Out of West Africa: Evidence on the Efficient Allocation of Resources within Farm Households*

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Abstract

Previous contributions to the literature have suggested that the evidence based on data from agricultural production activities in West Africa, revealing that plots of land managed by women are less productive (on average) than the ones farmed by their husbands, indicates a rejection of the intrahousehold efficiency/cooperation hypothesis. The present study re-examines the decision process within those households and, contrasting choices related to production and to the allocation of resources towards consumption, empirically examines restrictions derived from a Pareto-efficient model. The evidence presented strongly suggests that heterogeneity of preferences within farm households does not preclude an efficient allocation of family resources.

Keywords: Pareto-efficiency, farm households, agricultural production, consumption patterns.

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"It is abundantly clear (...) that West African husbands and wives seldom form a unified production unit. (...) Of course this is not to deny that there is much mutual dependence and complementarity within the household".

Polly Hill, 1975, p. 123.

1 Introduction

Ethnographic studies have shown that considering households an undifferentiated decision-making unit applies poorly to many social contexts and is a very bad characterization of kinship systems in West Africa.[1] Most West African men and women have their own budgets, control resources and make decisions based both on those resources and on individual preferences. In the case of farm households in that region, intermingled decisions regarding consumption and productions add another layer to this discussion. Individuals living in the same household undertake agricultural production in a fairly non-unified way, simultaneously farming independent plots of land. Therefore, a question of capital importance is to what extent the heterogeneity in preferences and the separation of spheres hinders cooperation between husbands and wives. Non-cooperative behavior has potentially serious implications: it may undermine profit maximization and yield an inefficient allocation of welfare (derived from consumption) across household members. This paper tackles this question and presents evidence that, although individualistic behavior is pertinent within farm households in Senegal and Ghana, heterogeneity of preferences does not preclude the exhaustion of mutually advantageous trades on the allocation of family resources.

The theoretical characterization of households as groups of individuals sharing a common goal (i.e., common preferences) has been recurrently contested by empirical contributions to the literature.[2] Although a number of theoretical formulations that highlight both the role of individual actors and the intra-household balance of "decision power" have been proposed, there is no clear consensus around a particular alternative model. The most general individualistic characterization of intra-household interactions is the "collective rationality" model proposed by Chiappori (1988). The collective model is based on the assumption that household members, independent of the actual negotiation mechanism, achieve Pareto-efficient outcomes in the allocation of resources. Therefore, it is natural that tests rejecting

[1] Guyer (1980) argues that there are clear separate spheres: "a men and his wife do not share the same purse" and society clearly has "a men's side and a women's side." See also the collection of studies in Mook (1986).

[2] See Schultz (1990) and Thomas (1990), Lundberg et al (1997), Rubalcava and Thomas (2000) and Rangel (2005), among others.

the "unitary" model be followed by empirical verification of Pareto-efficiency restrictions over household behavior.

Evidence drawn by a small number of studies has shown that consumption patterns of households in the United States (Chiappori et al, 2002), Canada (Browning and Chiappori, 1998), France (Bourguignon et al., 1993) and Taiwan (Thomas and Chen, 1994) suggest that the intra-household allocation of resources is efficient. On the other hand, very influential contributions focusing on aspects of the agricultural productivity and input usage of farm households in West Africa have reached the opposite conclusion.[3] Udry (1996) and Owens (2001),[4] for example, have indicated that the simple reallocation of land from women to their husbands, without change in the allocation of labor, could increase total agricultural output of families in Burkina Faso and Senegal, respectively.[5] They have concluded such evidence contradicts the Pareto efficiency of resource allocation within the household and implies that there is an impediment to apparently mutually advantageous trades between members of the household.

This inconclusive overall evidence on the efficiency hypothesis indicates that more work is needed to understand when, if so, non-Pareto efficient outcomes are attained. Are inefficiencies within households a characteristic of the West African families and societies? The evidence uncovered in the present paper strongly suggests that this is not the case. Combining data on consumption and production decisions by a sample of households in West Africa, the evidence presented here indicates that one cannot reject that the allocation of resources towards consumption is efficient, even though tests based on production data (for the same families) point to a different conclusion. As thoroughly discussed in the text that follows, these results suggest that the conflicting evidence may be related to the relative robustness of the tests based on consumption and on production decisions. It also indicates that rejection of Pareto-efficiency based on production data, taken as a result of non-cooperation of husbands and wives, may have been premature.

In Section 2 a general ("collective rationality") model of agricultural-households is presented and empirical implications of the Pareto-efficiency hypothesis are discussed. Section 3 discusses the econometric evidence on the efficient allocation of resources within farm households. The conclusions are presented in Section 4.

[3]See Jones (1983) and Von Braun and Webb (1989) for early contributions.

[4]Akresh (1999), using an alternative data set for Burkina Faso indicates that the differences in male-female productivity are also pertinent in regions contiguous to the ones studied in Udry (1996).

[5]For the case of Burkina Faso, Udry et al. (1995) estimates a 10 to 15 percent potential increase in the value of household agricultural output if the proposed reallocation takes place.

2 The agricultural-household theory

Farm households are characterized by overlapping decisions regarding consumption and production. That is to say, farm-households produce partly for sale and partly for subsistence. They also purchase/rent inputs and non-agricultural goods/services from functioning markets, while taking simultaneous decisions regarding the supply of labor to the market and to the family farms. Researchers have traditionally focused on modeling the behavior of such arrangements in order to, ultimately, evaluate the effects of changes in policies attached to agricultural activities over production, consumption and labor-supply across households located in rural sectors.[6]

A less explored aspect is the process by which decisions are taken *within the household*, even though they may have implications for the final outcome of the policy changes. There are various examples that highlight the importance of intra-household adaptation to changes in the environment. Take the responses in the allocation of family labor following governmental investments in the productivity of irrigated rice in the Gambia and cotton in Tanzania. Although the programs have targeted crops that were traditionally raised by either women (Gambia) or men (Tanzania), reallocation of resources within the household have made unclear the assignment of gains and losses across household members. In the Gambia, men ended up taking primary control over the crop, while in Tanzania women did not perform tasks that were expected in the program design such that the cotton has died while they carried on with their own maize farming.[7] Therefore, in order to evaluate the impact of policies over the well-being of farm-households, it is of key importance to consider that individuals within the household may respond differently to incentives and interventions.

