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Agricultural Factor Markets in Sub-Saharan Africa

An Updated View with Formal Tests for Market Failure

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Abstract

This paper uses the recently collected Living Standard Measurement Study–Integrated Surveys on Agriculture Initiative data sets from five countries in Sub-Saharan Africa to provide a comprehensive overview of land and labor market participation by agrarian households and to formally test for failures in factor markets. Under complete and competitive markets, households can solve their consumption and production problems separately, so that household factor endowments do not predict input demand. This paper implements a simple, theoretically grounded test of this separation hypothesis, which can be interpreted as a reduced form test of factor market failure. In all five study countries, the analysis finds strong evidence of factor market failure. Moreover, those failures appear general and structural, not specific to subpopulations defined by gender or geography.

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Agricultural Factor Markets in Sub-Saharan Africa: An Updated View with Formal Tests for Market Failure

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Introduction

In the structural adjustment era of the 1980s-90s, widespread belief in the efficiency of markets underpinned the broad transition away from government management and toward market liberalization in much of Sub-Saharan Africa (SSA). In the ensuing decade and a half, as it has become clear that liberalization *per se* was insufficient to raise growth rates and rapidly reduce poverty throughout the region, attention has returned to market failures. Substantial resources are committed each year to programs aimed at remedying these failures, which are widely presumed to be a general feature of African economies. But is this presumption correct?

The agricultural factor markets of Sub-Saharan Africa are among those most widely believed to be failing or incomplete. The proclaimed shortcomings are many: bad roads, unavailable or unreliable electricity and telecommunications services, insufficient credit and insurance, tenure systems that do not ensure secure property rights in land and water, corrupt officials, crowded ports, slow development of improved technologies at agricultural research centers, labor supervision problems, and others. A belief in these and other forms of market failure pervades the policy briefs and strategic plans produced by the development community for Africa.

Take as an example the 2011 Rural Poverty Report of the International Fund for Agricultural Development (IFAD). This report contains an in-depth discussion of key factor markets for rural households (pp. 125-140), and also touches on contract farming and the need for low-income countries to capture a larger share of the agricultural value chain. However, while the authors consider a range of policies as remedies for failing markets, they provide no evidence that markets indeed fail. Similarly, input market failures are implicitly assumed in various sections of the 2008 World Development Report (WDR) on *Agriculture for Development*. The WDR covers the topic of “mak[ing] input markets work better” without discussing whether or how we know that input markets currently fail (i.e., that those markets do not simply reflect the underlying fundamentals). In the FAO Regional Strategic Framework for Africa, 2010-2015, the authors point out that Africa has the world’s lowest levels of improved inputs per unit of cultivated land (p. 10). While this is not necessarily evidence of failures in input markets, it is consistent with such failures, and it underpins the document’s emphasis on correcting input market failures. Finally, the 2010 Abuja Declaration on Fertilizers for an African Green Revolution makes explicit the concern that input market failures contribute directly to food insecurity. Yet while there is little dispute about the degradation of soils across SSA from underinvestment in land productivity, it is not clear that current fertilizer use rates are sub-optimal for many farmers, given current output prices, transaction costs, and the risks associated with rain-fed agricultural production (Marenya and Barrett 2009, Ricker-Gilbert et al. 2009, Sheahan 2011).

We mention these documents not to imply that they misstate the problems facing small-scale farmers in Africa. Indeed, these reports typify the public discourse on this issue. Our point is that priority setting in this area is based largely on longstanding perceptions about factor market failures, not on empirical evidence from rigorous hypothesis testing using current data. Given the magnitude of the investments made based on the assumption of market failure, careful empirical study of the fundamental hypothesis – factor market failures are widespread in rural Africa – seems desirable to better inform programming by governments and the development community. In the absence of such research we cannot determine whether markets in Africa frequently fail to clear (in the sense that prices do not adjust to clear supply and demand), or whether markets generally work well but the central problem is that many households are endowed with insufficient quantities and qualities of land and labor to generate returns, *at market prices*, that lead to sustained productivity growth out of poverty.

