Constraints to Agricultural Development: Input Use in Households Under Non-Separability

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Highlights

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- I estimate household labor demand functions using panel data from Tanzania in sub-Saharan Africa including estimating the effects of managerial characteristics on plot-level labor demand

- In a novel contribution to the literature, I estimate separate demand functions for 6 separate labor categories: family labor, hired labor, preparatory (non-harvest) labor, harvest labor, adult men's labor, and adult women's labor. Using Wald tests for equality of coefficients the tests reject, indicating the presence of different demand functions for different labor types

Constraints to Agricultural Development: Labor Types and Labor Use in Households Under Non-Separability

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Abstract

This paper analyzes labor market frictions and evaluates the demand for different labor types in Tanzanian agricultural labor markets. Using panel data from the World Bank's Living Standards Measurement Study (LSMS) I estimate labor demand functions separately for different types of labor (family, hired, prep, harvest, men's and women's) and find significant differences in the coefficients on the estimated labor demand functions. Dividing labor into appropriate categories and estimating demand for preparatory and harvest labor separately is critical since agricultural labor demand is highly-seasonal. Plots of land managed by household heads receive a disproportionate share of men's labor. Plots managed by women receive a lower share of the labor applied by adult men in the household and a higher share of the labor applied by adult women involved in farming. The result indicates intra-household inefficiency resulting from gender and social norms and suggests potential for gains from more extensive cooperation and coordination among household members.

Keywords: Agricultural Development, Labor Markets, Agricultural Labor Markets

JEL: J1, J43, O12, Q10, Q12, Q13, Q16

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1. Introduction

In this paper I analyze determinants of labor demand on smallholder farms in Tanzania utilizing the framework of the separation hypothesis which was first examined empirically by Benjamin (1992). The separation hypothesis states that household productive activities and consumption may be modeled separately as long as production does not rely on household-level parameters. In order to estimate consumption and production separately farm labor decisions must not be linked to household characteristics. In this way we can analyze households and farms that are not price takers in the context of complete markets where earlier theoretical models assumed complete markets (LaFave and Thomas, 2016).

The primary purpose of this analysis is to provide panel data evidence of the differential effect of plot, manager and household characteristics on plot-level labor demand. Relatively few papers in the development literature have explored the idea of differential effects of household, plot and managerial characteristics on family and hired labor (Frisvold, 1994; Deolalikar and Vijverberg, 1983). To the best of my knowledge I provide the first panel-data evidence regarding differences in demand for different labor types.

I dis-aggregate and compare coefficients of separately-estimated labor demand functions along 3 distinct dimensions: family labor versus hired labor, preparatory period (pre-harvest) and harvest period and adult men's labor versus adult women's labor. Wald tests for the equality of coefficients between different labor types strongly indicate the existence of coefficients of different magnitude for different labor types. The tests indicate labor rationing is a primary source of separation although I am unable to rule out low quality of hired labor and worker monitoring issues as other drivers of separation.

It is a well-known result that without supervision hired workers may not apply intensive labor (shirk) when the product of their work is unobserved by the farmer or manager (Foster and Rosenzweig, 1994). This dynamic occurs when worker output is not directly observable and thus the effect may be mitigated in the harvest season when output (amount of crop harvested) can be directly observed by the plot manager or owner. I examine this fact by testing for equality of coefficients between family labor demand functions and hired labor demand functions and find important differences in demand for family versus hired labor. Wald tests indicate that farmers who invest by supplying organic fertilizer to their fields are less likely to utilize hired labor. This may be evidence of a trust issue between managers and workers. This dynamic is hypothesized to be a primary driver of separate effects on labor demand - in general farmers appear to to be willing to rely on their family members more than they do the current stock of hired laborers.

In addition to the observability of labor, importantly, pre-harvest or preparatory labor tasks such as land preparation and tillage, weeding and fertilizing are distinct from harvesting tasks. To the best of my knowledge no paper tests for equality of labor demand coefficients in the harvest and preparatory periods separately. For these reasons the labor demand functions are estimated separately here and the magnitude of the coefficients is compared for preparatory and harvest periods using Wald tests. In many cases the Wald test rejects equality of coefficients for the labor demand functions bolstering the case for separate labor demand functions.

In an attempt to clarify the channels of separation I estimate labor demand functions separately for labor applied to plots by adult men and labor applied to plots by adult women. Important distinctions arise such as the fact that women have to work more days on their plots in the absence of support from adult men family members. Although this is indicative of productive inefficiency if we take into account the behavioral component this indicates that there may be gains from more extensive planning and cooperation within the household.

There are legitimate concerns regarding the endogeneity of the number of adults in the household with respect to agricultural labor demand. I incorporate exogenous village-level rainfall measures in the form of rainfall shocks: droughts and high-rainfall periods. In most cases the Wald test rejects equality of coefficients indicating that positive rainfall shocks have a different effect on hired labor than family labor, a different effect on harvest labor than preparatory labor and different effect on labor supplied to plots by adult men within the household versus labor supplied to plots by adult women. As a robustness check I also remove all labor days provided to the household by recently-added household members. This change only alters the coefficients on the number of household members though other sources of separation remain.

LaFave and Thomas (2016) reject separation due to the effects of household composition on labor demand. The separation tests I use include a full set of controls as well as household fixed effects. The tests reveal that household and managerial characteristics are an important correlate of labor decisions particularly the manager of the plot being the household head. Consistent with the findings of other authors in the literature I reject separation between production and consumption in the context of Tanzanian agricultural households.

The analysis is supported by high-quality nature of the Tanzanian Living Standards Measurement Survey (LSMS) farm and plot-level data including soil quality measures, plot slope controls and soil type variables as well as variables measuring managerial human capital. The plot-level details are a key characteristic of this dataset as estimates which exclude managerial human capital or soil characteristics could be plagued by omitted variable bias. The panel dimension of the dataset allows the utilization of household-specific fixed-effects. Critically, this permits me to control for time-invariant household-specific heterogeneity including accounting for differences in taste for farm work among households.

An important point is that, with the notable exception of Dillon et al. (2019), panel data separation analysis has predominantly focused on southeast Asia. Compared to Indonesia, the country used by both Benjamin (1992) and LaFave and Thomas (2016), Tanzania has a relatively inactive agricultural labor market with a smaller percentage of farms hiring-in agricultural labor (43%). The total number of hired days per acre is quite low at around 2.5 hired-labor-days per acre in Tanzania while in Indonesia 95% of farms hire any labor and farmers utilize about 90 days of hired labor per acre on average (Benjamin, 1992). Central Indonesia is fairly homogenous with respect to agro-ecological zones and population density while the geographic breadth and variety of Tanzania is substantial. Tanzania encompasses many agro-ecological zones. It shares borders with 8 countries[1] and enjoys broad het-

[1]Kenya, Uganda, Rwanda, Burundi, Democratic Republic of Congo, Zambia, Malawi and Mozam-

erogeneity in geophysical characteristics including mountains, vast savannah, dense jungle in the western part of the country and lakes in the northwest and southwest parts of the country.

An example of a potential policy recommendation to stimulate hired labor markets would be to provide free or subsidized transportation between population dense urban areas and rural areas in harvest times or to facilitate cross-border movements of laborers in those periods. Policies which increase trust between the owners/managers and hired workers may also yield positive results. There is interesting new work using digital monitoring devices that might lower substantially the cost of monitoring (Kelley et al., 2021). Another example would be to offer credit to farmers for the purpose of alleviating working capital constraints allowing them to hire more labor from the market while permitting farm managers to spend more time supervising hired labor (Fink et al., 2014). Last, policies which promote inter-household cooperation and diminish ideas about traditional roles of women in society could lead to greater cooperation in production within the household.

