and education)	5.20	98.77	12.12	99.56	4.97	91.83
	(0.24)	(0.87)	(0.64)	(0.44)	(0.10)	(0.55)
Housing	4.22	99.38	11.01	100.00	10.71	100.00
	(0.31)	(0.62)	(0.44)		(0.10)	
Clothing and shoes	4.75	88.89	7.89	86.34	8.23	99.12
	(0.45)	(2.48)	(0.55)	(2.28)	(0.12)	(0.18)
Adult goods (beverages and tobacco)			1.95	63.00	4.57	63.76
			(0.22)	(3.21)	(0.13)	(0.96)
Transport and communication	0.62	48.77				
	(0.12)	(3.94)				
Other non-food	3.35	96.30	6.65	94.71	7.61	94.70
	(0.27)	(1.49)	(0.61)	(1.49)	(0.17)	(0.45)
Sample size (# households)	162		227		2,508	

Notes: Standard errors in parentheses under sample means.

* for Senegal, milk-beverages and food aggregates include tobacco and alcohol, and vegetables include tubers and exclude fruits. More disaggregated level data is not available.

Table A4 : Male and Female Heads - Land Holdings as Potential Measures of Bargaining Power

	Senegal 1989		Ghana 1997-1998		Ghana 1991-1992	
	Male	Female	Male	Female	Male	Female
Land Holdings						
Total area in hectares	4.67	0.50	1.46	0.27	1.87	0.30
	(0.34)	(0.04)	(0.13)	(0.02)	(0.10)	(0.02)
Non-zero report indicator	93.83	78.40	90.31	71.37	73.29	32.78
	(1.90)	(3.24)	(1.97)	(3.01)	(0.88)	(0.94)
Single headed households					15.39	24.80
					(0.72)	(0.86)
Land Holdings and Farm Decision-Making						
Area in which crop sale is holder's decision			1.13	0.16	1.25	0.20
			(0.12)	(0.01)	(0.06)	(0.02)
Non-zero report indicator			85.46	48.46	61.20	24.52
			(2.34)	(3.32)	(0.97)	(0.86)
Area in which crop choice is holder's decision					1.44	0.23
					(0.06)	(0.02)
Non-zero report indicator					71.77	29.51
					(0.90)	(0.91)
Land Holdings and After-Divorce Rights						
Area that can be farmed after divorce			0.79	0.07		
			(0.08)	(0.01)		
Non-zero report indicator			64.76	24.23		
			(3.18)	(2.85)		
Sample size (# households)	162		227		2,508	

Notes: Standard errors in parentheses under sample means.

a) Senegal total cultivated area instead of total area holdings.

b) Ghana (1991-1992), zeros are assigned to male head when female-single-headed households and vice versa.

c) Ghana (1991-1992), crop sale decision area corresponds to area for which holder keeps revenue from crop sales.