Consider the following illustration. High transaction costs, weak enforcement of contracts, significant output risk – features common to rural economies in SSA – could induce market failure by causing mismatches in supply and demand or by supporting non-competitive pricing. But these features also increase suppliers' costs, which shifts supply curves inward, raises equilibrium prices, and reduces trading volumes. In the latter case, low input use levels are the equilibrium outcome of competitive markets, even though they may be sub-optimal from a social perspective.

Distinguishing between these two cases is essential to policy design, because the instruments necessary to fix broken or missing markets are not the same as those used to add value to products in well-functioning markets. If markets actually work well, then greater attention should be paid to increasing the value *above* current market prices of the land and labor that constitute the primary endowments of most poor households in Africa. Such policies could take the form of training and education, subsidies, taxes and transfer to mitigate endowment inequalities, or temporary assistance (e.g., through credit, insurance or extension services) to connect better to value chains so as to stimulate learning by doing or agglomeration externalities. If, by contrast, we can reject the hypothesis that African agricultural factor markets are complete and competitive, then a prima facie case exists for interventions directly targeted to address the sources of market failure so as to liberate the latent productivity and growth potential of African rural households. Such policies might include interventions to firm up property rights, to improve contract enforcement, to end collusion or non-competitive pricing, or to lower costs of production through investment in public goods and services such as physical (e.g., power, roads, telecommunications, water) and institutional (e.g., grades and standards) infrastructure.

The aim of this paper is to offer a first step toward rigorous assessment of factor market performance in SSA. Using newly available data from the Living Standard Measurement Study-Integrated Surveys on Agriculture Initiative (LSMS-ISA), we test for factor market failures in five of the major economies of Sub-Saharan Africa (Ethiopia, Malawi, Niger, Tanzania, Uganda). Our specific goals are twofold, and admittedly modest. First, we document the observed patterns of factor market participation by agricultural households. We focus on land and labor markets, as the prevailing wisdom seems to be that few farmers participate in these markets in rural Africa, instead relying on household labor and owned or informally allocated land. We show that, in fact, a large share of farmers transact in agricultural labor and/or land markets. These markets plainly exist and are used extensively, naturally raising the question of how well they function.

Our second goal is to use a well-established, reduced form approach to test for market failures using the input demand functions of agrarian households (Benjamin 1992, Udry 1999). For all five of the study countries we strongly reject the null hypothesis of complete and competitive factor markets. We further show that the pattern of market failures is general and structural, not related to the gender of the household head, nor to geographic characteristics such as the distance to roads or large population centers. We show that in some countries the degree of market failure varies between agro-ecological zones, suggesting that market performance across the region is related at least in part to agro-climatic factors outside households' control. The overall message is a strong endorsement of the maintained hypothesis that underpins much current discourse on

African agricultural and rural development: there is a pressing need to address widespread, systemic market failures that impede productivity growth and poverty reduction.

The test of market failure that we employ is grounded in the standard model of the agricultural household (Singh et al. 1986). The model makes explicit the prediction that when markets are complete and competitive, households can make decisions about production and consumption separately and recursively. This is widely known as the “separation hypothesis”. If the separation hypothesis holds, households behave as if they allocate resources so as to maximize farm profits first, and then make consumption choices conditional on the budget set that results from farm profit maximization. Endowments and preferences affect consumption choices, but they should not affect first-stage production behaviors. At the heart of this reduced form test is the observation that when markets are complete and competitive and the separation hypothesis holds, household size – the household’s labor endowment – is not predictive of labor demand.[1]

Non-separability between the household’s producer and consumer resource allocation decisions is generally understood to arise from two conditions. First, households must have preferences over some factor of production independent of those related to the value of final output. An obvious example in the case of agrarian households is that household members use their time to supply labor to the family farm, but they also consume time as leisure. If hired labor is a perfect substitute for household labor, then the consumption and production uses of labor endowments can be effectively separated. But if hired and household labor are not perfect substitutes, or if people have strong sectoral or locational preferences for where they work – so that labor produces more than just income – then separability fails. Second, *at least two* factor markets must fail to clear at prices determined competitively by the prevailing supply and demand curves. Resource allocation can adjust to a single quasi-fixed factor of production caused by a unique market failure (Feder 1985). If credit, labor, land and other factor markets are competitive and complete (up to, at most, a single market failure), and if household-specific shadow prices do not vary substantially around prevailing market prices (de Janvry *et al* 1991,

[1] There is also a structural approach to the study of the separable household model, involving estimation of production functions and comparison of the marginal product of inputs to their market prices (Jacoby 1993, Skoufias 1994, Barrett et al. 2008, Le 2010). We focus on the reduced form approach because it lends itself more readily to interpretation as a specific test of market failures.