2. Theoretical Background

Market failures are often the defining characteristics of rural markets (De Janvry and Sadoulet, 2006; Thorbecke, 1993). Analysis that considers households without an understanding of the constraints agricultural households face is potentially a fruitless exercise. Though rural agricultural households in developing economies face some particular constraints other themes from farms and farm-household dynamics apply

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in both developed and developing countries. An example is the well-known stylized fact that agricultural labor markets "tighten" during the harvest period when demand for laborers goes up.

Market prices and wages should function as indicators if markets are complete and efficient (Benjamin, 1992; Card et al., 1987). If this type of signalling mechanism is in operation it should lead to a detectable 'separation' between household productive and consumption activities. Benjamin (1992) identifies three sources of breakdowns in the labor market that lead to non-separation: (1) a binding constraint on off-farm employment (2) labor rationing and (3) differences in the returns to on-farm and off-farm employment. With respect to the first source very few Tanzanian households are engaged in salaried work outside of the primary sector. Tanzania has a low labor force participation rate (less than 60% for the LSMS sample) and relatively high official unemployment. Over 35% of households in the LSMS sample have an unemployed adult member. Households in our sample appear to face an environment with limited outside opportunities. I add a fourth source of separation: (4) gender norms and inefficient household non-cooperation.

Estimating the effect of the number of adults in the household or other household characteristics on plot-level labor demand goes directly to the question of labor rationing and whether households are reliant on family labor for household farm activities. If households rely on family labor holding constant a household's taste for agricultural labor this indicates separation that may be driven by labor rationing. Rationing could be seasonal: labor markets can be dormant in the preparatory period when few salaried jobs are available and farming tasks can be more easily divided over days. At harvest time required tasks need to happen within a tight window and at a moment when other farm households experience a surge in demand for labor. In nearly all of the labor demand regressions I can reject the non-reliance of household farms on family labor.

Demand for Labor Types

Whether labor hired from the market is comparable to family labor is an important question since a quality or skill differential between hired and family labor could indicate a source of separation. In this case farmers may be more reluctant to hire low-skilled workers or they may be constrained by unmotivated family laborers. Put differently if household members provide higher quality labor on the farm or vice-versa it is possible we would observe a stronger correspondence between household characteristics and labor use.

Labor Demand Equations

With respect to the estimations of plot-level labor demand the dependent variables are the log of family labor days and the log hired labor days. The regressions mirror those in LaFave and Thomas (2016) and take the following form for plot i in household h in wave t:

$$L^b_{iht} = \beta N_{iht} + \delta X_{iht} + \alpha_h + \epsilon_{iht} \tag{1}$$

where N is vector of household characteristics and X is a vector of other plot characteristics. b represents the labor type: family, hired, prep, harvest, men's and women's. The regressions all include a set of household dummies α_h.

3. The Setting and the Data

Tanzania is a country well-suited for agricultural production. Farming makes up a substantial portion of the activity of low-income households: 37% of men in the survey worked on their own farm last week compared to 39% of Tanzanian women. Tanzania straddles several agro-ecological zones and the dataset used in this paper is nationally representative meaning all agro-ecological zones are included in the analysis.[2] In the north around Lake Victoria and in the south-western part of Tanzania there are cool sub-humid tropic climates. Much of the southern and eastern as well as south-eastern parts of Tanzania are warm sub-humid tropical climate while a large central swath of Tanzania is characterized by warm and cool semi-arid tropical climate. This is an important dimension of heterogeneity within the data and is the reason for the inclusion of household fixed effects. Principal crops grown in Tanzania can be seen in table 1. They include maize, rice, sweet potatoes, cassava and sorghum among others with a higher share of farms growing peanuts in the second shorter cropping season. According to the LSMS data agriculture and livestock make up a substantial part of Tanzanian economic activity. Workers outside of the agricultural business are engaged in teaching, civil service or natural resource/extractive industries.

The primary data used are from the World Bank's Living Standards Measurement Survey (LSMS) instrument from Tanzania which includes a substantial agricultural

[2] a map of the agro-ecological zones can be found in the appendix

Long Rainy Season		Short Rainy Season	
Variable	Acres Planted	Variable	Acres Planted
Maize	19701	Maize	4211
Paddy	4346	Beans	1528
Beans	4161	Groundnut (Peanut)	579
Groundnut (Peanut)	3791	Sweet Potatoes	453
Sorghum	2503	Paddy	434
Cotton	2128	Cotton	416
Sweet Potatoes	2036	Cowpeas	259
Sunflower	1738	Green Gram	217
Cowpeas	1409	Sorghum	203
Pigeon Pea	1361	Cocoyams	113
Sesame	923		
Green gram	892		
Tobacco	692		
Bulrush Millet	645		
Chickpeas	548		
Bambara Nuts	496		
Cassava	334		
Cocoyams	298		
Finger millet	282		
Pumpkins	267		
Irish Potatoes	179		
Kiwi	161		
Tomatoes	148		
Cashewnut	102		

Table 1: Area Planted by Crop in Tanzania During the Survey Period

component captured over four waves from 2008-2015. All waves of data are freely available from several sources including the World Bank microdata website and the website of the Tanzanian National Bureau of Statistics. Villages, also known as enumeration ares, were drawn from the 2002 Tanzanian Population and Housing census with around 400 villages selected. A map detailing the villages can be found in the appendix. Data were collected on basic household demographic characteristics and the questionnaire included modules on labor, consumption and assets. Agricultural data were recorded separately but at the same sitting for the two agricultural seasons experienced in some parts of Tanzania.[3]

An important feature of this dataset is that records kept at the plot level are highly detailed. Information is included on plot ownership, seed type and purchases, fertilizer use, which household member manages the plot as well as which family members provide labor on the plot and how many labor-days they provided. The plot-level data also capture if any hired labor was applied and how much was applied. Descriptive statistics for household demographic characteristics as well as farm assets and other characteristics can be found in table 2.

Wave 1 of the survey was collected from September 2008 and the bulk of interviews were completed by September of the following year. The sample contains 5,126 plots held by 2,284 farm-households households. Wave 2 was collected from October 2010 with the majority of interviews completed by September 2011. The wave 2 sample contains 2,630 farm-households with 3,829 planted plots. Collection for wave

[3]For the two separate seasons, locally referred to as the 'short rainy' season and the 'long rainy' season, plot inputs and are recorded as one observation per year, though outputs are recorded separately and summed across seasons for our analysis.

	(1)	(2)	(3)	(4)	(5)
	obs	mean	sd	min	max
Age of Household Head	5,712	47.8	15.6	16	108
Household Head Completed Elementary School	5,712	0.95	0.21	0	1
Household Head Completed Secondary School	5,712	0.83	0.34	0	1
Gender Household Head	5,712	0.22	0.40	0	1
Number of Children	5,712	0.93	0.59	0	3.2
Number of Adult Members	5,712	1.31	0.44	0	3.1
Number of Senior Members	5,712	0.17	0.32	0	1.4
Number of Children*	5,712	0.93	0.59	0	3.2
Number of Adult Members*	5,712	1.22	0.49	0	3.0
Number of Senior Members*	5,712	0.14	0.29	0	1.4
Animal Units	5,712	0.51	0.96	0	6.3
Total Household Assets†	5,712	37.3	47.92	0	186.9
Total Farm Area in Acres squared	5,712	3.2	3.22	0	42.9

*variables are those household controls used in robustness checks

*variables are the same as previous conrols without including newly added household members

† in 100,000s of 2015 Tanzanian Shillings

All variables except gender of the household head are in log form

HH assets winsorized at the 5% level

Table 2: Household-level Descriptive Statistics

3 began in October of 2012 with interviews nearly complete by the end of October 2013. Wave 3 of the survey is expanded with 3,300 farm-households including a total of 4,934 plots. The fourth wave of the survey sampled the same villages but replaced the households in the sample. The wave 4 data were collected from October 2014 through August 2015 and includes 3,352 households with data on 4,291 plots. The sample used in the estimations in this paper is restricted to only those households which own and operate a farm though other non-farm households were also sampled. In the full sample of farm households there are 4,356 farm-households in waves 1-3 and 2,093 new farm-households in wave 4 for a total of 6,447 households. For a number of households soil-quality plot-slope and soil type data are missing reducing the usable sample to 5,768 households. Table 2 contains household-level descriptive statistics of the farm households in the sample. The average household head is 48 years old and has 4 years of education which is roughly equivalent to a primary education. Households include 2 children and 3 adults on average.

