Her land and his leisure: Testing household models using distributional factors

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Abstract

In rural Tanzania, land is acquired primarily through inheritance. Land is a distributional factor that can improve the bargaining power of women. Exogenous crop losses of equal value from 'male' and 'female' crops constitutes another set of distributional factors. I exploit this fact to explore if a relative increase in the size of wife's land within the household or a rise in wife's relative income lead to an increase in her share of household resources. The results from KHDS 1991-94 panel imply partial acceptance of the bargaining model. Higher land ownership improves women's relative leisure but not relative private consumption expenditures. Crop losses of equal value from 'male' and 'female' crops seem to have the same impact on household decision making.

Keywords: Intra-household allocation, collective model, developing country

JEL classifications: C3, D1, J1, J2

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1 Introduction

Empirical studies that have tested for alternate models of household decision making, for example Fortin, Lacroix (1997), **?**, Browning and Gortz (2006) etc, have found overwhelming support for the collective model in the developed world. The unitary model has been rejected in the context of both developing countries as well as developed countries.[1] Previous research has found that a rise in one's income and age relative to one's spouse is associated with a rise in one's consumption. This supports the view that couples bargain over the allocation of resources within the household. However, most of these papers are focused on the developed countries. In the context of developing countries, Duflo and Udry (2003) and Udry (1996) explore if the assumption of Pareto efficiency holds for Côte d'Ivoire and Burkina Faso respectively. Both the papers reject the assumption of Pareto efficiency.

This paper adds to the literature by investigating if the allocation of household resources between husbands and wives in rural Tanzania are determined by their relative bargaining strengths within the household. The uniqueness of this study is that it uses information on both private consumption expenditures of the spouses as well as their leisure time. Most surveys elicit information on either time use or expenditures.[2] The advantage of being able to use leisure time is that it is one of best example of private good that one can observe in a survey. The Kagera Health and Development Survey, 1991-94 surveyed approximately 840 households in rural Tanzania at an interval of six to eight months for two years. The longitudinal nature of the data allows me to account for the time-invariant omitted variables that might confound the analysis. Another contribution of this study is that it reveals some of the distributional factors that affect household decision making in rural Tanzania.

I analyze the responses of the relative leisure and private consumption ratios of the couples to exogenous changes in factors that potentially alter the distribution of power within the

[1] Hallberg (2004) is an exception.

[2] The Danish Time Use Survey is an exception. Browning and Gortz, 2007 use DTUS to test for the relevance of the collective model by exploiting the cross-sectional variation in the relative wage rate of the husband.

household. The environmental factors considered in this study are:(1) crop losses from male crops and female crops; and (2) female land ownership vs. male ownership. According to the predictions of the bargaining model, holding the total land size constant, a rise in the fraction of land owned by the female members should reduce the the husband's relative leisure and private consumption ratio by diminishing his bargaining power within the household. By the same logic, a rise in the share of coffee in the total value of crop lost in the previous harvest would tilt the distribution of household resources toward the wife. Additionally, if the 'collective' model holds, i.e. the household allocations are Pareto efficient, then the responses of the household choice variables are subject to certain restrictions that can be taken to the data. Within the 'unitary' set up, such events as a redistribution of land within the household members or reallocation of a dollar worth of loss from coffee to beans should have no implications as the household dictator's position is unaffected.

2 Theory

I develop a simple model of allocation of leisure time and consumption within the household. The model follows closely on the work of Browning and Gortz (2006). There are two members in the household, husband (H) and wife (W).[3] They engage in income generating activities and housework. Table 1 presents the notation. Let the husband and wife's utility functions respectively be denoted by U^H and U^W. These depend on the consumption of private goods, leisure time and the consumption of household public goods. The choice variables are C_H, C_W, C_Z, L_{HZ}, L_{WZ}, L_{HF} and L_{WF}

[3]It is possible that spouses have different preferences over children. At this point I ignore such issues.

The following equations describe the constraints faced by the household.

$$C_H + C_W + C_Z = ph(L_{HF}, L_{HF}, K) + y_H + y_W \quad \text{(Budget constraint)}$$

$$T = L_{HR} + L_{HZ} + L_{HF} \quad \text{(Time constraint of the husband)}$$

$$T = L_{WR} + L_{WZ} + L_{WF} \quad \text{(Time constraint of the wife)}$$

$$Z = Z(L_{HZ}, L_{WZ}, C_Z); Z_v > 0 \ \& \ Z_{vv} < 0; v \in \{L_{HZ}, L_{WZ}, C_Z\} \quad \text{(production function of household good)}$$

Table 1: Notations

	$i \in$ {husband H,wife W}
C_i	i's private expenditure;
C_Z	expenditure incurred for the public good production
Z	household public good
L_{iR}	leisure/rest of agent i;
L_{iZ}	housework of agent i;
L_{iF}	farm work of agent i;
y_i	non-labor income of agent i;
h(.)	farm production function
p	price of crops grown
K	Size of land owned by household

Given the preferences and the constraint set, the household maximization problem is:

$$\max_{C_H, C_W, C_Z, L_{HF}, L_{HZ}, L_{WF}, L_{WZ}} [U^H + \mu U^W]$$

$$\text{subject to} \quad C_H + C_W + C_Z = ph(L_{HF}, L_{WF}, K) + y_h + y_w$$

and time constraints and household good production function

Here $\mu(X_H, X_W)$ is the relative weight on the wife's utility, and X_H and X_W are two distributional factors that tilt the relative bargaining power in favor men and women respectively, holding the budget set constant. If μ is a constant, household choices will be invariant to changes in X and we have the unitary model set-up. When $\mu(X_H, X_W)$ is rising in $(\frac{X_W}{X_H})$, we have a bargaining model. Under the collective model set up, we assume further that the household choices are Pareto efficient.[4] This implies that the response of the choice variables to changes in X are subject to some restriction implied by Pareto efficiency. These facts can be used to test for the relevance of the unitary model, bargaining model and the collective model.