Barrett 1996, Barrett et al. 2008), then the efficient allocation of resources on the farm is independent of household endowments.

A number of recent papers have sought to evaluate market function in a variety of settings in Africa. Not surprisingly, results have been mixed. Berg (2013) uses anticipated changes in household income in South Africa to test for the presence of credit constraints. While he cannot reject that the observed patterns are due to precautionary savings, he does find strong indicative evidence of credit market failures. In the context of a multi-factorial randomized controlled trial, Karlan et al. (2013) find strong evidence for incomplete insurance markets among farmers in Ghana. Barrett et al. (2008) show with data from Côte d'Ivoire that significant differences exist between shadow wages derived from estimated production functions and local market wages paid the same workers, which can be interpreted as evidence of failure in multiple agricultural input markets. On the other hand, separate studies from Kenya and Malawi suggest that given the relative prices of outputs and fertilizer, subsidies may induce most farmers to apply fertilizer at levels well beyond that which is profitable, calling into question the degree to which input market failures are a binding constraint on productivity (Ricker-Gilbert et al. 2009, Sheahan 2011). This paper augments these country-specific studies by applying the same, general test to recent, high quality data from five different countries, offering the most comprehensive tests to date for market failures in rural African factor markets.

The rest of the paper proceeds as follows. In the following section we briefly review the core theoretical model, the optimal conditional factor demand functions derived from that model that underpin the separation hypothesis, and the empirical specification of the reduced form test of that hypothesis. Descriptive statistics are presented in Section 3. Section 4 presents results, and Section 5 concludes with implications for both policy makers and researchers.

1. Theory and empirical framework

In this section we outline a basic model of the agricultural household and emphasize the role played by the separation hypothesis. Our goal is only to describe the basic empirical framework, so we leave aside certain complicating factors that can be readily incorporated into future work. The exposition in this section most directly follows Udry (1999) and Barrett et al. (2008).[2]

In a particular cropping year a household has a total labor endowment of $\bar{L}$, which it divides between leisure L^l, work on the household farm L^h, and supply of labor to the market, L^m. The household has preferences over consumption of goods, C, and leisure, L^l, represented by the strictly increasing, concave utility function $U(C, L^l|Z)$. The utility function is conditional on household characteristics Z, which includes endowments not explicitly denoted elsewhere. The household produces a single food commodity for sale or consumption using a strictly increasing, concave production technology $F(L, X, A\,|W)$, where L represents total labor application, X is a vector of non-labor inputs, A represents land inputs, and W represents exogenous agro-climatic factors such as pests and weather conditions. The household owns land A^o and rents in (net) land area A^r, the sum of which is total land in cultivation, A. The household can hire labor on the market, represented by L^d. Let p_x be the vector of non-labor input prices, w be the market wage rate, p_A be the price of land, and p be the price of the output, all of which are known to the household. Abstracting from uncertainty over exogenous conditions, the household's utility maximization problem is:

(1) $$\text{Max}_{C,L^l,L^h,L^d,L^m,A^r,X}\ U(C, L^l|Z)$$

subject to:

(2) $$pC - wL^m \leq pF(L, X, A\,|W) - wL^d - p_x X - p_A A^r$$

(3) $$L \equiv L^h + L^d$$

(4) $$A \equiv A^o + A^r$$

(5) $$\bar{L} \geq L^h + L^m + L^l$$

(6) $$L^l, L^h, L^d, L^m, X, A, C \geq 0$$

Under the standard assumptions about the utility function, weak inequalities (2) and (5) bind at the solution. The problem can be solved by first choosing total agricultural labor demand L, non-labor inputs X, and land inputs A to maximize farm profit, conditional on W. This is represented

[2] The canonical reference is Singh et al. (1986). Lau et al. (1978) and Benjamin (1992) were also helpful in developing the model outlined here.

by the right-hand side of the inequality in (2). The household then solves its utility maximization problem conditional on optimal profits. This is the essence of the separation hypothesis. With complete and competitive markets, the household can buy and sell labor, land and other inputs at exogenous, market-clearing prices, so that its production and consumption decisions can be explored as if they were completely separate.