The analysis of multiple decision makers within households is of particular interest in the West African context, where for many households the agricultural production is simultaneous carried out on multiple plots managed by different members. Moreover, there is a large number of ethnographic studies indicating that women and men are expected to have influence over separate spheres of the household decision-making process, and that this influence is proportional to the resources they individually hold.[8] Do the apparent independence of production activities and the supposed heterogeneity of preferences within the household hinder cooperation? Do they induce families to either produce less than they are

[6] See Singh, Squire & Strauss (1986) for a review.
[7] See Dey (1993) and Fortman (1986), respectively.
[8] See Orubuloye et al. (1991).

capable of or to misallocate consumption goods within the household? Can the welfare of one household member be improved without hurting others? These questions motivate the present study.

This section delves inside the traditional models of agricultural-households, allowing for individualistic behavior and heterogeneity of preferences. The focus is on the "collective rationality" alternative to the unitary models,[9] which is based on the assumption that household members achieve an efficient allocation of resources. The final objective is the derivation of empirical implications originated by the heterogeneous preferences and the Pareto-efficiency assumptions that can be meaningfully assessed with available data.

2.1 General model

The static welfare evaluation of such households can be translated into the aggregation over "felicity functions" of different members (individuals), or sub-groups of members (generations, couples, gender, etc.). Without loss of generality, consider a household formed by two groups:[10]

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

where the superscripts m and f stand for male and female, for example. C represents the consumption vector, l stands for leisure, while X represents characteristics of the farm-households and/or its members. The consumption vector includes market goods (non-food or processed-food, for example) 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 time and budgetary restrictions, and their total expenditures can be summarized in the following accounting relation:

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

where P_c represents the vector of consumption prices. The income generating process consists of returns to labor supplied to the market, profits from farms' production (i.e., rents to the fixed-factor), and non-labor/non-business income (transfers, gifts, etc.). As mentioned

[9] See Chiappori (1997).

[10] Extended-households decision-making is an important issue in itself, but it is put to the side on this paper. See Rangel (2004).

above, farm profits regarding specific individuals are characteristic to the West African context.[11]

The farm production is assumed to be based on both food (partially consumed by the household, and partially sold) and cash-crops (exclusively sold in the market place). The production is assumed to follow technical relations determined by an implicit production function:

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

Where, Q represents output, L the labor demand, while Z and Φ indicate the observed and unobserved characteristics of the land plots, respectively. Crops are either food-crops (a) or cash-crops (k). Finally, A indicates the total amount of land held by the household. 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. The implicit assumption here is that all household members have access to the same production technology.

The farm-profit can be defined as the result from the (technically restricted) optimization:

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

This is equivalent to state maximum profits as the sum (across plots) of the returns to the fixed factor (land), or plot yields:

$$\overline{\pi}^m + \overline{\pi}^f \equiv \sum_{n=1}^{N_a+N_k} R_n^* \left(A_n, p_a, p_k, Z_n, \phi_n\right) \tag{5}$$

The outcome of the consumption and production decisions by households that simultaneously maximize profits and welfare is a series of reduced-form demands for inputs, demands for consumption goods, and farm-output supplies. Their exact characterization depends, however, on the environment faced by the households, or, more specifically, the functioning of (and the household participation on) markets at the village level. When markets are complete, household members take prices as parametrically given. In this way,

[11] In the abscence of additional information on profits' division, the formulation used in the current paper assumes that the profits originated from agricultural activity in a plot pertains to its manager/holder.

decisions and characteristics specific to the household (or its members) cannot influence prices practiced in the market. In such an environment, the household members behave as if all production decisions could be delegated to a profit maximizing third party, while retaining all the proceeds of the production unit. Therefore, even if production and consumption decisions are taken simultaneously, the decision-making can be modeled as recursive. In a first stage, the household members maximize the income made available by farm production subject to the technical constraints. Second, subject to the total income available, utility maximization is undertaken.

The recursivity assumption is not always appealing, however. Market imperfections, non-participation of the household members in some markets, transaction costs, or externalities related to sales/purchases, all introduce a wedge between implicit prices (commanded by household members) and market prices. These non-parametric prices are not taken as given by household members. Rather, they are set by the influence of their preferences, technological knowledge and plot-characteristics. As opposed to the case of perfectly functioning markets, preferences, household characteristics, prices of non-agricultural commodities, and exogenous income do affect production decisions. Moreover, technology, fixed-inputs and plot characteristics, or (non-consumed) output and input-prices not only affect consumption decisions through the changes in income level, but also through a "shadow" price-effect.

2.2 Empirical implications of heterogeneity and efficiency

The Pareto-efficiency concept derived from the social welfare literature refers both to the maximization of profits in the production activity, and to the allocation of resources to consumption. In terms of intra-household allocations this concept should embody:

i) efficient production across plots employing production technologies - it should be impossible 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 of another, and;

ii) optimal allocation of available goods across individual members - given the aggregate amounts of income available, consumption distribution should maximize each individual's well-being while meeting (minimum) utility requirements for all other members.

Strict sense, even though both production and consumption/utility efficiency should be achieved for a household to be classified as efficient, the empirical tests can be discussed

separately due to their specific data requirements and potential limitations. The objective is to set up empirical approaches that can be applied to the same households, revealing the relative robustness of production and consumption-based tests regarding intra-household efficiency.

2.2.1 Production

Independently from the characterization of household preferences as unitary or heterogenous, and from the recursive assumption, the allocation of resources across production units managed by household members should attend efficiency (or profit maximization) conditions. They can be characterized as the result of identities in the marginal returns to inputs allocated across different plots. The return to one unit of labor, for example, should be identical across plots, being independent of whichever member has managerial control over it. In the same way, the returns to land, or plot yields, should be identical amongst plots with the same characteristics (as area and land quality). Or in other words, the differences in plot yield should be fully explained by the variation of plot characteristics.

The 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.[12] In its simplest specification, 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:

$$R_n = R_n(1) \cdot D_n + R_n(0) \cdot (1 - D_n) \tag{6}$$

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 unobservables — $R_n(1) = \alpha_1 + A\delta + Z\beta + \Phi$ and $R_n(0) = \alpha_0 + A\delta + Z\beta + \Phi$, the resulting relation is just:

$$R_n = \alpha_0 + D_n\left(\alpha_1 - \alpha_0\right) + A_n\delta + Z_n\beta + \Phi_n \tag{7}$$

In this formulation it is clear that the efficiency test consists of determining if the effect of re-assigning a plot of land between two household members could increase total output with

[12] Instead of estimations based on marginal product, these tests are simply based on the comparison of average productivities.

no change in labor (or other factors) supplied to each individual's plot.[13] In other words, it corresponds to testing the null-hypothesis that there is no additional gain to the household production in case of plots' reallocation:

$$H_0 : \alpha_1 - \alpha_0 = 0 \tag{8}$$

In taking this specification to the data, household specific effects should be incorporated to assure that only the within-household variation is being captured (and the analysis is insulated from imperfections in the markets at the village level). The objective is to verify if household members can "trade" and generate markets within the household to insulate them from potential limitations existent at the larger village environment. The final formulation reflects the introduction of these additional controls, and the yield of plot n, producing crop j, being managed by a member of household h is represented by:

$$R_{hjn} = A_{hjn}\delta + Z_{hjn}\beta + D_{hjn}\gamma + \eta_{hj} + \phi_{hjn} \tag{9}$$

This formulation, and the test of the exclusion restriction ($\gamma = 0$), have been the basis for the studies on the allocation of resources for farm households in Africa. This empirical model is further discussed below.