2.1 Theory: Restrictions on the collective and unitary model

Let $\tilde{l} = f(\mu, \Theta, P)$ and $\tilde{c} = g(\mu, \Theta, P)$ be the leisure and consumption ratios respectively. These depend on the relative weight on the wife's utility (μ), preference and technological parameters (Θ) and prices (P). Suppose X_1 and X_2 are two distributional factors. A key characteristic of **distributional factors** is that they neither affect preferences nor the budget set.[5] They **affect choice variables through μ only**. Thus, X_1 and X_2 can affect the leisure and private consumption ratios of wife to husband, $\tilde{l}$ and $\tilde{c}$ respectively, only through μ.

$$\frac{\partial \tilde{l}}{\partial X_1} = \frac{\partial f}{\partial \mu}\frac{\partial \mu}{\partial X_1}; \frac{\partial \tilde{c}}{\partial X_1} = \frac{\partial g}{\partial \mu}\frac{\partial \mu}{\partial X_1} \tag{1}$$

$$\frac{\partial \tilde{l}}{\partial X_2} = \frac{\partial f}{\partial \mu}\frac{\partial \mu}{\partial X_2}; \frac{\partial \tilde{c}}{\partial X_2} = \frac{\partial g}{\partial \mu}\frac{\partial \mu}{\partial X_2} \tag{2}$$

The unitary model restrictions are: $\frac{\partial \tilde{l}}{\partial X_i}=\frac{\partial \tilde{c}}{\partial X_i}=0$; i=1,2. ($\mu$ is a constant)

A rejection of this test implies the relevance of a bargaining model. If household allocations are Pareto efficient as well, then (1) and (2) imply that the response of the consumption and

[4]The collective setting does not require that households actually maximize weighted sum of utilities. It uses the fact that no matter how the household arrives at the efficient outcome, if household choices lie on a convex Pareto frontier, then for any point on the frontier, there exists a set of linear weights such that maximization of the weighted household utility function leads to the same Pareto efficient outcome. The advantage of modeling household decision-making within this set up is that it can accommodate several household-models. For instance, Nash bargaining models and the unitary model are special cases of this set up.

[5]We only require that they do not affect preferences directly.

leisure ratios to any distributional factor is collinear:

$$\frac{\partial \tilde{l}}{\partial X_1} = \frac{\frac{\partial f}{\partial \mu}}{\frac{\partial g}{\partial \mu}} \frac{\partial \tilde{c}}{\partial X_1}; \frac{\partial \tilde{l}}{\partial X_2} = \frac{\frac{\partial f}{\partial \mu}}{\frac{\partial g}{\partial \mu}} \frac{\partial \tilde{c}}{\partial X_2} \quad \text{(Collective model restriction)}$$

$$\text{OR } \frac{\frac{\partial \tilde{l}}{\partial X_1}}{\frac{\partial \tilde{c}}{\partial X_1}} = \frac{\frac{\partial \tilde{l}}{\partial X_2}}{\frac{\partial \tilde{c}}{\partial X_2}}$$

The empirical interpretation is that the structural coefficient on X will be the same in both the leisure and consumption ratio equations. The reduced form parameters differ by the factor $\frac{\frac{\partial f}{\partial \mu}}{\frac{\partial g}{\partial \mu}}$. In general, we do not observe this and so some papers rely on identifying two distributional factors and testing the equivalent restriction instead: $\frac{\frac{\partial \tilde{l}}{\partial X_1}}{\frac{\partial \tilde{c}}{\partial X_1}} = \frac{\frac{\partial \tilde{l}}{\partial X_2}}{\frac{\partial \tilde{c}}{\partial X_2}}$

3 Empirical Specification

Following Browning and Gortz (2006), I make the following functional form assumptions about the utility functions.

$$u^H = \theta_H ln(C_H) + \tau_H ln(l_{HR}) + Z(L_{HZ}, L_{WZ}, C_Z) \tag{3}$$

$$u^W = \theta_W ln(C_W) + \tau_W ln(l_{WR}) + Z(L_{HZ}, L_{WZ}, C_Z) \tag{4}$$

The separability of public goods consumption from other components is required as I do not observe the production of public goods within the household. The main advantage of this functional form is that they imply linear reduced forms for the leisure and consumption ratio. I denote $\frac{\theta_W}{\theta_H} = \theta$ and $\frac{\tau_W}{\tau_H} = \tau$.

The empirical specification of the unobservable parameters, μ, θ and τ are as follows:

$$\mu = \exp(\alpha_0 + \alpha' \mathbf{X} + \epsilon_\mu) \tag{5}$$

$$\theta = \exp(\gamma_{\theta 0} + \gamma_\theta' \mathbf{a} + \epsilon_\theta) \tag{6}$$

$$\tau = \exp(\gamma_{\tau 0} + \gamma_\tau' \mathbf{a} + \epsilon_\tau) \tag{7}$$

Here **a**= 'taste' variables, **X**=distributional factors. The relative marginal productivities of the husband and the wife are assumed to take the following form: $\frac{f'_{L_{HF}}}{f'_{L_{WF}}} = \omega e^x$, where x includes other variables that affects relative productivities. The term ω is the relative wage ratio of men to that of women. The FOC with respect to consumption and leisure (see Appendix) imply:

$$\frac{u^H_{CH}}{u^W_{CW}} = \frac{C_W}{C_H} = C = \theta\mu \tag{8}$$

$$\frac{u^H_{L_{HR}}}{u^W_{L_{WR}}} = \frac{L_{WR}}{L_{HR}} = L_R = \mu\tau\omega e^x \text{ where, } \omega \text{ is the relative wage ratio} \tag{9}$$

Substituting (5) and (7) respectively in (8) and (9) and taking logs, we have:

$$ln(\frac{C_W}{C_H}) = \pi_{C0} + \pi_{C1}X + \pi_{C2}a + (\epsilon_\mu + \epsilon_\theta + \epsilon_O) \tag{10}$$

$$ln(\frac{L_{WR}}{L_{HR}}) = \pi_{R0} + \pi_{R1}X + \pi_{R2}a + \pi_{R3}ln(\omega) + (\epsilon_\mu + \epsilon_\tau + \epsilon_O) \tag{11}$$

where π_{C0}=$(\alpha_0 + \gamma_{\theta 0})$, π_{C1}=α', π_{C2}=γ'_θ. Also, π_{R0}=$(\alpha_0 + \gamma_{\tau 0})$, π_{R1}=α', π_{R2}=γ'_τ and π_{R3}=-1.

The restriction implied by the collective model comes from the fact that X's affect leisure and consumption ratio through μ only; hence, the coefficient on X in the leisure ratio equation is linearly related to the coefficient on X in the consumption ratio equation.

Test for Unitary model: $H_0 : \pi_{C1} = 0$ and $\pi_{R1} = 0$ (Household choice is invariant to X). The rejection of this test implies that couples bargain over their private consumption and leisure.

Test for collective model: $H_0 : \pi_{C1} = \pi_{R1}$[6] (X affects choices through μ only)

Error Structure I assume that the error in the consumption ratio equation, ϵ_c= $(\epsilon_\mu + \epsilon_\theta + \epsilon_O) = (\psi_i + \tilde{\epsilon_C})$ and the error in the leisure ratio equation, ϵ_l=$(\epsilon_\mu + \epsilon_\tau + \epsilon_O) = (\psi_i + \tilde{\epsilon_l})$.