If the separation hypothesis holds, then the solution to the household's problem implies the following:

(7) $\Pi^*(p, p_x, p_A, w) = \max_{A,X,L} pF(L^*, X^*, A^*|W) - wL^{d*} - p_x X^* - p_A A^*$

(8) $L^* = L(p, p_x, p_A, w|\, W)$

(9) $A^* = A(p, p_x, p_A, w|\, W)$

(10) $X^* = X(p, p_x, p_A, w|\, W)$

(11) $C^* = C(p, p_x, p_A, w, \bar{L}, A^o|\, W, Z)$

where equation 7 is the profit function, equations 8–10 are the input demand functions, and equation 11 is the consumption function.

Various tests based on equations 7–10 can be interpreted as tests of the underlying assumption of complete and competitive factor markets. As is clear in these equations, inputs depend only on exogenous prices, plot and weather characteristics if the separation hypothesis holds. This suggests a reduced form strategy for testing the separation hypothesis: include in the estimation of an input demand function any other variable that does not appear in equations 7-10 but that does appear in equation 11, that is that should only affect consumption behaviors and not production behaviors. Natural options are the household labor endowment or other household characteristics that should influence consumption patterns without impacting the household's full income. A test of complete and competitive markets can be implemented as a test of the exclusionary restriction implied by the theory, that production input demands are invariant to household characteristics. In particular, labor factor demand should be invariant to household labor endowments, $\bar{L}$. This is the intuition underlying most of the tests in the seminal paper of Benjamin (1992). Following this approach, in this paper we focus on the restriction implied by equation 8, the conditional labor demand function of the household under the null hypothesis of complete and competitive markets.

To test this restriction we estimate regressions of total labor demand on prices, land inputs, and household characteristics Z_h, using the following general specification:

$$(12)\qquad \log L_h = \alpha + \beta \log \bar{L}_h + \delta \log A_h + \gamma Z_h + \phi Prices + \mu_h$$

where $(\alpha, \beta, \delta, \gamma, \phi)$ represent coefficients, the subscript h indicates households, and μ is a mean zero, iid, normally distributed error term. In this case the separation hypothesis is represented by the null hypothesis, $H_0: \beta = 0$. Rejection of that null in favor of the alternate hypothesis, $H_A: \beta \neq 0$, implies rejection of the exclusionary restriction that follows directly from the presence of complete and competitive markets.

We report OLS estimates of equation 12, separately for each of the five study countries. In focusing on this baseline specification we make a number of simplifying assumptions. In particular, we treat land inputs as fixed within the cropping season and household size as exogenous. Household size in our empirical tests is defined as the number of adults aged 15+, but we do not further disaggregate household size by demographic characteristics of household members (although we do include some demographic controls in Z_h). And we ignore the role of supervisory household labor as a complement to hired labor. We also do not make adjustments for possible productivity differences between hired workers and household workers. Finally, following Benjamin (1992), we drop child labor inputs from the calculation of total labor demand, and we ignore harvest period labor because it is usually proportional to output, rather than an input to production.[3] Extensions to cover these concerns are left for future work.

The test of the separation hypothesis implicit in equation 12 cannot be interpreted as a test of labor market failure specifically. It is well understood that multiple market failures are required to generate distortions in factor or output markets because relative prices – not absolute prices – are what matters in determining the efficient allocation of resources. If we reject the null hypothesis that the coefficient on household size is statistically indistinguishable from zero, all that we can conclude is that *some multiple* factor markets (potentially including markets for

[3] Harvest labor is included in total labor demand for households in Uganda, because hired labor is not disaggregated by activity.

credit, insurance, or land) are failing. A detailed exploration of precisely *which* markets are failing requires structural estimation that is left to future analysis.

2. Data

The data for this paper are from the Living Standards Measurement Study and Integrated Surveys on Agriculture (LSMS-ISA) project, sponsored by the Bill and Melinda Gates Foundation and implemented by the national statistics offices of participating countries with technical expertise and oversight provided by the Development Research Group of the World Bank.[4] These nationally representative data sets cover a comprehensive set of demographic, health, economic and agricultural topics. Although there is variation in survey content between countries, efforts were made to ensure as much cross-national comparability as possible in questionnaire design and coverage. Panel data are available for some countries and will be available for all study countries in the coming years, though in this paper we make use of only a single cross section for each country. For each country we restrict the sample to households that report cultivation of a positive amount of land during the season under study.