Table 3 shows descriptive statistics of both family and hired labor use at the plot level. Labor is split into planting, weeding and harvesting periods though in the analysis planting and weeding activities are combined. This is because tasks in the pre-harvest season involve lighter amounts of work and may be spread out more easily over time. This choice is supported by the literature on observability of agricultural activities (Eswaran and Kotwal, 1985; Foster and Rosenzweig, 1994). Family labor use is much higher than hired labor use on average. Average hired labor use in both the preparatory and harvest periods also appears to be very stable across all waves. In previous separation papers most farms hire labor while in Tanzania a smaller percentage of farms sampled in the LSMS hire-in labor (43%) and the average total number of hired days per acre is quite low at around 2.5 hired-labor-days per acre. In Indonesia 95% of farms hire labor and farmers utilize about 90 days of hired labor per acre on average (Benjamin, 1992).

	Pct Used Family Labor	Mean Total Labor Days	Pct. Used Hired Labor	Mean Hired Labor Days	Mean Total Labor Days Per Acre	Mean Hired Labor Days Per Acre	Median Wage Ag. Workers
Planting Labor	1.00	137.8	0.34	2.35	48.94	2.23	2,667
Weeding Labor	0.88	105.9	0.28	8.83	30.12	1.28	3,750
Harvesting Labor	0.97	49.2	0.20	7.05	17.27	0.60	2,500

Statistics reported at the household-wave level
Wages in 2015 Tanzanian Shillings

Table 3: Labor Use on Farms in LSMS Sample

4. Results

4.1. Family and Hired Labor Demand Estimates

Based on the the earlier discussion and analysis family labor and hired labor are further divided into pre-harvest preparatory labor and harvest labor. Columns 1-2 of table 4 contain within-household estimates of family preparatory and harvest labor demand while columns 3-4 contain within-household estimates of hired labor demand. All columns containing estimates include controls for soil quality, soil type, for the slope or gradient of the plot and individual household fixed-effects. Due to evidence of the potential for recall bias in data collection I have included a dummies for the month in which the survey interview was conducted (Beegle et al., 2012). Additionally farms are broken into quintiles based on the area under control by each farm and dummies are included for each quintile. The smallest quintile of farms are less than a football field while the largest quintile of farms includes farms over ten football fields in size.

This table represents the primary labor demand regressions with plot, manager and household-level controls. The first part of the table reports plot level controls such as the size of the plot and the collective/individual ownership status of the plot. I want to underscore that statistical significance or the indication of any relationship between plot-level characteristics and plot-level labor demand is not evidence of non-separation between consumption and production.

Plot characteristics

The plot-level control variables follow the expected patterns: labor is increasing in plot area though plot-level family labor demand is more responsive to the plot size. This could reflect the higher quality of family labor relative to the quality of hired labor in prep and harvest periods. Collectively farmed plots meaning familial plots receive a higher amount of family labor and a lower amount of hired labor although the estimates for the effect of collective plot status on hired labor demand are not statistically significant at standard levels. Plots which are rented receive more family labor though they receive less hired labor which might indicate the trust/quality differential between hired labor and family labor: rented plots generate more pressure to return a profit and thus it is better to use trusted family labor inputs rather than non-trusted laborers.

Managerial characteristics

The next grouping of variables are the individual characteristics of the plot managers. Plot managers are the individuals who determine what should be planted on a given plot. Statistically significant variables in the managerial characteristics group may indicate non-separation since certain individual characteristics of managers such as their gender should not drive labor demand, primarily or exclusively the plot-level characteristics must determine labor demand in order for there to be separation. In the case of these Tanzanian households we can see that the gender of the managers as well as the status of the individual in the household affect the amount of labor demanded on the plot. The managers all being women also increases the amount of hired harvest labor demanded which is consistent with the idea that although women are highly competent and proficient farmers it is more difficult for women to supply highly physical labor needed for particular tasks such as at harvest time. The plot manager being the head of the household also adds substantially to the amount of family labor supplied in both the harvest and the prep seasons.

Household characteristics

Household characteristics are primary coefficients of interest since these characteristics, in a separable model or a separable household context, should not relate to plot-level labor demand neither for family labor nor hired labor. The number of adult members is indicated to increase family labor by a magnitude of .384 for the prep period and .203 in the harvest period. This provides suggestive but strong evidence that labor markets face extreme challenges and one way farmers deal with a shortage of high-quality trustworthy labor is to use their own family rather than hire specialized farm workers.

Animal units, an indexing of the total amount of animals a household owns, are indicated to increase family labor demand. This is likely due to the fact that draft animals are being used to prepare the soil and to carry harvested crops. Consistent with the earlier evidence of households preferring to apply family labor with high-value inputs, animal units could also be considered a high-value input as individuals must be trusted with a valuable animal that could relatively easily be liquidated.

Less family labor is applied in the preparatory period for households that are headed by a woman. Women-headed households tend to be the result of widowhood or divorce and so the decrease in family labor most likely indicates the lower social status of households headed by women who therefore lack access to productive resources including fewer adult men being present in women-headed households.

Last are the controls for rainfall shocks. These represent positive rainfall shocks and negative rainfall shocks where rainfall at the village level was above the 80th percentile (positive shock) or below the 20th percentile (negative shock). Across both rows the signs of the rainfall shock variables appear to be correctly estimated with the effect being an increase in labor demanded resulting from positive rainfall shocks and a decrease in labor demanded corresponding to a negative rainfall shock. The magnitude of the effects is slightly different though this could be consistent with the demands of different crops in different phases of development prior to and during the harvest.

4.2. Estimates by Quantile of Farm Size

As an exercise I divide the sample into categories based on the size of the total acreage controlled by the household, farm size. The output tables for this exercise are omitted from the text for brevity and are instead included in the online appendix available here. Farms in the smallest quantile are less than a football field in size while farms in the largest quantile are over ten football fields in size.

Family

For plot-level controls this exercise appears to largely validate the full-sample estimates. Family prep labor is increasing in other inputs and in distance to the household. Women-managed plots receive more family prep labor to meet the physical demands of agriculture as a result of the lack of support from household members that are men. Again, the household head commands a sizeable labor premium independent of the size of the farm in terms of the preparatory period. Interestingly the number of adults is predicted to have a positive effect on family preparatory labor on farms in the top two quintiles where the effect is positive and statistically significant.