[6]This is an implication of my functional form assumption. The general test is that π_{C1} is proportional to π_{R1}.

Here ϵ_O captures measurement and aggregation errors.[7] ψ_i captures household-specific time invariant factors and $\tilde{\epsilon_c}$ and $\tilde{\epsilon_l}$ are identically and independently distributed.

4 Data and environmental factors

The Kagera region of Tanzania is located on the northwestern corner of Tanzania. At the time of the survey Kagera consisted of 6 districts. The population of Kagera (1.3 million in 1988, about 2 million in 2002) is mostly rural. This region is regarded as the land of coffee and bananas. The population, which is primarily rural, grows both cash crops like coffee and food crops like beans, maize, cassava, sorghum etc. Unlike some other places in Africa, most of the marriages are monogamous.

The data for my analysis comes from the first four rounds of the Kagera Health and Development Survey (KHD,1991-94). The KHDS was specially designed to capture the economic well being of households that were potentially affected by the HIV/ AIDS epidemic. An enumeration round was held prior to the actual survey. The aim was to group the households in each of the PSU's (defined by the 1988 Tanzania Census) into 'high-risk' and 'low-risk' category. A household was designated as a high risk household if it had experienced any prime-age (15-49) adult deaths in the past one year or if it had adult members who were too sick to work.[8] Next, from each of the 51 PSU's that were selected for the survey, a random sample of 14 households were chosen from the high-risk group and 2 households were randomly picked from the low risk group. The final longitudinal survey follows approximately 816 households from 1991-94, resurveying them every six-eight months for 2 years. Over 70 % of these households are farm households. KHDS has a wide array of individual and household characteristics. This includes time spent in the previous week on income earning activities and on household chores. Another unique feature of the dataset

[7] Suppose c (c*) and l (l*) are the observed (true) value of the variable. I assume that c=c* e^{ϵ_O} and l=l* e^{ϵ_O}.

[8] For details about the survey methodology, please refer to Users Guide to the Kagera Health and Development Survey Datasets available from the LSMS website

is that it has detailed information on the private consumption expenditures of the couples. It has a wealth of information on household demographics, assets, and health status. The dataset also contains information on shocks (rainfall, land inheritance, crop losses, illness etc.) faced by households.

What are the environmental factors? In rural Tanzania, women's access to land gives them a separate source of income other than working on the husband's farm.

> "As a form of property, land has a significance which few other forms of property enjoy. It provides one's livelihood, determines one's status, and provides a sense of belonging and identity within a village. Similar importance is not attached to other forms of property, such as cattle or jewelry. Land is thus of economic, political and symbolic significance. Women's employment outside the agricultural sector is restricted to insecure, low -paying jobs."(Manji, 1996)

Here it is important to point out that in Tanzania, husbands and wives work on the farm jointly irrespective of who owns the plot, unlike some other regions in Africa where men and women have separate farms. The size of the female and male land potentially determine the bargaining strengths of men and women within the household. Some of the land is also held jointly by all household members and some jointly by the husband and wife. It is not clear to me a-priori how joint land affects the relative bargaining strengths. Household land size changes when someone inherits land. Share of male and female land changes within the household when a household member inherits land or when size of land held jointly changes. Hence, if a female member or the wife inherits land, I treat it as a change in the female land and if the husband or another male member inherits the land, then I treat it as a change in the size of male land. This was done partly due to data limitations and partly due to theoretical considerations. Recall, that my model assumes there and only two decision makers within the household; I am assuming that the husband's (wife's) preferences are perfectly aligned with preferences of other adult men (women) if any within the household.

The household can lose a plot of land is the primary owner dies. I assume that gain or loss of land is unanticipated. If agents know well in advance about their future inheritance, it will affect their bargaining power well in advance. Then, ex-post, a change in the share of female land may not affect decision making.

Unexpected pest attacks or weather shocks that destroy men and women's crops asymmetrically are another set of environmental factors. As mentioned in the introductory section, cash crops like coffee are primarily male crops while food crops like beans are female crops. Loss of beans can reduce the bargaining power of women as they have very little opportunity of growing coffee outside marriage or within a non-cooperative marriage. Similarly, loss of coffee could have the opposite effect if men suddenly find their chief source of income under threat.

My primary source of classifying crops into 'male' and 'female' crops are Tibaijuka (1984) and Tesha (1998). Please refer to table 5. For empirical estimation, I categorize all crops except coffee, maize, beans and cooking banana in to 'other crops' group. It is important to mention here that the crop losses that I consider are harvest losses and not losses to standing crops. Beegle, Dahejia and Gatti (2006) present a detailed table that shows that most of the crop losses were concentrated in the first two rounds of the survey. I report Table 6 that illustrates this point.

Tables 6, 7 and 8, illustrate the nature of time variation in crop loss and land variables. Table 6 shows that most of the crop losses were restricted to the first two rounds. In table 7, I focus on three crops, coffee, cooking banana and beans and explore how the losses were distributed across different crops within the household. Households seem to have lost a portion of the different crops to varying degrees. A section of the households lost coffee but not beans and vice-versa. Some households lost both while others lost none. A similar pattern emerges for other crops. There is even more variation across households in the dollar value of losses of different crops.

Land variation (Table 8) across the rounds comes from land inherited by husband and wives. Men inherit land more often than women. Households can lose land if a senior member dies or if Clan land is taken away from the household for some reason. Both of these change the fraction of land held by females within the household. Households can also lose land of the primary owner dies or if they have a dispute with other relatives over who the rightful owner of the land is.

4.1 Variables

Dependent Variable The dependent variables are the log of the leisure and private consumption ratios of the spouses. The private consumption expenditure of the husband and wife are measured by the sum of their expenditure on each of the following categories of goods: food, drinks, tobacco, gambling, newspaper, expenditures on motorized transport, candles, batteries, sports, personal hygiene, clothing, footwear, jewelery, haircut, toys, fashion accessories like handbags and makeup etc. Some of the items like candles and toys potentially have public goods characteristics. However, the survey made it clear to the individuals that they should report only those expenditures that were made for their private consumption only. Hence, I assume that they are private in nature. Figure 1 shows the distribution of log of relative private consumption expenditure of the wife. Leisure is measured by the difference between 119 (I assume that everyone has at least 7 hours of rest time each day or 49 hours of rest each week) and the total time spent is any income generating work or housework within a week. Figure 2 shows the distribution of log of relative leisure ratio of the wife.