Of the six LSMS-ISA countries – Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda – we use data from all but Nigeria, because the Nigeria data lack sufficient information on agricultural labor demand. Because the hypotheses of interest to this paper relate to market function within a cultivation period, we have not combined data across multiple cropping seasons. Instead, we use data relevant for the major cropping season in the most recent wave of each of the data sets. These are the 2011 cropping season in Ethiopia; the 2008/2009 rainy season in Malawi; the 2010 rainy season in Niger; the 2010 long rainy season in Tanzania; and the first cropping season of 2010 in Uganda.

Household-level summary statistics

Table 1 shows summary statistics at the household level for all five study countries. In Ethiopia, the average household has 5.24 members of all ages, with slightly more males than females. Just over 80% of households are male-headed. Education levels among household heads are the

[4] See the project website for additional details: http://go.worldbank.org/OQQUQY3P70.

second lowest of the study countries, at 1.61 years of education on average. Of the 2.81 acres owned by the average household, 76% is cultivated, 3% is left fallow, and 22% is used for all other purposes, including pastures, forest land, and renting out. The average household cultivates more than 11 plots, with each crop stand on a single parcel listed as a separate plot. Eighteen percent of cultivated acreage is described as rented or borrowed. Household allocate a majority of cultivated land to the production of staple grains – maize, sorghum, and teff – with significant allocation of remaining land to cash crops, pulses, and nuts.[5]

The next set of columns show similar statistics from the 2010-2011 Malawi survey. The Malawi survey includes over 10,000 households, only a quarter of which are designated as panel survey households. We restrict our analysis to the panel households because the labor demand modules given to cross-sectional and panel households are slightly different, and labor demand issues are central to the questions in this paper.

In Table 1 we see that households in Malawi are slightly (but not statistically significantly) smaller than those in Ethiopia, with 4.96 members on average. Household heads are far more educated on average (4.98 years of education) than in Ethiopia, and almost a quarter of households are female-headed. The average household owns 1.58 acres and owns or cultivates 2 separate plots.[6] Of the acreage owned by households, only a very small fraction is listed as "rented out".[7] Finally, crop distributions in Malawi are heavily dominated by maize production, which accounts for 1.45 acres of cultivated land on average. Farmers primarily use the remaining land to cultivate pulses, nuts, and cash crops.[8]

In the middle of Table 1 we show summary statistics for the Niger sample. Niger is the poorest country in the study. Households are especially large, encompassing almost seven people, on average. Only 8% of household heads are female. Educational attainment by household heads is the lowest among study countries, averaging less than one year completed. Households report significantly greater land ownership than in the other study countries, with average holdings of

[5] For Ethiopia, Malawi, and Tanzania we use only the primary crop listed on the plot, ignoring inter-cropping. However, the Uganda survey provides data on the percentage of land allocated to each crop at the plot level, and we use this information to distribute plot-level acreage to every crop listed on each plot.
[6] The definition of a "plot" varies between surveys, so that this statistic is not directly comparable across countries.
[7] We are not sure what to make of this figure, given that households in Malawi describe a much greater proportion of land as "rented in" than "rented out".
[8] For the summary statistics we define as cash crops all non-food crops, including tobacco, cotton, and sisal, as well as coffee and tea.

almost 12 acres. Although this statistic is driven in part by a small number of large landowners, the median household owns 7.4 acres, which is still larger than the average acres owned in any other study country. Farming households in Niger cultivate almost all of the land that they own, and rent an average of 1.6 acres of additional land for cultivation. Cultivation is concentrated heavily in sorghum, millet, and beans, with relatively small amounts of land allocated to other crops.