2.2.2 Consumption

Farm households have traditionally been characterized by the "unitary model". In such 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 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 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:

[13] An interesting (and possibly more realistic) 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 hand of the other - interaction of the group dummy and area measures. This alternative strategy is not explored in the present study. Udry (1996) presents some results of this augmented formulation (pp. 1027).

$$C = C\left(P, Y; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right) \tag{10}$$

where P includes production prices, wages and consumption prices.

Alternatively, households can be considered a composition of individuals with heterogeneous preferences. One of the less restrictive characterizations is the "collective rationality model". This model was developed by Chiappori (1988, 1992) and further extended by that author and his collaborators. The motivation is similar to other contributions to the literature based on bargaining concepts,[14] but collective rationality abstracts from specifying the bargaining process. 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 collective model's basic form (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. More generally, the efficiency assumption is equivalent to the following implicit structure for the household maximization problem:

$$\begin{aligned}
&\max_{C,l^m,l^f} W = U^m(C, l^m, l^f; X, \epsilon) + \mu U^f(C, l^m, l^f; X, \epsilon) \qquad (11)\\
s.t. \quad &: \quad P_c' C = \left[w(T - l^m) + w(T - l^f)\right] + \left(\pi^m + \pi^f\right) + \left(y^m + y^f\right)\\
&: \quad F(\underline{Q_a}, \underline{Q_k}, \underline{L_a}, \underline{L_k}; A, \underline{Z}, \underline{\Phi}) = 0\\
&: \quad \pi^m + \pi^f = \sum_j \sum_{n=1}^{N_j} \left(p_j Q_{jn} - w L_{jn}\right)
\end{aligned}$$

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

[14] See Manser & Brown (1980), McElroy & Horney (1981), and Ulph (1988).

model, they 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, these "distribution factors" which affect the choices without directly affecting the budget constraint or individual preferences captured by elements of the vector Λ. In other words, $\mu = \mu\left(\lambda^m, \lambda^f\right)$.

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:

$$C = C\left(P, Y, \lambda^m, \lambda^f; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right) \tag{12}$$

It is clear that demand functions originated from the unitary model assumptions are restricted versions of the ones imposed by the collective model (as well as by cooperative and non-cooperative bargaining models).[15] In particular, the demands consistent with the unitary model are neutral with respect to the distribution factors. The empirical test of the unitary model consists, therefore, of the reduced-form demand system estimation and the verification of the following exclusion restrictions:

$$\frac{\partial C_s}{\partial \lambda^i} = 0 \quad \forall s \quad i = m, f \tag{13}$$

The rejection of the unitary model does not shed light on the actual mechanism of household decision-making, however. Interestingly, the collective rationality model, as shown in Browning & Chiappori (1998),[16] also provides restrictions regarding the efficiency assumption in the context of heterogeneous preferences. The reasoning is that, if distribution factors only affect decisions by shifting the attractiveness of outside-options (or "power") for

[15] See McElroy (1990).

[16] See also Chiappori et al (2002) and Bourguignon et al (1993).

each household decision-maker,[17] the ratio of marginal propensities to consume a good with respect to different distribution factors should be the same across goods. These conditions can be expressed as a cross-equation restriction:

$$\frac{\frac{\partial C_1}{\partial \lambda^m}}{\frac{\partial C_1}{\partial \lambda^f}} = \frac{\frac{\partial C_1}{\partial \mu_1}\frac{\partial \mu}{\partial \lambda^m}}{\frac{\partial C_1}{\partial \mu_1}\frac{\partial \mu}{\partial \lambda^f}} = \frac{\frac{\partial \mu}{\partial \lambda^m}}{\frac{\partial \mu}{\partial \lambda^f}} = \frac{\frac{\partial C_s}{\partial \lambda^m}}{\frac{\partial C_s}{\partial \lambda^f}} \quad \forall s \tag{14}$$

or simply:

$$\frac{\partial C_1}{\partial \lambda^m}\frac{\partial C_s}{\partial \lambda^f} = \frac{\partial C_s}{\partial \lambda^m}\frac{\partial C_1}{\partial \lambda^f} \quad \forall s \tag{15}$$

The intuition for this results is the following: If the optimal production plan and the sharing of household income negotiations take place before the individual consumption decisions, power redistributions within the household can only affect the choices as pure income effects in the latter (and individualized) stage of the decision process. Therefore, the effects of any two factors affecting bargaining power should be proportional.

It is important to note that the conditions just derived are not expected to be valid if more than two individuals have decision-making power within the household. This is the case because, if a third individual has decision power, for example, the demands become:

$$C = C\left(P, Y, \mu_1, \mu_2; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right) \tag{16}$$

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

$$C = C\left(P, Y, \lambda^m, \lambda^f; X, \epsilon, A, \underline{Z}, \underline{\Phi}\right) \tag{17}$$

As a direct consequence:

$$\frac{\partial C_1}{\partial \lambda^m} = \frac{\partial C_1}{\partial \mu_1}\frac{\partial \mu_1}{\partial \lambda^m} + \frac{\partial C_1}{\partial \mu_2}\frac{\partial \mu_2}{\partial \lambda^m}$$

Hence:

$$\frac{\frac{\partial C_1}{\partial \lambda^m}}{\frac{\partial C_1}{\partial \lambda^f}} = \frac{\frac{\partial C_1}{\partial \mu_1}\frac{\partial \mu_1}{\partial \lambda^m} + \frac{\partial C_1}{\partial \mu_2}\frac{\partial \mu_2}{\partial \lambda^m}}{\frac{\partial C_1}{\partial \mu_1}\frac{\partial \mu_1}{\partial \lambda^f} + \frac{\partial C_1}{\partial \mu_2}\frac{\partial \mu_2}{\partial \lambda^f}} \neq \frac{\frac{\partial C_s}{\partial \lambda^m}}{\frac{\partial C_s}{\partial \lambda^f}} \tag{18}$$

[17] Specifically the collective rationality model imposes a weak separability assumption between measures of bargaining power and other factors that affect demands.