Right hand side variables Based on the discussion on environmental factors in the data section, I use the following X's in my empirical study: (1) the size of the land owned exclusively by women or owned jointly by men and women as opposed to that controlled exclusively by men; (2) the crop losses that come from male and female crops. To capture the first factor, I include total land of the household as an explanatory variable and then introduce the size of female land, joint land, other land (male land is the excluded category) to see if these have a separate impact on the dependent variable. If land resources are pooled perfectly within the household, land ownership of the husband and wife should not matter after controlling for the total land of the household. If couples bargain over household resources, then the relative consumption and leisure ratio of the wife should be increasing in the fraction of household land owned by her. In the same vein, I control for the total value of crop lost after harvest due to pests, fire etc. and then include monetary losses from the loss of coffee, beans, maize, and cooking banana as additional variables. If a dollar is just a dollar, then equal valued losses from coffee harvest and bean harvest should have the same impact on household decision making. On the other hand, if husband's relative bargaining power is decreasing in the share of coffee in the total value of crops lost, then his relative consumption and leisure ratio should decline with a rise in the share of coffee in the total value of crop losses within the household.

The 'taste' variables are the sickness status of the husband and wife. The sickness variables are dichotomous variables if the husband (wife) had fallen ill in the last 4 weeks preceding the date of the survey. Most of variables that capture the taste for consumption and leisure like education are time invariant and so drop out of the analysis.

Other variables: To capture the relative productivities of the husband and wife at farm work, I include agricultural wages. I use information on the agricultural and non-agricultural wage collected in the survey. The agricultural wage information was elicited from a knowledgeable person in the village. He reported usual wages for men and women for three agricultural activities:clearing the land, planting, and harvesting. Agricultural wages (See Table 4) don't vary a lot between husband and wife. There is also very little inter-survey round variation.[9] I acknowledge that labor markets are thin (a fact supported by the data)

[9] I use wages for clearing the land for my regressions as they seem to vary both across survey rounds and across husband and the wife.

in this part of the world. The incidence of off-farm employment and hired labor is very low albeit non-zero. At this point I don't have anything to repudiate these wage measures. I include several variables that potentially affect the relative productivities of the husband and the wife. These include information on the amount of rainfall and the size of the land owned by the household.[10] In Kagera, rainfall is bimodal. The 'short' or 'vuli' rains occur between March to May while 'long' or 'masika' rains arrive between the month of October to December. The rainfall data was collected by Tanzanian Meteorological Agency and is publicly available at http://edi-global.com/research/khds/introduction.htm.[11] To get a measure of how the rains affected the individual household, I interact total land of the household with the corresponding rainfall shock in that district for that year. The rainfall shock is the deviation of the actual rainfall in that year from its long run average value, normalized by standard deviation. So, if Z is the short rain shock, Z=$(\frac{Z_t - Z_{average}}{\sigma_Z})$. The weekly labor allocations may also be affected by the agricultural calender, with some weeks slack and others taut. I include the survey month to capture this. I also control for the sickness status and mortality status of the household members and relatives. In regressions that test if land ownership (male and female crop losses) affects resources allocation within the household, the total value of crop lost (total size of household land) is included as an additional time varying factor. The descriptive statistics are presented in table 3.

4.2 How does the special nature of the survey affect the empirical estimation?

The outcome variables of interest are leisure ratio and consumption ratio. The stratification in KHDS is due to exogenous variables, sickness and mortality status of the households and geography of the region. Hence, this does not constitute a choice based sampling. Intuitively,

[10] $\frac{f'_{L_{HF}}}{f'_{L_{WF}}} = \omega e^x$, where x includes other variables that affects relative productivities. If labor markets are perfect, relative wages will contain all the information and none of these x variables should be significant.

[11] I would like to thank Kathleen Beegle for directing me to the rainfall data.

in this study the treatment group is a couple with low levels of female land (or low female crop loss share) in one period and the control group is the same couple in another period with a higher female land share (or high female crop loss share).

Consistency requires that unmeasured determinants of leisure and consumption ratios be uncorrelated with land and crop loss variables. Crop loss was concentrated in round 1 and 2 and affected the Kagera region. This was an exogenous shock that should not be correlated with household heterogeneity. However, the share of male and female crops lost could vary between households and this may depend on unobserved factors. Here, the panel structure of the dataset is very helpful. The fixed effect specification controls for any time invariant factor that might be correlated with X variables. This fact is also discussed in Verbeek, Nijman (1990). The equation below summarizes the basic idea. We want the expected value of the error term be zero conditional on the X's, the covariates effecting the leisure and consumption ratio and Z's, the covariates affecting the probability of being present in the panel survey. The Z's include factors like sickness status and mortality status of the household. Here λ is the term that corrects for the stratified sampling structure the survey. But since the high risk households are over-represented in all the four rounds (based on the exogenous variables in the enumeration round), this term is wiped out by the fixed effects.

$$E(y_{it}|X_{it}) = X_{it}\beta + \gamma\lambda(Z_i\delta) + \epsilon_{it} \tag{12}$$

To get an idea of how different the high and low risk households are based on outcome variables and the right hand side variables, I conduct a means test (see table 2).The table suggests that on an average the high and low risk households are similar to each other.

The land variables change due to inheritance or disinheritance. Hence, we expect them to be related to death of household members and relatives. Once again the household fixed effects control for any time invariant correlation between X and unmeasured factors. To control for time variant factors I use a rich specification of sickness and mortality experiences of the households.

4.3 Land Ownership and relative leisure ratio

Table 9 reports fixed effect model estimates of regressing the ratio of the leisure time of the husband to his wife on land variables and other relevant covariates. The estimates reported in col [1] and [2] are those from the biggest sample(high risk as well as low risk households). For results reported in col[2], the additional regressors include the interaction of the low risk household dummy with the land variables. The low risk dummy takes a value of 1 if the household had experienced prime aged adult mortality or chronic sickness of adult members during the enumeration round. this variable is constructed using data on the enumeration round which is provided in the KHDS. According to column [1] estimates, when an acre of male land is redistributed in favor of the wife, the relative leisure ratio of the husband falls by 5.4%. Note that the average relative leisure ratio of the husband in the sample is 1.12; the average size of male land is 4.39 acres while the average size of female land is only 0.06 acres. (table 3). The coefficient estimates suggest that redistributing an acre of male land in favor of female members, would move the relative leisure ratio of the husband to 1.06 on an average. This is suggestive of a bargaining model. A rise is the share of the female land within the household improves the wife's relative bargaining strength and hence her relative leisure time. To get a better understanding of how time allocation changes within the household, table 12 presents estimates of fixed effect regression of husband and wife's time devoted to housework and farm work on the land variables. The results reveal that a rise in female land ownership is associated with a rise in husband's farm work and a fall in wife's housework. The coefficient estimates imply that transferring an acre of male land in favor of the female members would cause husband's farm work to rise by 1.9 hours per week and reduce wife's housework by 2.4 hours per week. If total market time (farm work plus any other income earning work) is used instead of farm work, we find that the husband's market work rises by 3.22 hours while wife's market work does not change significantly just as in the case of her farm work. According to KHDS sample, the raw gap in the weekly leisure time of the husband and wife is around 12 hours.[12] The regression results suggest that land redistribution can have significant impact on the allocation of leisure time within the household.