The next set of columns in Table 1 provides summary statistics for the 2010-2011 data from Tanzania. As mentioned above, agricultural variables for Tanzania refer only to the long rainy season. Not surprisingly, the demographic characteristics of households in Tanzania are more similar to those for Malawi than Ethiopia or Niger. The average sample household from Tanzania has 5.55 members, with slightly more females than males. Household heads are 25% female, and have 4.58 years of education on average. Households in Tanzania report owning less land than those in Niger, but much more land than those in smaller Malawi or more populous Ethiopia: 5.31 acres on average, 81% of which is cultivated and 15% of which is fallow. Only 2% of owned land is described as “rented out”, while 14% of cultivated land is listed as rented in or borrowed. Maize is the primary crop in Tanzania, with 2.2 acres of maize grown by the average household. Land allocation to the other crop categories – other grains, rice, tubers (including cassava), pulses and nuts, cash crops, and other crops (including banana) – ranges from 0.31-0.57 acres on average.

Finally, in the rightmost columns of Table 1 we provide a similar set of summary statistics for Uganda. Households in Uganda have 6.64 members on average, again with slightly more females than males. Only 71% of households in Uganda are male-headed. Households own 3.29 acres on average, and own or cultivate 5.65 plots. Ninety percent of owned land is cultivated, 7% is fallow, and essentially none is described as “rented out”. Households report cultivating just under 3 acres on average, 79% of which is owned and 21% of which is described as rented in or borrowed. Tubers, including cassava, account for the largest proportion of cultivated acreage, followed by pulses/nuts and “other crops” (which includes all bananas). Only 0.41 acres of maize are cultivated on average.

Factor market participation: Summary statistics

In Table 2 we present sample statistics for participation in land markets by sample households. Across study countries there is surprising consistency in the pattern of renting or borrowing land for cultivation, with percentages ranging from 23.2% in Tanzania to 36.6% in Uganda. The percentage of sample households renting land in is much larger than that renting land out. There is likewise general consistency in the average amount of land rented or borrowed in, with estimates in all countries but Niger lying between 0.44 and 0.55 acres. In Niger the average household cultivated almost two acres of rented or borrowed land. Average acres rented out is less than average acres rented in for all study countries, as one would expect in a sample restricted to households that cultivate, as the subsample of cultivators necessarily omits households that own but do not cultivate land, who are by definition net suppliers of rented land.

Turning to the market for agricultural laborers, Table 3 shows the percentage of households that report hiring workers for various non-harvest activities during the studied cultivation period. This is one area where there is substantial heterogeneity in the level of detail covered in the LSMS-ISA surveys, therefore cross-country comparisons should be made cautiously, if at all. Nevertheless the overall pattern of labor hiring is consistent across study countries, with approximately 30-50% of households hiring workers at some point during the cultivation season, not including the harvest. In Ethiopia and Tanzania, just under a third of households report hiring of some laborers (30.2% and 30.8%, respectively). For these two countries the distribution of hiring across activities is generally consistent, with the exception of very limited hiring for fertilizer application in Tanzania. In Malawi, Niger, and Uganda, over 40% of households hire workers. In Malawi and Niger the rate of hiring for non-harvest activities is almost twice that for the harvest. This is consistent with the widespread perception that if labor constraints bind because of seasonality in demand, they are most likely to do so in the harvest period (Benjamin 1992). The labor module in Uganda does not disaggregate activities by type.

The clear message of Tables 2 and 3 is that a large share of African agricultural households hire in labor, land, or both, in any given year. Even excluding harvest labor hiring and those households that hire themselves out as agricultural workers and do not hire others, at least a large minority of cultivating households participate in labor or land markets, or both. Clearly these markets exist and have sufficient numbers of transactors that households in large part act as price-takers. But the existence of markets with adequate transactional density is merely a necessary condition for the separation hypothesis to hold. As de Janvry et al. (1991) make clear, markets can fail idiosyncratically for specific households for any of a host of reasons.

Descriptive kernel regressions of labor hiring and labor demand patterns give a preview of the multivariate regression results we present in the next section, where we test the separation hypothesis formally. Figure 1 shows a local polynomial regression at the household level of the demand for non-household hired labor (person-days) on the household land-to-labor endowment ratio (acres owned per household member) in Ethiopia.[9] In aggregating labor across individuals, we count each child person-day as 50% of an adult person-day. Grey shading indicates the 95% confidence interval around the regression estimate.