In these circumstances, statistical tests based equation (14) are actually expected to over-reject Pareto efficiency.[18]

3 Econometric evidence and discussion

In order to combine tests of efficiency on production and consumption, this paper bases its estimations on survey data from farm households in West Africa. The first data-set contains the agricultural production of farm-households in Burkina Faso. This data is used to reproduce the results of Udry (1996), to further explore some additional information contained in the survey, and to put the results on other data-sets into perspective.[19] The second and third data sets contain production and consumption decisions by agricultural-households in Senegal and Ghana, respectively. The fourth data set is a larger data set on consumption decisions of Ghanaian farm households and is used to check the robustness of the smaller samples' results.[20]

3.1 Descriptive statistics

Table A1 presents the basic statistics on the demographics of the households and land holdings in the three countries studied here. The samples in Senegal and Ghana were restricted to households for which consumption information was available in order to guarantee consistency across the empirical exercises presented in the next subsections. The figures in Table A1 indicate that, on average, households are headed by men in their mid-late forties (or early fifties) and women in their mid-late thirties. Polygyny is higher among men in the French colonized areas (Burkina Faso and Senegal), corresponding 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 difference in household size across these countries.[21]

[18] This occurs even if the household is actually Pareto-efficient.

[19] Inumerous attempts to obtain the section of the ICRISAT Burkinabe data set that includes consumption decisions were undertaken. After contacts with many researchers and institutions, Thomas Reardon (MSU), one of the researchers in charge of the actual data collection, informed us that the data had been lost.

[20] The four surveys are briefly described in Appenix A.

[21] Household composition is highly variant throughout Africa and other developing countries, but in this paper their structure is taken as given. See Foster (1998) for a discussion on the topic.

Table A1 also presents the general statistics for food-consumption as a share of the household budget (except for Burkina Faso), and land holdings. The data indicate that Senegalese households dedicate a larger share of the budget to food.[22] In the three countries, all households sampled have one member or more as farmers (controlling a plot of land). Total area in hectares is bigger in Senegal, somewhat smaller in Burkina Faso, and significantly smaller among Ghanese households. Per capita measures bring the countries closer together in terms of area holdings, however. Male heads concentrate most of the land. Participation of women in farming activities is higher in Burkina Faso, and is in the 70th percentile for the farm-level studies in Senegal and Ghana. The data based on the Ghanaian household survey (GLSS3), not centered on land plots, indicates a much smaller participation rate. This possibly reflects the different focus of the survey and the fact that on GLSS3 the household head was asked to list the plot holders. Plot holders were then interviewed about the amount of land and the number of plots they hold.

Table A2 focus on the plot characteristics for the sample of heads and spouses (senior wives and others in case of polygyny) that hold at least one plot. Spouses' plots are quite smaller than heads', with the smaller differences observed on the 1997-1998 Ghanaian survey, where the logarithm of female plots' area was (on average) half of the male plots' (in the other surveys female plots are three to four times smaller). As missing data at the plot level was an issue for the Senegalese and Ghanaian surveys,[23] these measures were imputed using very simple techniques.[24] The plots that had the area measure imputed were flagged and this indicator is included in the regressions estimated in the subsections below. These indicators reveal that the measures of area for female plots are more likely to be missing. As the area measures are later aggregated to the holder's level, this may suggest that female land holdings are more likely to be mismeasured.[25] Table A2 also presents information on the nature of decision making for each plot sampled in the Ghanaian surveys, as well as after-divorce rights in the case of the 1997-1998 survey. Once more, the two surveys differ on the results. For the 1997-1998 sample, women clearly have decision power and divorce rights over a smaller share of the plots they hold, while for the 1991-1992 survey the differences are not significant.[26]

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

[23]For GLSS3, given that samples were large enough, households with at least one plot with missing area data were completely dropped from the working sample.

[24]See Appendix A.

[25]The implication of mismeasurement is discussed below.

[26]A closer look on the data indicates, however, that information on decision power and divorce rights

Patterns of consumption are reproduced in Table A3. As consumption aggregates reflect yearly consumption shares, the proportion of zero consumption is pretty small for most of them. This result is consistent across the surveys employed in the estimations. Consumption shares are slightly different between the two samples from Ghana. This reflects the different structure of the surveys but also differences in regional patterns of consumption — the 1997-1998 sample is drawn from the Southern sector of the Ghanaian Eastern region. According to such statistics Senegalese families can be considered poorer than the Ghanaian ones. The share of food on the household budgets is, on average, one-fourth higher among the former. These figures also reflect the structure of production in Ghana, where more "cash-crops" not consumed by the household (pineapple, in particular) have lately been cultivated for sale in international markets. Although poorer in terms of cereals, the diet of Ghanaian households appears to be richer in animal protein (mostly fish) than the one of Senegalese families.

Table A4 summarizes individual land holdings. These measures are latter 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 Senegalese women area holdings are one-nineth 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 the decision-power or after-divorce rights.

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

3.2 Production efficiency

Pareto-efficiency implies that factors of production should be allocated efficiently across plots controlled by different household members. The model presented in equation (9) can be used in the empirical verification of 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 field. Table 5 presents the results of this estimation after conditioning on the primary-crop choice (combined with household and year fixed-effects), as in the following empirical

information is more likely to be missing for women in the 1997-1998 sample, while less likely for women in the 1991-1992 sample. For each of these categories, individuals are flagged if they have missing information - and these indicators are included in the regressions estimated below.

specification (household h, year t, crop j, plot n):[27]

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

where D is one when the plot is managed by one of the household female heads.[28]

The figures in Table 1 essentially reproduce the patterns found by Udry (1996) for Burkina Faso,[29] Owens (2001) for Senegal, and Goldstein & Udry (2002) for Ghana. 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 columns reflect the inclusion of different controls, as area (indicators for plot-area distribution deciles) and some limited information on other plot characteristics. The specification comparable across countries (with area controls only) is presented in column 2 of each panel, and indicate that yields in plots controlled by wives are *smaller* than the ones controlled by their husbands (γ is significantly smaller than zero). The differences amount to 33% of the average yield in Burkina Faso, 58% of the average yield in Senegal, and 71% of the average yield in Ghana.

Table 2 turns to the evaluation of the same model for specific crops in each of the countries. The results obtained in the more general model also apply to the crop-specific equations, and plots controlled by wives are found less productive than the ones farmed by household heads for different crop choices. At their face value, these results cast doubts on the efficiency of intra-household resource allocation throughout West Africa.