	(1) Family Prep Labor	(2) Family Harvest Labor	(3) Hired Prep Labor	(4) Hired Harvest Labor
Family Prep Labor		0.446***		
		(0.014)		
Hired Prep Labor				0.265***
				(0.011)
Plot Area	0.421***	0.123***	0.371***	0.068***
	(0.023)	(0.023)	(0.025)	(0.018)
Collective Plot	0.177**	0.063	-0.081	-0.008
	(0.078)	(0.080)	(0.074)	(0.049)
Plot is Rented	0.214***	-0.019	0.200**	0.084
	(0.069)	(0.078)	(0.087)	(0.065)
Plot has Irrigation	0.089	-0.113	0.056	-0.036
	(0.062)	(0.090)	(0.065)	(0.044)
Quant. of Organic Fertilizer	0.043***	0.007	-0.007	-0.003
	(0.005)	(0.005)	(0.006)	(0.005)
Plot is Intercropped	0.232***	-0.015	0.040*	-0.005
	(0.020)	(0.021)	(0.022)	(0.015)
Improved Seeds Used	0.214***	0.013	0.107***	0.019
	(0.022)	(0.023)	(0.023)	(0.017)
Dist. to Household in miles	0.123***	-0.006	0.132***	0.041***
	(0.014)	(0.012)	(0.012)	(0.008)
Farmer-estimated Plot Value	0.043***	0.039***	0.038***	0.033***
	(0.010)	(0.009)	(0.009)	(0.006)
Household Has Land Title	-0.123***	-0.061	-0.010	0.029
	(0.043)	(0.041)	(0.040)	(0.026)
Managers All Women	0.327***	-0.027	0.063	0.081**
	(0.061)	(0.059)	(0.055)	(0.032)
Managers Mixed Gender	-0.078	-0.153*	0.086	0.008
	(0.080)	(0.083)	(0.077)	(0.051)
Manager w/Primary Educ.	0.177***	0.048	0.050	0.021
	(0.063)	(0.060)	(0.056)	(0.037)
Manager w/Secondary Educ.	0.095*	-0.024	0.062	0.004
	(0.057)	(0.059)	(0.059)	(0.036)
Manager Also HH Head	0.532***	0.169***	0.147***	0.026
	(0.071)	(0.062)	(0.055)	(0.036)

Table 4: Labor Demand Regressions

	(1) Family Prep Labor	(2) Family Harvest Labor	(3) Hired Prep Labor	(4) Hired Harvest Labor
# of Children	0.019	0.014	-0.035	-0.053*
	(0.042)	(0.046)	(0.044)	(0.029)
# of Adult Members	0.384***	0.203***	-0.206***	-0.115***
	(0.059)	(0.067)	(0.064)	(0.041)
# of Senior Members	0.280***	-0.007	0.003	0.046
	(0.087)	(0.115)	(0.097)	(0.068)
Animal Units	0.094***	0.067**	0.001	0.001
	(0.031)	(0.027)	(0.031)	(0.019)
Age of HH Head	0.132	0.101	-0.055	0.037
	(0.123)	(0.113)	(0.125)	(0.081)
Head Compl. Elem. School	-0.000	-0.032	-0.025	0.067
	(0.082)	(0.083)	(0.077)	(0.056)
Head Compl. Secondary School	-0.053	0.088*	-0.058	-0.036
	(0.046)	(0.052)	(0.052)	(0.033)
Gender of HH Head	-0.089	0.017	-0.005	-0.037
	(0.060)	(0.060)	(0.053)	(0.035)
Positive Rain Shock	0.054	0.102*	0.082	-0.049
	(0.058)	(0.055)	(0.057)	(0.035)
Negative Rain Shock	-0.037	-0.013	0.009	-0.012
	(0.029)	(0.029)	(0.027)	(0.017)
Observations	19,478	19,478	19,478	19,478
Number of HH	5,712	5,712	5,712	5,712
HH FE	Yes	Yes	Yes	Yes
Soil Controls	Yes	Yes	Yes	Yes
Slope Controls	Yes	Yes	Yes	Yes
Interview-Month Dummies	Yes	Yes	Yes	Yes
Farm Quantile Dummies	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: Labor Demand Regressions

Looking at family harvest labor we can see that there is a very consistent effect of preparatory period labor on harvest period labor representing a kind of inertia of agricultural labor. In the case of harvest time it looks like mixed-gender plots receive disproportionately less labor than plots managed exclusively by men.

Hired

Hired labor is increasing in plot area though decreasing in the use of organic fertilizer indicating perhaps again the trust issue between hired laborers and farm or plot managers. Plots further from the household are more likely to receive hired labor which appears to be an "offshoring" of the cost of walking or travelling to the plot particularly on plots where no (other) high-value inputs have been used. Hired labor use is decreasing in the number of adult household members again suggesting that family labor and hired labor are substitutes and suggesting that family labor is preferred to hired.

5. Wald Tests for Equality of Coefficients

The following tables, tables 5-7, contain the results of Wald tests comparing the equality of coefficients across the different demand estimates. Again, this includes separate estimates for family, hired, preparatory, harvest, adult men's and adult women's labor days. The first table, table 5 tests for equality of coefficients between family prep labor and hired prep labor, then for equality between family harvest labor and hired harvest labor. The first two columns are Wald tests for equality between the Family Prep labor coefficients and the Hired Prep labor coefficients. The left column is the Wald statistic while the right column is the associated p-value. The third and fourth columns represent family harvest labor compared to hired harvest labor. Included in the Wald tests are all controls used in the labor demand regressions. Table 6 tests for equality of coefficients in the estimated labor demand function for preparatory versus harvest period labor. The first two columns represent the results of the test for equality between effects of the controls on family preparatory and family harvest period labor. The last two columns are the same tests repeated with hired labor. The final table 7 of Wald tests analyzes potential differences in the effect on labor demand for adult men and for adult women. Labor days are divided into men's labor days and women's labor days and this allows me to evaluate which areas or characteristics might have a differential effect on demand for men's labor relative to demand for women's labor.

5.1. Wald Tests for Equality of Coefficients - Family Versus Hired Labor

5.1.1. Plot Controls

The first coefficient test is for equality between the parameters that measure the elasticity of labor demand with respect to plot size. The coefficients on family labor are larger than those on hired labor indicating that family labor is more responsive to changes in plot size than hired labor in the preparatory period. This supports a quality differential between family and hired labor meaning that family labor is higher quality or more trusted. It could also be due to a lack of availability of agricultural laborers or that hired laborers are more likely to shirk without concomitant monitoring expenses which farmers are unwilling or unable to invest. The Wald test firmly rejects the equality of these coefficients.

Improved seed use boosts both family and hired labor though by different amounts as the Wald test rejects. This is consistent with the idea of a yield bonus due to improved seeds though there is also the cost of additional labor which may also require concomitant monitoring costs. It also is consistent with the idea that farm managers prefer to use trusted family laborers when applying or utilizing high-value inputs. Last for the Wald tests of plot-level controls of family versus hired labor is the presence of an official land title in the household. The household holding the title may induce different effects on labor demand in the harvest and preparatory periods. It is not immediately clear why holding the title should have differential effects on the preparatory versus the harvest period but perhaps farmers are more willing to make investments in their plots and therefore invest more in the preparatory period when fertilizers are applied.

5.1.2. Managerial Controls

Plots which have exclusively women managers also tend to receive more labor. Descriptive analysis reveals that this is because men work fewer days on woman-managed plots than they do on their own or mixed-gender plots of land. This is also consistent with the idea that, in general, men have an easier time gaining body mass and strength which is an important characteristic for agricultural work in many cases and one of the reasons women may provide more labor days (Pitt et al., 2012).

The manager being the household head means the plot commands more labor. There is also a smaller effect of head-managers for hired than for family labor. This reinforces that it is easier or preferable to motivate family labor to their plots. The Wald test rejects equality of coefficients between family and hired preparatory labor and harvest labor meaning that when the plot manager is also the household head the amount of labor the plot receives increases, though hired labor increases by a smaller amount than family labor.