There are two things to note in the figure. First, labor hiring is statistically significantly increasing in the number of acres owned per household member, as we would expect in a country with at least some agricultural labor market activity. Second, to the extent that any patterns are apparent in the figure, the relationship is concave at higher levels of owned acreage. Or, if linear, the slope of the regression line is clearly less than one. As the number of acres per household member increases, hiring of outside workers does not increase proportionally. In theory, this could be due to economies of scale in either household labor, hired labor, or both, although the empirical literature on smallholder agricultural production routinely supports the constant returns to scale hypothesis. However, this pattern is also consistent with labor or credit market failures that prevent households with greater need for outside laborers from hiring at optimal levels.

Figure 2 shows a kernel regression of total labor demand (family labor plus hired labor, in adult person-days) on total household size, again for households in Ethiopia. If labor markets were complete and competitive and the separation hypothesis held, we would expect to see no clear relationship between these two variables. Instead we see that total labor demand is increasing in the number of household members until a household size of 7, after which the regression line tapers off and becomes noisier. Although this figure does not constitute a formal separation test, because the underlying result does not condition on important covariates, it does suggest that there exists a strong relationship between household labor endowments and the application of labor on the family farm.

[9] The estimator for each of these figures is a local mean smoother using an Epanechnikov kernel and a bandwidth chosen using the Stata default optimal rule-of-thumb.

Figures 3-4, 5-6, 7-8, and 9-10 show similar pairs of kernel regression results for Malawi, Niger, Tanzania, and Uganda, respectively. The general patterns in Figures 3, 7, and 9 are consistent with that from Figure 1 for Ethiopia: hiring of outside workers in increasing in the number of acres per household member, but at a decreasing marginal rate. In Figure 5, however, we see no such pattern for households in Niger, particularly in the region over which most of the data are concentrated, i.e., below eight acres per person. Instead, the number of person-days demanded from outside workers is flat or even slightly decreasing in the household land:labor endowment ratio. One interpretation of this result, in combination with the observation that households in Niger rent significantly more land than those in other study countries, is that credit-constrained households borrow against expected harvest output to rent land, but that such loans cannot be converted into cash to hire workers.

In Figures 4, 6, 8, and 10, the picture is clearer and absolutely consistent with that of Figure 2. Total labor demand is increasing in household size in all study countries. This pattern anticipates the formal hypothesis testing results presented below, that household factor demand varies strongly with household labor endowments, contradicting the separation hypothesis implied by the canonical agricultural household model under the assumption of complete and competitive factor markets.

3. Regression results

In Table 4 we show summary statistics for the variables used in the country-specific regression estimates of equation 12. Median wages in local currency units are based on reported wages, including both cash and in-kind payments. These median wages are calculated at the smallest level of geographical aggregation with at least 10 observations (beginning at the zone, *grappe*, or TA level, depending on the country, and moving to larger areas as needed).[10] "Prime age" is defined as ages 15-60 years, while "Elderly" indicates age >60 years. The excluded demographic category is elderly male. Note that our household size variable is the sum of those two age categories; we omit children under age 15 so as to mitigate concerns about the possible endogeneity of household size and so as not to mix adults with young children unable or unlikely

[10] This measure has some shortcomings in this setting. In particular, counterfactual or marginal wages are likely underestimated in those places with potentially thin labor markets, because the probability of hiring (and therefore of observing a wage) is decreasing in the wage level.

to work. Note that we do, however, still count child contributions to agricultural labor demand, assuming that one child work day is equivalent to half an adult's work day.

The results of the basic ordinary least squares (OLS) implementation of the separation hypothesis test from equation 12 are reported in Table 5. All regressions are weighted by inverse sampling probabilities, and standard errors are clustered at the level of the zone (Ethiopia), TA (Malawi), *grappe* (Niger) or district (Uganda and Tanzania). All of the signs of the estimated coefficients in Table 5 are consistent with expectations, when statistically significant. The estimated elasticity of labor demand with respect to area cultivated ranges from 0.34 in Niger to 0.53 in Malawi and is statistically significant in all cases at the one percent level. It is not possible to determine whether the finding that this elasticity is less than unity is due to economies of scale, labor market constraints, credit market constraints, or some other factors. Only in the Malawi regression is the coefficient on median wages statistically significant, and it is negative as expected. The coefficient on wages is also negative in the Niger and Tanzania regressions, where the t-statistic is greater than one in absolute value and reasonably similar in magnitude, ranging from -0.08 to -0.16 across those three samples. The household composition variables are for the most part not statistically significant, although when they are we see that labor demand is increasing in the share of prime age adults and decreasing in the share of elderly females (relative to elderly males).