On the caveats of production efficiency tests

The estimations based on this model are potentially subject to the effects of any systematic difference in the quality of the land farmed by wives and husbands. This unobserved heterogeneity bias may drive the gender differential in yields if women's plots are of lower quality than men's. In terms of the estimated parameter, it means that:

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

[28] 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.

[29] Differently from the model estimated in that article, this paper restricts the sample to husbands and wives. Moreover here controls for the choice of secondary and tertiary crops in each field are also included in the fixed-effects estimations.

$$\widehat{\gamma} \xrightarrow{p} \gamma + \frac{E\left[\phi_{htjn}\ D_{htjn}\,/A, Z\right]}{E\left[D_{htjn}\,/A, Z\right]} \tag{20}$$

Udry (1996) tries to address this concern, and explores an indirect argument that can be constructed to investigate its plausibility. The reasoning is 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. The comparison of columns in Table 1 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 are quite similar.

Altonji et al. (2003) has formalized this idea, and indicates that for this strategy 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. How stringent these assumptions are in this context is not object of examination in this paper, however.

The nature of the surveys used for this estimation (and of plot-level surveys in general) is 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 possibly biased differential productivity.[30]

The selection issues surrounding the samples can also be thought in terms of endogenous plot size, which is a clear possibility according to the 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 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 indicate that, throughout West Africa, plots of land are allocated to each individual member by the household head.[31] Ultimately, women

[30]See Appendix B for a description of the strategies and potential biases.

[31]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.

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 the land plots they allocate, the gender differential is expected to 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 and family status of the bride could have important implications over the quality of land she farms as a wife.[32]

This reasoning suggests that the inclusion of family background variables on the plot-yield could explain the gender differential effects. Incidentally, Goldstein & Udry (2002), focusing on their indirect effects through the choice of fallow duration, actually indicate that the gender differentials for Ghanese households are eliminated if the family background variables are used in a two-stage estimation. In their case, the predicted fallow duration provides, in fact, a sufficient statistic for the unobserved characteristics at the plot level.[33]

The data sets from Burkina Faso and Senegal do not contain family background variables that could be used to extend these findings. There is a strong indication, however, that crop-choice conveys most of the information on the observable characteristics of the plots in Burkina Faso, as suggested by Udry (1996). One alternative 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).[34] When fixed effects of household-year-crop choice are combined with fixed effects for the crop being farmed last season in that plot (if the plot was under fallow or if the same crop was being cultivated), the gender differential becomes much smaller and insignificant. The results presented in Table 3 suggest a closer relation between gender and the crop history at the plot level (or, arguably, between gender and unobserved quality).

It is important to keep in mind that the difference in productivity can be correctly measured and yet not reflect non-cooperation among household members. Non-convexities and indivisibilities to which agricultural production is subject to can be an alternative explanation for the findings. In any case, measures of productivity that can indicate cooperation (or its absence) beyond reasonable doubt are very hard to come up with.

Focusing on an alternative route, the next two subsections discuss tests based on consumption patterns for the same Senegalese and Ghanese families, as well as for a larger sample of households in Ghana.

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

[33]Family background variables were not made available by the researchers, and, therefore, the results are not reproduced here.

[34]Of course, these are endogenous variables in a dynamic context.

3.3 Testing the unitary model

As presented in the theoretical section above, the test of the unitary model consists on the verification of an exclusion restriction: factors that affect 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 for the so-called "distribution factors" is not well defined. It is clear that household members may derive "power" from a myriad of sources, each reflecting a different aspect of the options a person would have outside the household.

The present paper estimates Engel curves augmented by the factors that influence bargaining power in the following form:

$$c_h = X_h\alpha_1 + \beta^m\lambda_h^m + \beta^f\lambda_h^f + \varepsilon_h \tag{21}$$

where the distribution factors are replaced by the measures discussed below. This model is a linearized version of reduced-form demands derived from the collective model. The controls for household characteristics 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 for the Ghana model), and indicator functions for location (villages in Ghana and zones in Senegal). Total per-capita expenditures were included as (distributional) quartile splines to control for total resources available to the household.

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 is allowed to have a flexible influence over the consumption decisions (it was introduced as quartile splines). Moreover, budget shares as dependent variable allow a non-parametric interaction between total expenditures and each covariate included in the model.

The present paper follows the tradition of the literature on the subject and associates power to the control each member has over economic resources.[35] The idea is to operationalize this notion by treating asset holdings (land in particular) of husbands and wives as measures of factors affecting relative power. The intuitive appeal of these measures does not come without costs. Some caution is necessary on the interpretation of the

[35]See Haddad and Hoddinot (1995) for a study of farm households from Ivory Coast, and Doss (1996) for a study based on GLSS3, for example.

results since, in some circumstances, it is not possible to define measures of assets that are exactly assignable to the reporting individual (i.e., carried out of the household), and that are not outcome of the intra-household negotiations themselves (endogenous). Although not sustaining that these measures are perfectly suited for the analysis, the present study explores the reports of total land area held by the individual (cultivated area in the case of Senegalese households). For the case of Ghana, the indicators are slightly more appropriate, as they somewhat circumvent assignment and (static) endogeneity issues. The Ghanese surveys allows the computation of asset holdings in the period before the one used as reference for expenditures (1997-1998 Survey), land holdings over which the holder has more decision power, and land holdings that can be kept in case of divorce (1997-1998 Survey).

The model was estimated individually for a series of commodities and the standard errors reported are computed with the infinitesimal jackknife method. Tables 4 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 & 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.[36]

Table 5 replicates the exercise 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 the previous conclusion. Table 6 explores additional measures of factors affecting bargaining power available in the 1997-1998 Ghanese survey (areas that can be farmed in case of divorce and total assets). The unitary model is, once more, reasonably rejected.

On the caveats of tests of the unitary model

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. If that is the case, note that the marginal effect of the measures of power in a collective model is a composite of effects

[36]Not reported here.

through the Pareto weight and the effect of preferences over the shadow-prices (and then over demand):

$$\frac{\partial C_s\left(P,\mu(\lambda^m,\lambda^f)\right)}{\partial \lambda^i}=\left[\frac{\partial C_s}{\partial P}\frac{\partial P^*}{\partial \mu}+\frac{\partial C_s}{\partial \mu}\right]\frac{\partial \mu}{\partial \lambda^i} \tag{22}$$

and,

$$\frac{\partial C_s}{\partial \lambda^f}-\frac{\partial C_s}{\partial \lambda^m}=\left[\frac{\partial C_s}{\partial P}\frac{\partial P^*}{\partial \mu}+\frac{\partial C_s}{\partial \mu}\right]\cdot\left[\frac{\partial \mu}{\partial \lambda^f}-\frac{\partial \mu}{\partial \lambda^m}\right] \tag{23}$$

hence, even if the exclusion restriction still applies, the sign of the power effect might be uninformative.