5.1.3. Household Controls

Of the household variables whose coefficients were also tested for a differential between family and hired labor the most important is the number of adult members in the household. An increase in the number of adults per household results in an increase in the amount of family labor applied per plot as well as decreases the amount of hired labor. This indicates that family labor and hired labor are substitutes though family labor appears to be preferred. Given that the Wald test rejects equality of coefficients between the effect of an additional adult on hired and family labor it appears that family labor is preferred to hired labor based on the elasticity of demand of family labor being larger than the elasticity of demand (negative) of hired labor. A doubling of the number of adults in the family results in an .384 increase in family labor at the plot level and a decrease about half the size -.206 in the preparatory period.

With respect to the rainfall shocks a positive rainfall shock increases hired prep labor more than family prep labor. In the harvest season a positive rainfall shock leads to a larger increase in family labor while the effects with respect to hired harvest labor are small in magnitude and not statistically significant. Still, the Wald test rejects equality between hired and family labor in the prep season, and the Wald test also rejects equality of the coefficients on the responsiveness of family labor and hired labor to positive rainfall shocks.

	Family Prep = Hired Prep		Family Harv = Hired Harv	
	Test Statistic	p-value	Test Statistic	p-value
Plot Area	3.43	0.064	4.46	0.035
Collective Plot	10.56	0.001	1.13	0.287
Plot is Rented	0.06	0.808	1.86	0.173
Plot has Irrigation	0.11	0.741	2.28	0.131
Quant. of Organic Fertilizer	60.16	0.000	3.89	0.049
Plot is Intercropped	62.62	0.000	0.05	0.827
Improved Seeds Used	9.94	0.002	1.13	0.288
Dist. to Household in miles	3.13	0.077	10.96	0.001
Farmer-estimated Plot Value	0.52	0.472	0.56	0.455
Household Has Land Title	5.49	0.019	4.54	0.033
Managers All Women	19.94	0.000	4.52	0.034
Managers Mixed Gender	3.55	0.060	5	0.025
Manager w/Primary Educ.	6.54	0.011	0.05	0.817
Manager w/Secondary Educ.	0.58	0.448	0.14	0.707
Manager Also HH Head	34.78	0.000	6.99	0.008
Number of Children	0.24	0.627	1.24	0.265
Number of Adult Members	67.58	0.000	18	0.000
Number of Senior Members	5.42	0.020	1.09	0.297
Animal Units	9.17	0.003	6.21	0.013
Age of HH Head	1.41	0.235	0.52	0.470
Years Educ HH Head	9.73	0.002	10.74	0.001
Gender HH Head	1.82	0.177	0.11	0.744
Positive Rain Shock	0.79	0.374	7.21	0.007
Negative Rain Shock	1.03	0.310	0.14	0.704

Table 5: Wald Tests for Equality Between Family Labor Demand and Hired Labor Demand

5.2. Wald test of Preparatory vs Harvest Period Coefficients

The tests in table 6 are tests for differential effects between the harvest and preparatory periods. These tests compare family preparatory labor demand coefficients to family harvest labor demand coefficients and likewise for hired labor. The table is structured such that the first two columns of data represent tests on family labor while the second two columns represent tests on hired labor.

5.2.1. Plot Controls

Many of the tests on the plot-level controls relate more to agricultural processes than economic ones. For example the fact that the size of the plot has a differential effect on demand for preparatory versus harvest labor could simply be reflecting that different crops demand different levels of attention throughout the agricultural season. With respect to a differential effect of plot size on hired preparatory versus hired harvest labor this could also reflect underlying structural agricultural processes or changes in labor market conditions such as labor market tightening in the harvest period.

Another control whose Wald test rejects parity between harvest and preparatory labor demand coefficients is quantity of fertilizer. The elasticity of demand of family labor with respect to fertilizer in the harvest season and the preparatory season is also indicated to be different. This fits with the intuition as, in most cases, labor is required to apply organic fertilizer in the preparatory period while fertilizer is not usually applied at harvest time.

5.2.2. Managerial Controls

Some of the most important variables for rejecting separation are the characteristics of the plot manager. The fact that plots where the managers are all women receive more labor indicates separation in the case that women need to apply more labor to their own plots to compensate for a lack of men's willing to perform physical tasks on plots managed by women.

Importantly, plots managed by the household head appear to command a sizeable premium in both harvest and preparatory periods with respect to family labor. The Wald test rejects indicating a differential effect of the plot manager also being the household head on plot labor demand in the preparatory period versus the harvest period. This underscores a need to estimate plot labor demand separately for harvest and preparatory periods and the need for treating these processes separately in terms of analysis.

5.2.3. Household Controls

With respect to the household-level control variables very few of those variables have a differential effect. Of note is that there is a differential effect of senior household members on plot labor demand. Seniors, or household members over 65, are more capable at performing certain tasks in the preparatory period such as weeding that might not require much physical work or which are not time-sensitive. Furthermore it is clearly more difficult for senior members of the household to participate in harvesting activities.

Last is the effect of a positive and negative rainfall shock on labor demand. Using the Wald tests I reject the equality of coefficients on family preparatory period labor and family harvest labor. The coefficients of the effect of a marginal adult on labor demand are indicated to be different by the Wald test between preparatory and harvest periods. The Wald test also rejects equality of the coefficients on positive rainfall shocks' effect on hired preparatory and hired harvest season labor. These coefficients are not significant in the hired preparatory and hired harvest labor demand regressions.

5.3. Wald Test of Equality of Estimated Coefficients Between Men's Agricultural Labor Demand Functions vs Women's Agricultural Labor Demand Functions

The last table of Wald tests contains tests comparing equality of coefficients between demand for men's agricultural labor and demand for women's agricultural labor. This analysis helps to provide supporting evidence for the idea that women work more on woman-managed plots and men work more on plots which are managed by men indicating a potential inefficiency consistent with previous significant findings in the literature. The result tables of the corresponding fixed-effects regressions are included in the online appendix here.

5.3.1. Plot Controls

For the plot-level controls the most striking rejection of the Wald test comes with the use of improved seeds. In this case the Wald test rejects the equality of the effect of improved seed use on women's preparatory and men's preparatory labor as well as harvest labor. Improved seed use is indicated to increase women's plot-level labor more than it increases men's labor. This again underscores a lack of synchronization of household productive activities. The evidence here suggests that

	Family Prep = Family Harv		Hired Prep = Hired Harv	
	Test Statistic	p-value	Test Statistic	p-value
Plot Area	158.61	0.000	172.25	0.000
Collective Plot	1.97	0.160	1.24	0.265
Plot is Rented	10.62	0.001	2.82	0.093
Plot has Irrigation	10.32	0.001	3.10	0.079
Quant. of Organic Fertilizer	26.61	0.000	1.64	0.200
Plot is Intercropped	103.66	0.000	3.57	0.059
Improved Seeds Used	54.15	0.000	11.34	0.001
Dist. to Household in miles	42.93	0.000	35.01	0.000
Farmer-estimated Plot Value	0.21	0.648	0.20	0.653
Household Has Land Title	1.97	0.161	0.82	0.366
Managers All Women	36.87	0.000	0.06	0.799
Managers Mixed Gender	0.88	0.348	1.28	0.259
Manager w/Primary Educ.	8.85	0.003	0.66	0.418
Manager w/Secondary Educ.	1.70	0.192	1.10	0.295
Manager Also HH Head	28.24	0.000	6.26	0.012
Number of Children	0.24	0.625	0.00	0.973
Number of Adult Members	8.90	0.003	2.89	0.089
Number of Senior Members	9.36	0.002	0.12	0.726
Animal Units	1.19	0.275	0.08	0.772
Age of HH Head	0.00	0.947	0.29	0.591
Years Educ HH Head	3.65	0.056	3.58	0.058
Gender HH Head	2.31	0.129	0.04	0.848
Positive Rain Shock	1.39	0.238	5.78	0.016
Negative Rain Shock	0.10	0.749	1.41	0.235

Table 6: Wald Tests for Equality Between Preparatory Labor Demand and Harvest Labor Demand, Family and Hired Labor

even when women-managers are able to invest in high-value inputs they receive little help on their plots from the men in the household. Household productive activities appear to relate more to gender norms in Tanzanian society than to what would be efficient in terms of agricultural production.