In col [2], the interaction variables are introduced as additional regressors to test if low risk households respond differently from high risk households, who dominate the sample. The coefficient estimate on female land remains roughly the same due to the small fraction of low risk households. For results reported in col [3] and [4], the sample is restricted to low risk and high risk households respectively. Female land ownership has a bigger impact on relative leisure ratio of the husband for the low risk households than the high risk households. For the low risk group, if an acre of land moves from male to female land category, the relative leisure ratio fall by 8.08% (a fall in the relative leisure ratio from 1.13 to 1.03). However, since most of the households belong to the high risk category, I use the entire sample for regressions that follow, while acknowledging that the results are more representative of the high risk group.

One concern associated with the use of land variables is measurement error in the size of different categories of land. To address this issue, col [1] Panel A of table 13 uses dichotomous variables for the different categories of land within the housheold instead of a continuous variable. The measurement error, if any, in whether the wife owns a plot of land will be much smaller than in the case of the exact size of that plot of land. The coefficient on female land is larger and is also significant.

Another empirical issue is that of time varying omitted variables that might confound the results. One such set of variables is future sickness. The husband and the wife are likely to have a better sense of the true health status of the spouse than the econometricians. For instance, the wife might know that the husband's health is likely to deteriorate in the next few month and this might affect her bargaining power. To control for this, I introduce

[12]The mean value of time devoted different activities are much lower than other parts of the world. However, it is a common feature of several African countries. See for instance, Gender, Time use and Poverty in Sub-Saharan Africa, world bank working paper 73

future sickness status of the husband and the wife as additional regressors (col [1] Panel B of table 13). I also include a richer specification (by disaggregating deaths by the sex of the expired individuals) of the identity of the deceased relatives and household members. The results are roughly the same as before. A one acre rise in female land relative to male land reduces the relative leisure ratio of the husband by 5.5%.

4.4 Private consumption expenses and land ownership

In table 10, I report fixed effect regression results of ratio of consumption expenses of the husband to his wife on the land variables and other regressors. In col [1], the dependent variable consists of ratio of private expenditure on all categories of goods except medicines. The private consumption expenses of the spouses suffer from the 'infrequency of purchase' problem. Around 5% of the men and 10% of the women in the final dataset did not purchase any thing for their private consumption. If either the husband or the wife does not buy anything between the two consecutive survey rounds, then those observations drop out of the sample as these involve corner solutions. I lose around 13% of the sample due to this problem. The results in col [1] suggest that land ownership variables do not affect the allocation of private expenditures within the household. The introduction of interaction of land variables with low risk household dummy leaves the results unchanged, except that now 'other' types of land in the household seems to reduce the relative expenditure of the husband. To get a better understanding of how the household allocation of consumption expenditures responds to changes in land ownership, I disaggregare the dependent variable into clothing and non-clothing expenses. In col [3], [4] the dependent variables are expenditures on clothing while col [5], [6] report regression estimates on non-clothing items. These regression results suffer infrequency of purchase problem in a serious way. The results in this table, col [3], suggest that a rise in the relative female land within the household reduces husband's relative clothing expenses. The result is robust to the inclusion of the interaction of the low risk household dummy with the land variables. On the other hand, the non-clothing expenditures increase with a rise in the share of female land within the household, although the results are sensitive to the inclusion of the land and low risk household interaction variables. The non-cloth items include candles, newspapers, motorized transport, batteries, soaps etc. Many of these items have public goods characteristics. For instance, the data on candles reveals that for husbands, zero expenses are reported in only 20% of the cases whereas for the wives the corresponding number is 83%. It is also possible that social norms dictate that some of these expenditures be incurred by men only. For instance, in the dataset the expenditures on motorised transport are observed only for men, even though one cannot rule out that the wife gets to ride the vehicle as well. I use the aggregate variable, however, as all the expendiures were reported as private expenses.

One might argue that the ratio of expenses is a bad specification in the presence of zero expenditures. To deal with this problem, I assume that the dependent variable is $\log\frac{(1+C_H)}{(1+C_W)}$ instead of $\log\frac{(C_H)}{(C_W)}$. This ad-hoc specification allows me to use the entire sample. In col [7], [8], I report results for this specification, i.e it includes cases where either the husband or the wife incurred zero expenditures. The estimates reveal that after controlling for the interaction variables, the land variables do not have a significant impact on the relative allocation household expenses. In table 13 col[2], I explore if the results are sensitive to alternate specification of land ownership variables or the inclusion of a richer set of sickness variables. The land variables do not affect consumption allocation in a significant way even in this set of regressions.

To test the coefficient restrictions implied by the assumption of Pareto efficiency, the leisure and consumption ratio equations were estimated in a SUR framework after applying the within-estimation transformation to the data. Table 15 reports the results of coefficient restrictions tests. The first three rows test for the perfect pooling of land resources within the household. The assumption is rejected for female land. The collective model restrictions cannot be ruled out.

4.5 Crop losses and their impact on leisure and consumption ratio

In section, I explore the effect of another set of distributional factors- the relative crop losses of male and female crops. Since coffee is one of the crops whose proceeds are controlled by men, the sample used here is restricted to the region that is favorable for the growth of coffee. The results in col [1] and [2] (table 11) suggest that crop losses do not affect allocation of leisure time within the household. The low and high risk households, however, differ significantly in their response to crop losses. Relative to losses of 'other' crops (see table 5), which comprise of mainly female crops, the loss of any other type of crops reduces the relative consumption ratio of the husband. In col [5], [6], the estimation sample comprises of the high risk and low risk group respectively. Note that these coefficients are multiplied by 100000. Thus, according to col [6], if a 100 TSH (Tanzanian shilling) were to be lost through coffee crop instead of other crops, then the relative consumption ratio of the husband would fall by 3.149% (from an average value of 1.83 to 1.77). A 100 TSH loss of cooking banana and maize relative to other crops would reduce the relative consumption ratio of the husband by 2.028% and 1.906% respectively.

The results suggest that coffee losses always reduce husband's relative expenses, although the variable is not significant for the high risk households. For the other crops, the response of low risk households is always greater than the high risk households. Households that are potentially afflicted with HIV/AIDS seem to treat money losses from any source in an identical way but not the low risk households. The restrictions implied by the perfect pooling of crop losses cannot be rejected for the sample as a whole (see table 15). This implies that for analyzing the household responses to crop losses the 'unitary' version of the collective model is relevant.