The 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 senior wives is more likely to be mismeasured than their husbands'. Assuming a simple modeling of the measurement error, consider that the power measure for the female head in household h is represented by $A_h^{f*}=A_h^f\cdot\omega_h$, where ω is an error (between zero and one) unrelated to the actual measure of area (classical). As a result, 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 (upwards). This same structure also applies in the case in which the quality of land differs for men and women (a key point in the production analysis), and similar biases would emerge.

Note that, in these cases, a strategy can be designed to indirectly infer the relevance of the unitary model's assumptions. If power indicators are measured with error (as the one just described) or the quality of female area is inferior, one can explore multiple equations of the demand system to go around them. In particular notice that the ratio of marginal effects of power measures is insulated from the potential bias terms:

$$\frac{\widehat{\beta}_1^f}{\widehat{\beta}_s^f}\xrightarrow{p}\frac{\beta_1^f}{\beta_s^f} \tag{24}$$

hence, the test can be based on the difference of ratios (across goods) of the power effects for women and men:

$$H_0 : \frac{\beta_1^f}{\beta_s^f} - \frac{\beta_1^m}{\beta_s^m} = 0 \tag{25}$$

Incidentally, the test of the unitary model under measurement error corresponds to a test of Pareto-efficiency as described in the theoretical section. In other words, the test of efficiency is found to be invariant with respect to measurement error (under certain assumptions) in the power indicators and, most importantly, to differences in quality of land held by men and women.[37] Finally, using the same reasoning, note that it is also clear that the incompleteness of markets does not affect the tests based on the proportionality of power effects (the potential bias would cancels out when the ratios are taken).

3.4 Testing the collective rationality model

The testing of collective rationality, or Pareto-efficiency, restrictions consists of reproducing the proportionality conditions derived from the model presented above. It requires, therefore, the joint estimation of the system of demand equations and the imposition of non-linear (cross-equations) restrictions over the parameters attached to the power measures.

In the present paper these restrictions are tested using the Wald-test formulation:

$$Wald = h\left(\underline{\alpha}, \underline{\beta}\right)' \cdot \left[\frac{\partial h}{\partial\left(\underline{\alpha}, \underline{\beta}\right)} \cdot V \cdot \frac{\partial h}{\partial\left(\underline{\alpha}, \underline{\beta}\right)'}\right]^{-1} \cdot h\left(\underline{\alpha}, \underline{\beta}\right) \tag{26}$$

where V is the variance covariance matrix of the system of equations , and $h(.)$ is altered to reflect the same restrictions in terms of cross-multiplications instead of ratios. In other words:

$$H_0 : h\left(\underline{\alpha}, \underline{\beta}\right) = \beta_1^f \beta_s^m - \beta_1^m \beta_s^f = 0 \qquad \forall s \tag{27}$$

In principle, the restrictions could be tested jointly for all parameters in the system of equations. However, since the critical value derived from the chi-squared distribution

[37] Interestingly, Black et al (2000), shows that this condition could be valid even in a non-classical measurement error problem.

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), the results can be quite sensitive (in particular, towards under-rejection of Pareto-efficiency) if a large enough set of goods is employed in the estimation — the power of the test can be made arbitrarily small. This paper also presents pairwise tests of efficiency and, based on a system of 10 demand equations, reports results for 45 pairs of goods (food and non-food). An analytical advantage of this strategy is that potential rejections can be discussed in a case-by-case basis.

The results of the pair-wise test is presented in Tables 7 (Senegal), 8 (Ghana, 1997-1998) and 9 (Ghana, 1991-1992). Using total land holdings as the proxy for factors affecting bargaining power, these 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 yield 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 (an statistical artifact) in tests that have significance levels set at 10%. Tables 10 and 11 examine alternative measures of distribution factors that condition the land holdings to the degree of holder's decision power. Both Ghanese surveys allow this estimation, and the results corroborate previous findings.[38]

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.[39] Critchley et al (1996) has 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 and 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.[40] Hansen (2000) has shown how valuable is the GMM distance-statistics proposed by Newey and West (1987) in terms of reducing Type I error. Type I errors are not damaging to the test presented in this paper, to the extent that they make the inference more stringent than it should be. However, Hansen (2000) has not explored the occurrence of Type II errors across alternative estimation pro-

[38]Results using after-divorce land rights and total assets (not presented here) yield the same conclusion.

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

[40]Aside from the classical lagrange multiplier and lakelihood 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.

cedures. 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 even when it is actually false in a large number of circumstances.[41]

Finally, Table 12 focus on the joint test of the Pareto-Efficiency hypothesis over the system of commodities. Such 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.

4 Conclusions

This paper provides evidence that farm households in West Africa cannot be characterized as monolithic decision-units, as if they were unaffected by the amount of resources controlled by each of their members. These findings are compatible with anthropology studies in the region and also with investigations on the nature of household decision-making based on other developing and developed countries.

Extending the analysis presented in early contributions to the economics literature, the evidence uncovered here indicates that those West African households are able to achieve an efficient allocation of resources. This suggests that, in a environment where markets are hardly functional and survival 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 indicate that models that adopt the Pareto-efficient characterization of the intra-household allocation of resources, as Chiappori's (1988) collective model, can be regarded as an appropriate description of the agricultural-household decision-making in West Africa.

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Appendix A

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.[42] 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.

[42] See Matlon (1988).

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). Twelve households were randomly chosen in each village, and they were scheduled to be interviewed from Oct-1988 to Sep-1990 (2 harvest years).[43] 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.[44] 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.[45] 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.

[43] 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.

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

[45] See Diagne (1994).

3. The Survey on Agricultural Innovation and Resource Management in Ghana (1996-1998)[46]

This survey designed and undertaken by Christopher Udry (Yale University) and Markus Goldstein (LSE). 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).[47] 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,[48] 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.[49] 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.

[46]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.

[47]See Goldstein and Udry (1999).

[48]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.

[49]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.

4. The Ghana Living Standards Survey - GLSS3 (1991-1992)[50]

The survey was implemented by the World Bank and the Government of Ghana from September 1991 to September 1992. 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.[51]

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

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

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

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).