5.3.2. Managerial Controls

In this table managerial controls are the primary variables of interest. When plot managers are all women the use of women's labor on the plot is much higher and use of men's labor is much lower relative to plots managed exclusively by men. This is true for both the preparatory and during the harvest period. The Wald test also rejects for plots with mixed-gender managers in the preparatory period. This is again likely a result of a lower use of men's labor on plots with mixed-gender managers.

5.3.3. Household Controls

Additional senior members in the household decrease labor in the preparatory period indicating that senior household member's labor is a substitute for men's and women's labor in the preparatory period. According to the Wald test there are different effects on men's and women's adult labor with marginal senior household members reducing men's labor by a larger amount than women's labor. This indicates seniors within the household are more often employed to work on men's plots than on women's plots during the preparatory period.

Last, a positive rain shock is estimated to have a different effect on demand for men's labor and women's labor in the harvest period. Positive rainfall has a larger effect on demand for women's labor than for men's labor. Equality in the effect of positive rainfall shocks on women's labor versus men's labor is rejected here indicating another potential source of inefficiency in household production.

6. Robustness Checks

Check - Endogenous HH Size

According to a paper by Grimard (2000) endogeneity of household demographics and composition to agricultural decisions is a significant concern in the context of Cote d'Ivoire where large kinship networks facilitate the movement of family members to and from regions in need of agricultural labor. I argue that the earlier analysis of the effects of controls by quantile of farm size may account for much of the possibility of endogenous movement of family laborers.

To address concerns with respect to the endogeneity of household members to household labor demand I re-run the estimations excluding all labor which was carried out on the plot by household members that recently joined the household. This provides a measure of control against endogeneity of household composition to agricultural labor decisions. Based on the survey questionnaire it is possible to identify which household members have joined the household in the past year and for what reason they have moved. In this robustness check all labor contributions by survey participants who reported moving in the last year due to acquiring agricultural land or for work purposes are excluded.

This table represents a primary robustness check in the estimates for labor demand with plot, manager and household-level controls. These models include *only* labor days undertaken by the established family members and excludes labor days

	Men's Prep = Women's Prep		Women's Harvest = Men's Harvest	
	Test Statistic	P-value	Test Statistic	P-value
Plot Area	1.00	0.317	4.31	0.038
Collective Plot	1.60	0.205	0.04	0.837
Plot is Rented	0.45	0.504	0.02	0.881
Plot has Irrigation	0.36	0.551	0.04	0.846
Quant. of Organic Fertilizer	7.76	0.005	0.24	0.627
Plot is Intercropped	8.09	0.004	2.67	0.102
Improved Seeds Used	14.25	0.000	8.57	0.003
Dist. to Household in miles	1.08	0.300	4.57	0.033
Farmer-estimated Plot Value	0.59	0.444	3.09	0.079
Household Has Land Title	0.03	0.866	0.01	0.937
Managers All Women	421.31	0.000	27.04	0.000
Managers Mixed Gender	32.63	0.000	1.91	0.167
Manager w/Primary Educ.	0.38	0.536	0.17	0.677
Manager w/Secondary Educ.	8.72	0.003	1.08	0.299
Manager Also HH Head	2.64	0.104	3.53	0.060
HH Number of Children	15.15	0.000	8.42	0.004
Number of Adult Members	0.64	0.424	18.07	0.000
Number of Senior Members	4.26	0.039	2.10	0.147
Animal Units	0.37	0.545	1.59	0.208
Age of HH Head	4.01	0.045	0.79	0.374
Years Educ HH Head	0.59	0.441	3.08	0.079
Gender HH Head	4.14	0.042	0.72	0.396
Positive Rain Shock	3.36	0.067	4.36	0.037
Negative Rain Shock	9.56	0.002	2.15	0.143

Table 7: Wald Tests for Equality Between Men's Family Labor Demand and Women's Family Labor Demand - Preparatory and Harvest Labor

that are contributed by new members to the household. In this way I adapt the procedure for the presence of household members that arrive endogenously to participate in farming activities. Although their labor is excluded it is still possible that labor carried out by new members might influence the amount of labor provided by family members since the two are presumably substitutes. For this reason I have constructed a variable that measures the number of new members and I include that in the robustness check regressions. The first part of the table reports plot level controls such as the size of the plot and the collective/individual ownership status of the plot. The plot-level control variables and managerial characteristics are almost identical to the estimates from the model which includes new household members.

There are some clear differences in the estimates with long-term household members when it comes to household characteristics. Agricultural labor demand now responds much more strongly to changes in this household structure. A doubling of household adults corresponds to an increase of .686 household-supplied preparatory labor. With respect to additional new members we see a decline in the amount of family labor associated with an influx of the new family members which is as expected since the two are presumed to be substitutes. Newly arrived family members are clearly being used for agricultural labor though this may be for endogenous or exogenous reasons.

7. Conclusion

This paper uses high-quality panel data from Tanzania to examine labor market frictions or inefficiencies. The analysis uses the framework of the separation hypothe-

	(1) Family Prep Labor*	(2) Family Harvest Labor*	(3) Hired Prep Labor	(4) Hired Harvest Labor
Family Prep Labor*		0.450***		
		(0.013)		
Hired Prep Labor				0.265***
				(0.011)
Plot Area	0.401***	0.117***	0.372***	0.069***
	(0.024)	(0.023)	(0.025)	(0.017)
Collective Plot	0.180**	0.027	-0.085	-0.012
	(0.083)	(0.082)	(0.074)	(0.049)
Plot is Rented	0.159**	-0.022	0.197**	0.081
	(0.074)	(0.077)	(0.087)	(0.064)
Plot has Irrigation	0.102	-0.107	0.057	-0.034
	(0.069)	(0.091)	(0.065)	(0.044)
Quant. of Organic Fertilizer	0.039***	0.005	-0.007	-0.003
	(0.005)	(0.005)	(0.006)	(0.005)
Plot is Intercropped	0.225***	-0.021	0.039*	-0.006
	(0.021)	(0.021)	(0.022)	(0.015)
Improved Seeds Used	0.211***	0.004	0.107***	0.018
	(0.023)	(0.023)	(0.023)	(0.017)
Dist. to Household in miles	0.116***	-0.010	0.132***	0.041***
	(0.014)	(0.012)	(0.012)	(0.008)
Farmer-estimated Plot Value	0.043***	0.038***	0.038***	0.033***
	(0.010)	(0.010)	(0.009)	(0.006)
Household Has Land Title	-0.100**	-0.057	-0.011	0.028
	(0.048)	(0.041)	(0.040)	(0.026)
Managers All Women	0.332***	-0.033	0.065	0.081**
	(0.063)	(0.059)	(0.055)	(0.032)
Managers Mixed Gender	-0.063	-0.122	0.088	0.010
	(0.085)	(0.085)	(0.077)	(0.052)
Manager w/Primary Educ.	0.126*	0.040	0.049	0.021
	(0.067)	(0.060)	(0.056)	(0.037)
Manager w/Secondary Educ.	0.104*	-0.020	0.062	0.005
	(0.061)	(0.059)	(0.059)	(0.036)
Manager Also Head	0.524***	0.166***	0.148***	0.026
	(0.073)	(0.062)	(0.055)	(0.036)