5 Conclusion

Previous studies have found that in a rise in one's relative wage ratio is associated with increases in one's relative consumption expenditure within the household. This is supportive of the bargaining version of the collective model of household decision making. Most of these papers are focused on the developed countries. In this paper I use KHDS to investigate if a rise in female land relative to male land increases wife' relative leisure time in rural Tanzania. I also explore the impact of different types of crop losses, which potentially affect men and women differently on the relative leisure and consumption ratio of the husband. The results suggest that a rise in female land relative to male land reduces the relative leisure time of the husband. The land shares do not affect the relative allocation of consumption expenditures within the household. The responses of high risk and low risk households to crop losses are not similar. The results suggest that crop losses are pooled more effectively than land resources in the sample which is dominated by the high risk households.

The lack of a significant increase in wife's consumption expenditures following a rise in the share of female land may be driven institutional constraints associated with coffee cultivation. The Tea/Coffee Boards deal exclusively with men. Hence, women's ability to control proceeds from coffee may be limited following a rise in the share of female land. Men plausibly work more to compensate the fall in household public goods by increasing their consumption expenditures.

Table 2: Means Test between low risk (1) and high (2) households

Y=log relative	pValue	N1	N2	mean1	mean2
leisure	0.51	252	1414	0.10	0.09
expenditure	0.11	224	1216	-0.23	0.07
X					
TotalValue	0.99	252	1415	6558.45	6544.60
CoffeeVal	0.57	251	1412	950.00	1169.14
BeanVal	0.75	251	1412	557.85	612.90
MaizeVal	0.30	251	1412	1347.09	688.03
CkBananaVal	0.98	251	1412	3074.86	3123.34
OthCropsVal	0.98	251	1412	3074.86	3123.34
X					
TotalLand	0.76	252	1415	6.29	6.15
MaleLand	0.33	251	1414	4.11	4.43
FemaleLand	0.78	251	1414	0.07	0.06
JointLand	0.14	252	1415	1.59	1.04
OtherLand	0.20	251	1414	0.58	0.67

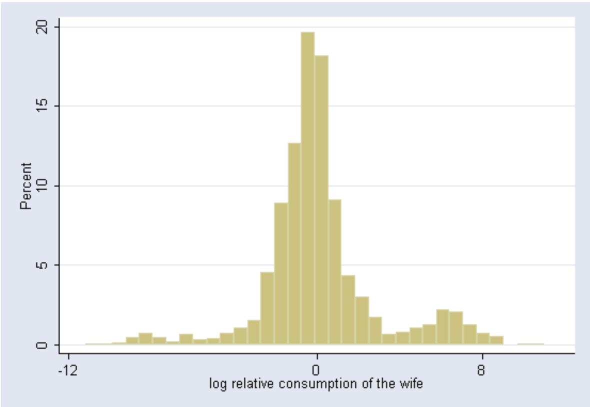

Figure 1:

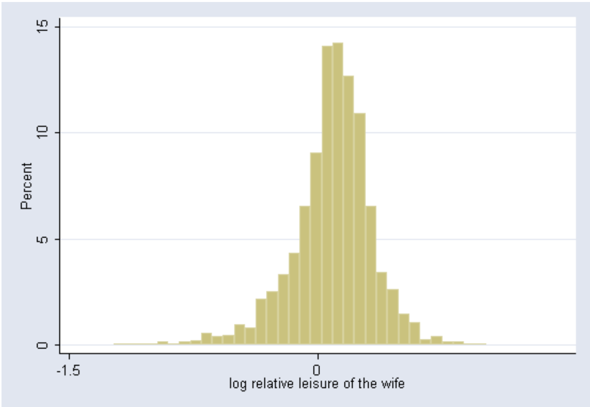

Figure 2:

Table 3: Descriptive Statistics

Y	N	mean	std. dev
log of leisure ratio	1662	0.088	0.246
log of expenditure ratio	1436	0.305	1.402
leisure ratio	1663	1.123	0.268
expenditure ratio	1436	3.206	19.837
X's			
total value of crop loss	1663	6546.237	28079.470
value of coffee crop loss	1661	1126.591	5638.503
value of bean crop loss	1661	605.048	2907.929
value of maize crop loss	1661	788.452	4830.229
value of Ck. banana crop loss	1661	3115.557	20796.810
value of other crops crop loss	1661	774.711	5893.679
total land in acres	1663	7.094	37.320
female land in acres	1663	0.062	0.347
jointly held land in acres	1663	2.010	37.183
other land in acres	1663	0.656	1.104
male land in acres	1663	4.389	5.066
no. of household members who died in between the rounds	1663	0.149	0.356
no. of relatives who died in between the rounds	1663	0.673	0.469
husband sick dummy	1663	0.624	0.485
wife sick dummy	1663	0.629	0.483
log average male wage to female wage	1663	0.141	0.766

Table 4: Wages for agricultural activities in TSH per day

	Clearing Land		Harvest		planting	
district level wages	women	men	women	men	women	men
wave 1	338.2696	340.7893	341.1355	341.1355	331.2756	335.6851
wave 2	332.5168	334.6896	335.0037	335.0037	326.726	330.3909
wave 3	315.588	317.8745	317.7525	317.7525	308.8617	312.7184
wave 4	310.1808	312.1279	312.5049	312.5049	303.7506	306.8661
Village level wages	women	men	women	men	women	men
wave 1	337.6923	340.2387	342.2376	342.2376	331.5633	336.0916
wave 2	330.615	332.8342	334.4568	334.4568	325.462	329.2663
wave 3	314.5	316.8056	317.7907	317.7907	308.3898	312.3446
wave 4	308.8889	310.8579	311.8009	311.8009	302.8898	306.0944

Table 5: Male and Female Crops

Crops	Banana	Coffee	Beans	Maize	avocado,mangoes,pawpaw, citrus fruits, pineapples, other fruits tomatoes, onions, eggplant, cabbage other vegetables, cassava, wood sorghum
type	Male	Male	Female	Female	Primarily Female
Source: Tibaijuka 1984, Teesha 1998					

Table 6: Distribution of crop losses across the rounds

	Wave 1		Wave 2		Wave 3		Wave 4	
Any Loss?	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
No	162	21.95	411	55.69	687	93.09	677	91.73
Yes	576	78.05	327	44.31	51	6.91	61	8.27
Total	738	100	738	100	738	100	738	100