Appendix B

This appendix briefly discusses the strategy employed in Udry(1996) and described in Altonji et al (2003) to examine the level of bias due to unobserved heterogeneity at the plot level. It also examines the potential selection bias on the estimation of gender differentials.

Let the model be described by:

$$r = z\beta + d\gamma + \phi$$

which corresponds to a simplified version equation (19) above. Indexes are dropped for simplicity, and variables are assumed to be scalars.

(i) Unobserved heterogeneity and no selection:

In populational terms, assuming the observed and unobserved heterogeneities are orthogonal:

$$\begin{aligned} E\left[r\,/z,d\right] &= z\beta + d\gamma + E\left[\phi\,/z,d\right] \\ &= z\beta + d\gamma + E\left[\phi\,/d\right] \\ &= z\beta + d\gamma + d\tau \end{aligned}$$

Hence, the implied bias on the estimation of γ on this formulation corresponds to τ. In other words, the estimated parameter associated to the plot assignment dummy corresponds to:

$$\frac{\partial E\left[r\,/z,d\right]}{\partial d} = \gamma + \tau$$

Alternatively, imagine that Z is not observed. The new populational relation can be described as:

$$\begin{aligned} E\left[r\,/d\right] &= d\gamma + E\left[z\beta + \phi\,/d\right] \\ &= d\cdot(\gamma + \tau_2\beta) + E\left[\phi\,/d\right] \\ &= d\cdot(\gamma + \tau_2\beta + \tau) \end{aligned}$$

Under the assumption that $\tau_2 = \tau$, the estimation would yield:

$$\frac{\partial E\left[r\,/d\right]}{\partial d} = \gamma + \tau(1+\beta)$$

Therefore, if $\beta \neq 0$, the bias should change when Z is dropped from the equation, unless $\tau = 0$. And this is the argument used by Udry(1996).

(i) Unobserved heterogeneity and selection:

The same populational model of yields still applies, but now plots are observed depending on their selection to productive activities. In other words, observation of r is possible according to the following rule:

$$s = 1\left\{d\delta_1 + z\delta_2 + v > 0\right\}$$

where $v \sim N(0,1)$.

The derivation of the populational relation requires some additional steps:

$$\begin{aligned} E\left[r\,/z,d,v\right] &= z\beta + d\gamma + E\left[\phi\,/z,d,v\right] \\ &= z\beta + d\gamma + E\left[\phi\,/d,v\right] \\ &= z\beta + d\gamma + d\tau + \varphi v \end{aligned}$$

Using iterated expectations:

$$\begin{aligned} E\left[r\,/z,d,s\right] &= z\beta + d\gamma + d\tau + \varphi E\left[v\,/z,d,s\right] \\ &= z\beta + d\gamma + d\tau + \varphi h(d,z,s) \end{aligned}$$

And the linear projection on the selected sample corresponds to:

$$E\left[r\,/z,d,s=1\right] = z\beta + d\gamma + d\tau + \varphi\lambda(d\delta_1 + z\delta_2)$$

where $\lambda(.)$ is the inverse Mills ratio.

Hence:

$$\frac{\partial E\left[r\,/z,d,s=1\right]}{\partial d} = \gamma + \tau + \varphi\delta_1\frac{\partial\lambda(d\delta_1)}{\partial d}$$

and the bias of unobserved heterogeneity is augmented by the selection bias.

Table 1: Testing Production Efficiency - plot yield per hectare (relative to sample mean)
Household-year-crops fixed effects estimation

	Burkina Faso 1981-1983			Senegal 1989		Ghana 1997-1998		
	(1)	(2)	(3)	(1)	(2)	(1)	(2)	(3)
Female	-2.93	-33.35	-30.96	-34.61	-58.20	-10.85	-70.65	-63.10
	(9.58)	(8.25)	(8.40)	(9.17)	(11.00)	(20.06)	(29.92)	(28.97)
Area decile 1		115.01	109.05		94.76		184.96	188.15
		(26.76)	(26.94)		(28.32)		(61.24)	(58.37)
Area decile 2		56.53	53.39		37.38		35.45	42.82
		(18.82)	(18.94)		(23.06)		(32.60)	(33.77)
Area decile 3		58.05	59.51		32.37		89.61	96.95
		(14.47)	(14.56)		(24.89)		(29.54)	(30.15)
Area decile 4		27.63	28.31		-0.07		9.82	9.64
		(12.61)	(12.62)		(23.08)		(33.78)	(32.66)
Area decile 6		1.67	1.68		9.55		62.29	67.69
		(11.86)	(11.84)		(24.23)		(38.70)	(39.32)
Area decile 7		-12.99	-12.61		-11.33		-11.17	-6.40
		(12.84)	(12.93)		(21.60)		(28.73)	(30.17)
Area decile 8		-27.18	-26.85		-1.81		-23.60	-23.23
		(13.85)	(13.95)		(23.32)		(47.23)	(43.98)
Area decile 9		-38.17	-37.25		-20.94		-59.65	-56.19
		(14.54)	(14.75)		(22.19)		(47.54)	(48.43)
Area decile 10		-44.66	-38.04		-31.62		-63.36	-59.54
		(15.87)	(16.18)		(21.90)		(37.29)	(38.55)
Topography	No	No	Yes	No	No	No	No	Yes
Soil Type	No	No	Yes	No	No	No	No	Yes
Location	No	No	Yes	No	No	No	No	No
Soil Quality	No	No	No	No	No	No	No	Yes
Observations	3,935	3,935	3,935	956	956	1,549	1,549	1,549

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 of (heads' and wives') plots.

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.

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 2: Testing Production Efficiency - plot yield per hectare (relative to crop-specific sample mean)
Household-year fixed effects estimation