Table 8: Robustness Check - Regressions Without New Members' Labor

VARIABLES	(1) Family Prep Labor*	(2) Family Harvest Labor*	(3) Hired Prep Labor	(4) Hired Harvest Labor
# of Children*	0.015	0.013	-0.041	-0.057*
	(0.045)	(0.046)	(0.044)	(0.029)
# of Adult Members*	0.686***	0.249***	-0.178***	-0.105***
	(0.061)	(0.060)	(0.058)	(0.036)
# of Senior Members*	0.330***	-0.002	-0.042	0.043
	(0.098)	(0.099)	(0.089)	(0.060)
# of New Members	-0.949***	-0.166***	-0.020	0.022
	(0.079)	(0.063)	(0.064)	(0.039)
Animal Units	0.102***	0.059**	0.001	0.002
	(0.032)	(0.027)	(0.031)	(0.019)
Age of Head	0.115	0.092	-0.039	0.040
	(0.132)	(0.110)	(0.123)	(0.080)
Head Compl. Elem. School	0.019	-0.039	-0.023	0.068
	(0.092)	(0.084)	(0.077)	(0.056)
Head Compl. Secondary School	-0.077	0.084	-0.061	-0.038
	(0.052)	(0.053)	(0.052)	(0.033)
Gender of Household Head	-0.083	0.024	-0.004	-0.035
	(0.065)	(0.060)	(0.053)	(0.035)
Positive Rain Shock	0.088	0.099*	0.081	-0.051
	(0.060)	(0.055)	(0.057)	(0.035)
Negative Rain Shock	-0.059*	-0.025	0.006	-0.014
	(0.032)	(0.029)	(0.028)	(0.017)
Observations	19,478	19,478	19,478	19,478
Number of HH	5,712	5,712	5,712	5,712
HH FE	Yes	Yes	Yes	Yes
Soil Controls	Yes	Yes	Yes	Yes
Slope Controls	Yes	Yes	Yes	Yes
Interview-Month Dummies	Yes	Yes	Yes	Yes
Farm Quantile Dummies	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8: Robustness Check - Regressions Without New Members' Labor

sis which says unless there is a non-reliance of production on household characteristics we must model household production and consumption jointly. In Tanzania labor use was found to be highly reliant on (social) managerial and household-level characteristics rather than on managerial human capital and plot-level characteristics. I estimate 6 types of labor separately and find that, in many cases, the effect size on my control variables is different for different types of labor. Most importantly I find that plots where the household head is also the plot manager received a disproportionately greater share of labor. Plots managed exclusively by women also receive a disproportionately greater share of labor, though dis-aggregating this analysis to the demand for men's and women's labor we can see large differences in the coefficients. I confirm that the differential in coefficients is present using Wald tests. The tests reject that coefficients for the men's labor demand functions are the same as those for the women's labor demand functions. The result provides a few policy implications or suggestions. First it appears there could be gains from increased cooperation among men and women in the household. This echoes other papers from the gender and agriculture literature in sub-Saharan Africa such as Akresh et al. (2016) which finds that wife-wife manager pairs are more productive than husband-wife manager pairs in Mali and Udry (1996) which finds that productivity is higher on woman-managed plots in Burkina Faso but also that women plant much less area of their land to crops.

If a greater harmony between husbands and wives could be achieved, perhaps through sensitization training or by randomly selecting some days when men would work on women's plots or vice versa, that could motivate greater coordination or cooperation that, in turn, results in increased income or robustness against shocks. Second, there is likely a need to stimulate rural agricultural labor markets in Tanzania as households there seem highly reliant on and trusting of family laborers. Some ideas for what might facilitate or stimulate those markets is providing subsidized transport between urban areas and farming regions during peak harvest times or facilitating cross-border movements of laborers who can participate in piece-rate agricultural labor markets.

	(1) obs.	(2) mean	(3) sd	(4) min	(5) max
Family Prep Labor	19,478	3.44	1.27	0	6.78
Family Prep Labor*	19,478	3.27	1.41	0	6.78
Hired Prep Labor	19,478	0.67	1.21	0	5.8
Family Harvest Labor	19,478	2.39	1.32	0	6.29
Family Harvest Labor*	19,478	2.27	1.36	0	6.29
Hired Harvest Labor	19,478	0.34	0.86	0	5.29
Plot Area	19,478	0.95	0.7	0	6.4
Collective Plot	19,478	0.5	0.5	0	1
Plot is Rented	19,478	0.03	0.13	0	0.69
Plot has Irrigation	19,478	0.03	0.19	0	2
Quant. of Organic Fertilizer	19,478	0.65	1.9	0	10.37
Plot is Intercropped	19,478	0.41	0.49	0	1
Improved Seeds Used	19,478	0.36	0.48	0	1
Dist. to Household in miles	19,478	1.01	1.02	0	8.01
Farmer-estimated Plot Value	19,478	13.26	1.63	0	22.84
Household Has Land Title	19,478	0.1	0.29	0	1
Managers All Women	19,478	0.22	0.41	0	1
Managers Mixed Gender	19,478	0.47	0.5	0	1
Manager w/Primary Educ.	19,478	0.73	0.45	0	1
Manager w/Secondary Educ.	19,478	0.6	0.49	0	1
Manager Also Head	19,478	0.93	0.25	0	1
Number of Children	19,478	0.97	0.62	0	3.3
Number of Adult Members	19,478	1.35	0.46	0	3.4
Number of Senior Members	19,478	0.17	0.33	0	1.39
Number of Children*	19,478	0.97	0.62	0	3.3
Number of Adult Members*	19,478	1.29	0.5	0	3.4
Number of Senior Members*	19,478	0.15	0.31	0	1.39
Number of New Members	19,478	0.13	0.33	0	2.2

All variables except gender of the household head are in log form
household assets winsorized at the 5% level
*variables are those household controls used in robustness checks

Table 9: Summary Statistics of Regression Variables

	(1) obs.	(2) mean	(3) sd	(4) min	(5) max
Animal Units	19,478	0.58	1	0	6.27
Age of Head	19,478	3.86	0.32	2.83	4.69
Head Completed Elementary School	19,478	0.95	0.22	0	1
Head Completed Secondary School	19,478	0.84	0.36	0	1
Gender of Household Head	19,478	0.19	0.4	0	1
Positive Rain Shock	19,478	0.14	0.34	0	1
Negative Rain Shock	19,478	0.26	0.44	0	1
Soil Quality - Bad	19,478	0.06	0.24	0	1
Soil Quality - Average	19,478	0.48	0.5	0	1
Soil Quality - Good	19,478	0.46	0.5	0	1
Soil Type - Sandy	19,478	0.18	0.39	0	1
Soil Type - Loam	19,478	0.61	0.49	0	1
Soil Type - Clay	19,478	0.18	0.38	0	1
Soil Type - Other	19,478	0.02	0.16	0	1
Plot has Flat Bottom	19,478	0.61	0.49	0	1
Plot has Flat Bottom	19,478	0.07	0.25	0	1
Plot is Slightly Sloped	19,478	0.28	0.45	0	1
Plot is Very Steep	19,478	0.04	0.19	0	1
Interview-Month Dummies					
January	19,478	0.11	0.31	0	1
February	19,478	0.09	0.28	0	1
March	19,478	0.07	0.25	0	1
April	19,478	0.06	0.25	0	1
May	19,478	0.09	0.29	0	1
June	19,478	0.08	0.26	0	1
July	19,478	0.09	0.28	0	1
August	19,478	0.09	0.28	0	1
September	19,478	0.05	0.21	0	1
October	19,478	0.09	0.29	0	1
November	19,478	0.1	0.29	0	1
December	19,478	0.1	0.3	0	1