Table 7: Distribution of coffee and bean losses within the household

All Waves							
	Lost Beans?				Lost Beans?		
Lost coff?	No	Yes	Total	Lost cooking banana?	No	Yes	Total
No	2,316	287	2,603	No	2,292	211	2,503
Yes	143	206	349	Yes	167	282	449
Total	2,459	493	2,952	Total	2,459	493	2,952
Wave 1							
	Lost Beans?				Lost Beans?		
Lost coff?	No	Yes	Total	Lost cooking banana?	No	Yes	Total
No	310	156	466	No	302	121	423
Yes	101	171	272	Yes	109	206	315
Total	411	327	738	Total	411	327	738
Wave 2							
	Lost Beans?				Lost Beans?		
Lost coff?	No	Yes	Total	Lost cooking banana?	No	Yes	Total
No	574	99	673	No	553	57	610
Yes	31	34	65	Yes	52	76	128
Total	605	133	738	Total	605	133	738

Table 8: Change in land size between the rounds

Change	Female Land		Male Land		Joint Land	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
	w2-w1		w2-w1		w2-w1	
decreased	215	29.05	106	14.32	212	28.65
unchanged	232	31.35	544	73.51	395	53.38
increased	293	39.59	90	12.16	133	17.97
Total	740	100	740	100	740	100
	w3-w2		w3-w2		w3-w2	
decreased	237	32.03	78	10.54	129	17.43
unchanged	261	35.27	557	75.27	465	62.84
increased	242	32.7	105	14.19	146	19.73
Total	740	100	740	100	740	100
	w4-w3		w4-w3		w4-w3	
decreased	227	30.68	90	12.16	163	22.03
unchanged	250	33.78	546	73.78	429	57.97
increased	263	35.54	104	14.05	148	20
Total	740	100	740	100	740	100
wi-wj means between waves i and j						

Table 9: Fixed effect estimates of leisure ratio

Y=	$\ln(\text{leisure}_H/\text{leisure}_W)$	$\ln(\text{leisure}_H/\text{leisure}_W)$	$\ln(\text{leisure}_H/\text{leisure}_W)$	$\ln(\text{leisure}_H/\text{leisure}_W)$
X	[1]	[2]	[3]	[4]
total hh land (in acres)	0.00322	0.00375	-0.00566	0.00617**
	[0.00225]	[0.00252]	[0.00382]	[0.00250]
female land (in acres)	-0.0547**	-0.0531**	-0.0808**	-0.0539**
	[0.0223]	[0.0248]	[0.0359]	[0.0248]
land held jointly (in acres)	0.000474	2.53E-05	0.00704	0.000629
	[0.00214]	[0.00269]	[0.00529]	[0.00281]
other land (in acres)	0.00154	0.00224	-0.00782	0.00421
	[0.00650]	[0.00733]	[0.0184]	[0.00708]
total land *low risk		-0.00377		
		[0.00438]		
female land *low risk		-0.0211		
		[0.0401]		
joint land *low risk		0.00256		
		[0.00420]		
other land *low risk		-0.0145		
		[0.0184]		
Observations	1662	1662	250	1412
Number of households	509	509	76	433
R-squared	0.073	0.074	0.297	0.054

NOTES: (1) All the regressions include year and month dummies. Standard errors reported in []
(2)The columns [1], [2] report results from the entire sample but [2] includes interaction with low-risk household dummy.
(3)The columns [3], [4] report results from the high-risk and low risk sample respectively.

Table 10: Fixed effect estimates of different category of consumption expenses

Y=ln(y_H/y_W) y is	All consump expenses	All consump expenses	Clothing expenses	Clothing expenses	non-Clothing expenses	non-Clothing expenses	All consumption expenses	All consumption expenses
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
total hh land (in acres)	-0.0292*	-0.0313	-0.0282**	-0.0156	0.00181	-0.00951	-0.0242	-0.0216
	[0.0171]	[0.0200]	[0.0142]	[0.0191]	[0.0180]	[0.0212]	[0.0287]	[0.0333]
female land (in acres)	0.061	0.0579	-0.292*	-0.329*	0.228	0.305*	0.430*	0.367
	[0.145]	[0.150]	[0.150]	[0.176]	[0.162]	[0.159]	[0.237]	[0.246]
joint land (in acres)	0.0137	0.00532	0.0256**	0.0153	0.0207	0.0114	0.0331	0.032
	[0.0130]	[0.0169]	[0.0123]	[0.0151]	[0.0201]	[0.0291]	[0.0250]	[0.0290]
other land (in acres)	-0.0194	0.00585	0.058	0.0447	-0.0296	-0.0155	-0.0179	-0.00199
	[0.0423]	[0.0440]	[0.0753]	[0.0872]	[0.0507]	[0.0546]	[0.0744]	[0.0810]
total land *low risk		-0.00392		-0.0409		0.0266		-0.0169
		[0.0282]		[0.0267]		[0.0357]		[0.0534]
female land *low risk		-0.176		0.217		-0.732		0.522
		[0.603]		[0.344]		[0.558]		[0.878]
joint land *low risk		0.0247		0.0286		0.00988		0.00702
		[0.0244]		[0.0222]		[0.0369]		[0.0409]
other land *low risk		-0.297*		-0.0126		-0.154		-0.171
		[0.175]		[0.172]		[0.173]		[0.286]
Observations	1436	1436	812	812	1087	1087	1662	1662
Number of households	496	496	400	400	459	459	509	509
R-squared	0.039	0.044	0.064	0.069	0.04	0.046	0.029	0.031

NOTES: All the regressions include year and month dummies. Std errors in []

Table 11: Crop Shocks

$Y=\ln(y_H/y_W)$	leisure ratio	leisure ratio	pvt exp ratio	pvt exp ratio	pvt exp ratio	pvt exp ratio
X	[1]	[2]	[3]	[4]	[5]	[6]
tot value of crop lost	0.0652	0.0737	-0.221	-0.38	-0.385	20.15**
	[0.0838]	[0.0862]	[0.601]	[0.602]	[0.607]	[7.635]
value of coffee lost	0.0831	0.077	-1.943*	-1.674	-1.769	-32.48***
	[0.142]	[0.154]	[1.119]	[1.136]	[1.165]	[11.05]
value of bean lost	0.723	0.605	1.895	1.561	1.827	-14.87
	[0.599]	[0.667]	[2.852]	[3.161]	[3.163]	[18.83]
value of maize lost	-0.177	-0.182	-0.264	2.583	2.738	-20.91**
	[0.192]	[0.300]	[0.994]	[3.092]	[3.080]	[8.254]
value of Ck Banana lost	-0.0042	0.0114	0.145	0.163	0.18	-20.13**
	[0.0913]	[0.0975]	[0.656]	[0.671]	[0.672]	[8.039]
tot value of crop lost*low risk hh dummy		-0.915		20.30***		
		[1.157]		[6.561]		
value of coffee lost*low risk hh dummy		1.283		-26.20***		
		[1.601]		[9.518]		
value of bean lost*low risk hh dummy		1.518		-27.84*		
		[2.738]		[15.80]		
value of maize lost*low risk hh dummy		0.81		-22.14***		
		[1.307]		[7.849]		
value of Ck Banana lost*low risk hh dummy		0.822		-20.03***		
		[1.200]		[6.846]		
Observations	1177	1177	1019	1019	884	135
Number of household	360	360	350	350	304	46
R-squared	0.053	0.055	0.055	0.067	0.059	0.309