	Burkina Faso 1981-1983				Senegal 1989		Ghana 1997-1998			
	Millet		Maize		Millet	Peanuts	Maize		Maize & Cassava system	
	(1)	(2)	(1)	(2)			(1)	(2)	(1)	(2)
Female	-29.60	-30.85	-109.63	-105.82	-71.68	-40.23	-68.59	-71.71	-84.78	-80.71
	(14.74)	(15.13)	(45.35)	(45.74)	(19.26)	(10.90)	(41.08)	(40.71)	(31.91)	(29.82)
Area decile 1	-79.92	-54.21	138.55	143.62	119.13	48.24	189.50	193.53	241.27	237.18
	(108.08)	(109.43)	(40.68)	(41.36)	(42.66)	(28.98)	(71.62)	(73.63)	(60.68)	(57.44)
Area decile 2	19.97	42.47	86.31	100.06	4.01	39.98	99.30	105.30	87.50	87.54
	(45.69)	(45.94)	(40.45)	(43.16)	(28.28)	(23.93)	(95.42)	(98.82)	(31.50)	(31.22)
Area decile 3	47.14	65.79	90.62	94.53	32.17	24.43	72.98	90.76	79.03	76.22
	(29.96)	(30.94)	(37.46)	(38.30)	(34.72)	(27.08)	(42.31)	(50.13)	(22.36)	(22.28)
Area decile 4	26.32	41.58	59.94	65.07	-11.42	-0.39	38.14	43.63	14.45	11.62
	(26.67)	(27.41)	(36.35)	(36.67)	(26.55)	(24.15)	(37.96)	(40.54)	(27.86)	(28.26)
Area decile 6	-12.91	6.54	-5.08	-2.65	-11.07	15.83	-20.59	10.16	-15.19	-19.22
	(24.45)	(25.18)	(41.32)	(41.83)	(25.21)	(27.87)	(44.85)	(51.02)	(19.86)	(22.03)
Area decile 7	-55.29	-42.14	-39.71	-25.14	-37.00	0.41	9.50	29.33	-14.51	-12.11
	(24.21)	(24.67)	(38.74)	(39.64)	(25.00)	(24.46)	(35.08)	(39.59)	(26.18)	(26.92)
Area decile 8	-48.07	-35.67	-63.63	-35.55	-26.91	7.27	-122.77	-123.62	-102.42	-105.58
	(23.85)	(24.60)	(41.64)	(43.83)	(24.22)	(27.74)	(99.99)	(102.61)	(42.53)	(42.51)
Area decile 9	-72.49	-60.80	-110.40	-86.41	-38.76	-15.47	-87.90	-72.06	-90.71	-90.57
	(23.94)	(24.46)	(44.09)	(46.97)	(25.33)	(25.85)	(85.43)	(88.46)	(46.33)	(47.85)
Area decile 10	-72.94	-60.94	-112.69	-105.33	-66.43	-13.62	-67.08	-68.00	-86.56	-90.30
	(23.62)	(24.22)	(80.45)	(82.79)	(25.00)	(25.50)	(44.23)	(48.69)	(25.47)	(28.13)
Topography	No	Yes	No	Yes	No	No	No	Yes	No	Yes
Soil Type	No	Yes	No	Yes	No	No	No	Yes	No	Yes
Location	No	Yes	No	Yes	No	No	No	No	No	No
Soil Quality	No	No	No	No	No	No	No	Yes	No	Yes
Observations	775	775	684	684	347	305	551	551	1,117	1,117

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

Mean yiled used to normalize the dependent variable is crop specific.

See notes in Table 1.

Table 3: Burkina Faso (1981-1983) - Production Efficiency
Plot Yield per hectare (relative to sample mean)

	Household-year-crops fixed effects	Household-year-crops-history fixed effects
	(1)	(2)
Female	-30.96	-13.12
	(8.40)	(10.10)
Area decile 1	109.05	108.25
	(26.94)	(32.86)
Area decile 2	53.39	55.29
	(18.94)	(22.61)
Area decile 3	59.51	70.63
	(14.56)	(15.97)
Area decile 4	28.31	30.54
	(12.62)	(14.09)
Area decile 6	1.68	-1.59
	(11.84)	(13.50)
Area decile 7	-12.61	-15.38
	(12.93)	(15.10)
Area decile 8	-26.85	-21.15
	(13.95)	(16.53)
Area decile 9	-37.25	-25.56
	(14.75)	(17.15)
Area decile 10	-38.04	-26.05
	(16.18)	(19.03)
Uppermost	-13.90	-54.78
	(25.35)	(31.11)
Adj. uppermost	-19.36	-45.11
	(22.01)	(26.79)
Mid-slope	-19.46	-40.46
	(21.65)	(26.21)
Adj. swamp	-20.55	-46.56
	(21.85)	(26.01)
Soil type 11	-14.60	-41.17
	(43.60)	(52.36)
Soil type 12	80.64	109.60
	(30.17)	(37.45)
Soil type 13	221.02	315.45
	(68.43)	(77.45)
Soil type 31	8.61	10.43
	(13.88)	(15.53)
Soil type 32	11.36	12.81
	(15.11)	(17.43)
Soil type 33	-9.65	-5.44
	(24.09)	(27.49)
Soil type 37	11.33	11.93
	(22.67)	(28.77)
Soil type 45	0.97	1.43
	(16.31)	(18.55)
Soil type 46	6.30	11.39
	(37.99)	(41.88)
Soil type 51	10.84	21.39
	(17.22)	(22.14)
Location: Village	6.46	5.80
	(11.03)	(13.43)
Location: Compound	-2.43	-12.85
	(8.58)	(10.28)
Observations	3,935	3,935

Notes: Standard errors in parentheses under coeficients computed by method of infinitesimal jacknife (White robust). Sample is restricted to heads and spouses. History corresponds to a set of two indicator functions: same crop farmed in previous season is also currently farmed, and plot was under fallow last season.

Table 4 : 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)	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). 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 5 : 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)	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). Samples are restricted to household that have land holdings.

See notes in Table 4

Table 6 : 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)	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)	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). Samples are restricted to household that have land holdings.

See notes in Table 4

Table 7 : 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 8 : 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																		
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 9 : 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 10 : 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 11 : 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 12: 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 A1 : Descriptive Statistics - Demographics, Food-share and Land Holdings

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

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

Table A2 : Descriptive Statistics - Plot Level Data

	Burkina 1981-1983			Senegal 1989			Ghana 1997-1998			Ghana 1991-1992		
	Male	Female	Fem-Male Diff.	Male	Female	Fem-Male Diff.	Male	Female	Fem-Male Diff.	Male	Female	Fem-Male Diff.
Area												
Plot size (hectares)	0.80	0.09	-0.71	1.19	0.40	-0.78	0.46	0.23	-0.23	1.53	0.62	-0.91
	(0.02)	(0.004)	(0.03)	(0.05)	(0.02)	(0.05)	(0.01)	(0.01)	(0.01)	(0.06)	(0.03)	(0.06)
Plot size (log hectares)	-1.33	-3.11	-1.78	-0.23	-1.32	-1.10	-1.09	-1.65	-0.56	-1.01	-2.03	-1.01
	(0.03)	(0.04)	(0.05)	(0.04)	(0.06)	(0.07)	(0.02)	(0.03)	(0.04)	(0.04)	(0.07)	(0.08)
Inputed area - self-reports (%)							11.61	18.07	6.46			
							(0.99)	(1.73)	(1.99)			
Inputed 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)		3,935			956			1,549			4,282	

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.