Table 10: Summary Statistics of Regression Variables

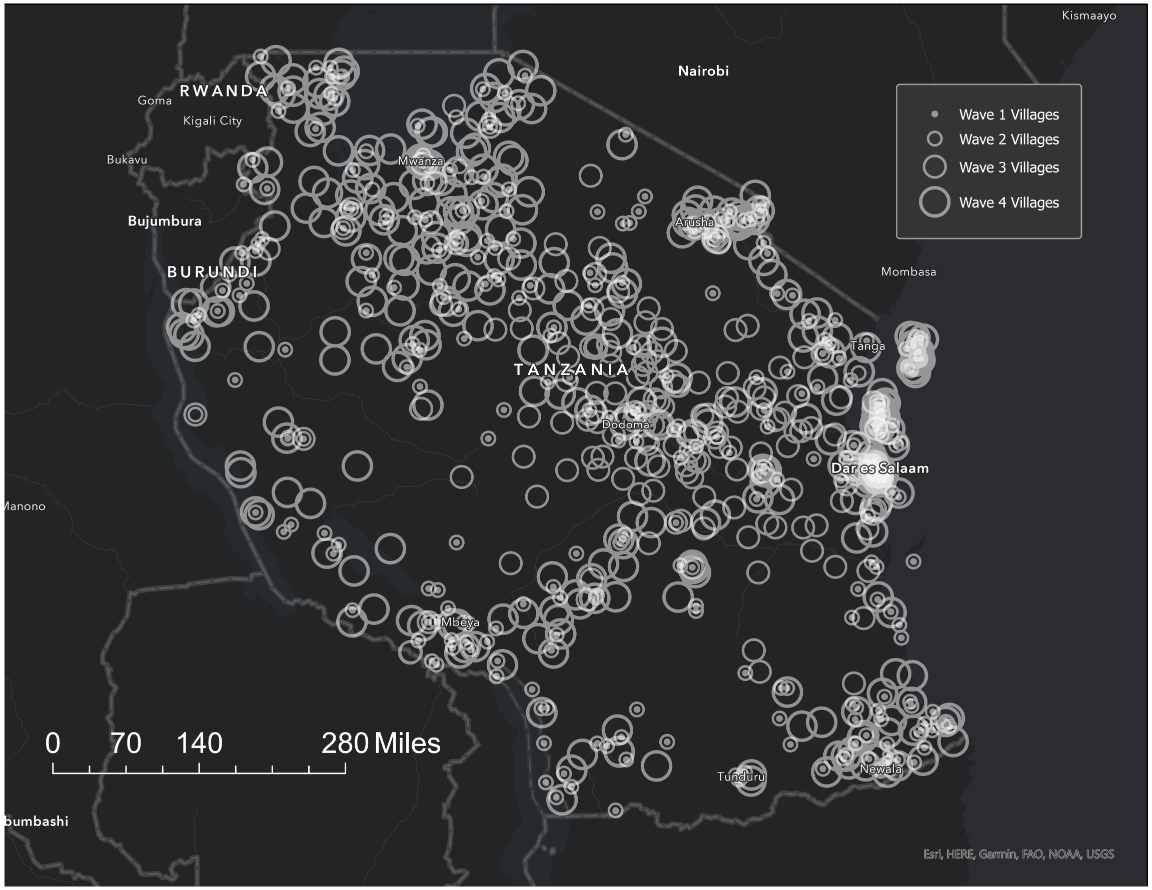

Figure 1: 2008 and 2012 Surveyed Villages, Tanzania LSMS
Source: Tanzania LSMS
Small white dot: Wave 1 Household, black circle: wave 3 villages

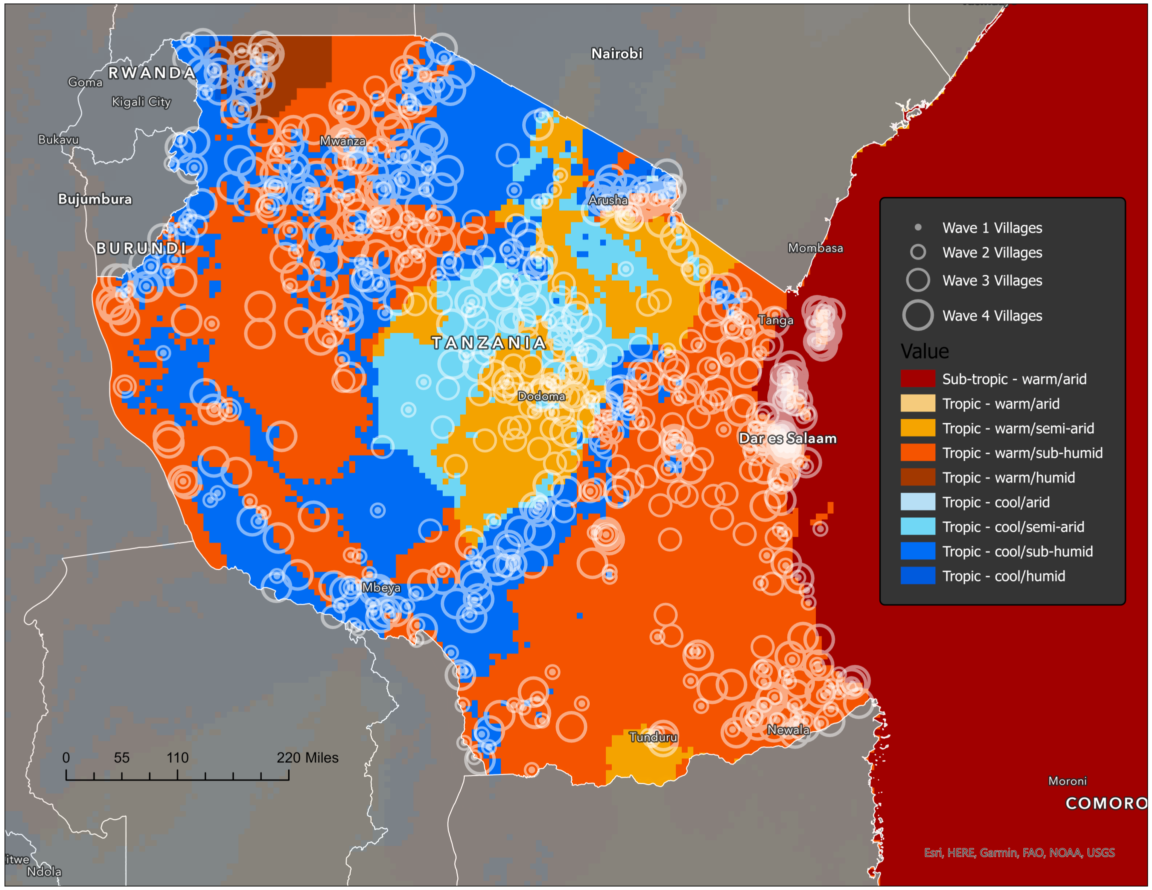

Figure 2: Tanzanian Agricultural Ecological Zones with Surveyed Villages
Source: Tanzania LSMS, IFPRI Raster Data; http://www.IFPRI.org

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