NOTES: (1) All the regressions include year and month dummies. Standard errors reported in []

Table 12: Fixed effect estimates of farm work, market work and housework

Y=	husband's farm work	wife's farm work	husband's housework	wife's housework	husband's market work	wife's market work
total hh land (in acres)	-0.0791	0.0256	-0.180***	-0.166	-0.495***	-0.107
	[0.104]	[0.111]	[0.0599]	[0.108]	[0.163]	[0.138]
female land (in acres)	1.926**	-0.92	0.884	-2.405*	3.223***	-0.404
	[0.807]	[0.905]	[0.704]	[1.328]	[1.533]	[0.889]
land held jointly (in acres)	-0.0433	0.209*	0.0807	0.197*	0.112	0.172
	[0.113]	[0.112]	[0.0645]	[0.112]	[0.156]	[0.138]
other land (in acres)	-0.213	0.189	0.317	0.696*	0.6	0.467
	[0.348]	[0.337]	[0.223]	[0.402]	[0.532]	[0.424]
mean of Y	4.16	22.39	12.37	15.50	25.64	18.86
Observations	1663	1663	1663	1663	1663	1663
Number of household	509	509	509	509	509	509
R-squared	0.059	0.072	0.05	0.057	0.067	0.087
NOTES: (1) All the regressions include year and month dummies. Standard errors reported in []						

Table 13: Robustness Checks

Y=	$\ln(\text{leisure}_H/\text{leisure}_W)$	$\ln(C_H/C_W)$
Panel A	[1]	[2]
total hh land (in acres)	0.00345*	-0.0258*
	[0.00187]	[0.0152]
female land dummy	-0.0615*	0.0847
	[0.0328]	[0.227]
joint land dummy	-0.00498	-0.0618
	[0.0170]	[0.108]
other land dummy	-0.0163	0.0812
	[0.0153]	[0.111]
Observations	1662	1436
Number of households	509	496
R-squared	0.071	0.039
Y=	$\ln(\text{leisure}_H/\text{leisure}_W)$	$\ln(C_H/C_W)$
Panel B	[1]	[2]
total hh land (in acres)	0.00245	-0.0389*
	[0.00258]	[0.0234]
female land (in acres)	-0.0557**	0.271
	[0.0281]	[0.178]
land held jointly (in acres)	0.000527	0.0141
	[0.00266]	[0.0182]
other land (in acres)	-0.00049	-0.106
	[0.00967]	[0.0730]
Observations	1144	999
Number of households	446	435
R-squared	0.098	0.073

NOTES: (1) All the regressions include year and month dummies. Std errors in []
(2)The columns [1], [2] in panel A replace continuous variables for female, joint and other land with corresponding indicator variables.
(3)The columns [1], [2] in panel B include future sickness and sex of recently deceased members and relatives as additional regressors.

Table 14: Robustness Checks

Y=ln(y_H/y_W)=	leisure ratio	exp ratio
X		
tot value of crop lost	0.0736	-0.0313
	[0.113]	[0.790]
value of coffee lost	0.00907	-1.84
	[0.183]	[1.312]
value of bean lost	0.783*	-0.125
	[0.447]	[3.343]
value of maize lost	-0.329	0.205
	[0.202]	[1.536]
value of Ck Banana lost	-0.0247	-0.0172
	[0.121]	[0.852]
Observations	809	705
Number of household	313	306
R-squared	0.087	0.096
NOTES: (1) All the regressions include year and month dummies. Std errors in []		

Table 15: Testing coefficient restrictions

	chi sq state	p-value
	land ownership	
$b^{leis}_{female} = b^{exp}_{female} = 0$	7.362	0.025
$b^{leis}_{joint} = b^{exp}_{joint} = 0$	0.643	0.725
$b^{leis}_{other} = b^{exp}_{other} = 0$	0.134	0.935
$b^{leis}_{female} = b^{exp}_{female}$	0.797	0.372
$b^{leis}_{joint} = b^{exp}_{joint}$	0.239	0.625
$b^{leis}_{other} = b^{exp}_{other}$	0.040	0.841
	crop losses	
$b^{leis}_{coffee} = b^{exp}_{coffee} = 0$	4.05	0.13
$b^{leis}_{beans} = b^{exp}_{beans} = 0$	3.98	0.14
$b^{leis}_{maize} = b^{exp}_{maize} = 0$	1.27	0.53
$b^{leis}_{CkBanan} = b^{exp}_{CkBanan} = 0$	0.13	0.94

6 Appendix

6.1 A.1

$$\mathcal{L} = \max_{C_H, C_W, C_Z, L_{HF}, L_{HZ}, L_{WF}, L_{WZ}} [\theta_H ln(C_H) + \tau_H ln(L_{HR}) + Z] + \mu[\theta_W ln(C_W) + \tau_W ln(L_{WR}) + Z]$$

subject to $C_H + C_W + C_Z = ph(L_{HF}, L_{WF}, K) + y_h + y_w$ and time constraints

Let Λ be the Lagrange multiplier. The FOC:

$$C_H : \frac{\theta_H}{C_H} - \Lambda = 0 \tag{13}$$

$$C_W : \frac{\theta_W \mu}{C_W} - \Lambda = 0 \tag{14}$$

$$L_{HF} : -\frac{\tau_H}{L_{HR}} + \Lambda h'_{L_{HF}} = 0 \tag{15}$$

$$L_{WF} : -\frac{\tau_W \mu}{L_{WR}} + \Lambda h'_{L_{WF}} = 0 \tag{16}$$

$$\text{From (13) and (14):} \frac{\theta_H C_W}{\mu \theta_W C_H} = 1 \text{ OR} \frac{C_W}{C_H} = \theta\mu; \text{where } \theta = \frac{\theta_W}{\theta_H} \tag{17}$$

$$\text{From (15) and (16):} \frac{\tau_H L_{WR}}{\mu \tau_W L_{HR}} = \frac{h'_{L_{HF}}}{h'_{L_{WF}}} \text{ OR} \frac{L_{WR}}{L_{HR}} = \tau\mu\omega e^x; \text{where } \tau = \frac{\tau_W}{\tau_H} \text{ and } \omega = \frac{\omega_H}{\omega_W} \tag{18}$$

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