Finally, and most importantly for this paper, the null hypothesis of the separability of consumption and production decisions can be strongly rejected at the one percent level of significance in all regressions. The estimated elasticity of labor demand with respect to household size (i.e., number of adults) ranges from 0.21 in Uganda to 0.64 in Niger. The magnitude of this elasticity can be taken as a rough indicator of the depth of market failure. In this sense the findings are similar to those from the kernel regressions, in that demand side participation in labor markets appears weaker in Niger than in the other study countries. Although many households in Niger hire agricultural laborers (Table 3), the total amount of labor applied to farms in Niger is linked more closely to the (larger) size of Nigerien households than it is in the other study countries. Nevertheless, the consistent message in Table 5 is that across all study countries, agricultural households are not served by complete and competitive markets for factors of production.

Table 6 reports a set of robustness checks, in which we repeat the regressions from Table 5 but now include location fixed effects. The median wage variable necessarily drops out because it was constructed as a location median from observed wage payments. Results are very similar to those in Table 5, and the separation hypothesis can again be rejected overwhelmingly for all study countries.

Finally, Table 7 repeats the specifications from Table 6, but includes land endowments (log acres owned) as an additional explanatory variable. Under complete and competitive markets this variable, just like labor endowments, should not be related to labor demand as it merely affects the budget set faced by the household in its consumer role. Although the coefficient on log acres owned is only statistically different from zero in the Malawi and Niger regressions, the land and labor endowments are highly jointly significant in all cases, and still driven by household size coefficient estimates that remain large in magnitude and statistically significant at the one percent level. The F statistics for this joint test are shown in Table 7; all have p-values of zero. In fact, land endowments likely play a greater role in determining input demand than suggested by these regressions, because acres cultivated is highly correlated with acres owned, rendering their separate effects difficult to identify in a single regression. The implication is that market failures create a dependency on endowments that spans multiple factor markets.

Are there patterns in market failures?

The preceding results describe a generalized, structural failure of multiple factor markets in rural Africa. But are these problems perhaps especially concentrated among identifiable subpopulations? In order to explore that question we examine some of the household- and location-level correlates of factor market failure. Our approach remains strictly reduced form. In order to test whether a particular characteristic is associated with a greater or lesser degree of market failure, we include the variable in equation 12 both independently and interacted with the log of household size variable. We are especially interested to see if these new variables diminish the magnitude or eliminate the statistical significance of the estimated relationship between log household size and labor demand. Such a result would suggest that factor market failures affect primarily distinct subpopulations and are not generalized within rural Africa. We consider three sources of heterogeneity in access to complete markets: gender of the household head, distance from key points such as paved roads and large population centers, and agro-ecological zone.

Gender inequities in access to credit, inputs, labor, markets, public services and technologies are often presumed to be widespread in rural Africa. There is indeed significant prior evidence of productivity differences by gender (Udry 1996, Doss and Morris 2000). Likewise, greater distances from paved roads and trading centers may proxy for prohibitively high transaction costs, which prior studies have shown are correlated with agricultural productivity (Stifel and Minten 2008). Sub-optimal investment in infrastructure can lead to incomplete factor markets, for example through stock-outs of seeds and fertilizer (because of prohibitively high transaction costs) or thin labor markets. Lastly, we consider whether variation in agro-ecological zone, which serves as a proxy for agricultural potential, explains variation in the degree of market failure.

Table 8 shows the results of regressions with controls for the gender of the household head. Perhaps surprisingly, we find little evidence of heterogeneity in factor market performance by gender of the head. In all study countries other than Niger, the coefficients on both the level and interaction variables are statistically insignificant and of relatively small magnitude. In Niger, the average relationship between household size and labor demand is the same for men and women (because the mean value of log household size is just over 1 – see Table 4). However, women with smaller families demand *more* agricultural labor than women with larger families and the household size effect falls by more than 60 percent for female headed households relative to male headed ones. This unexpected result is almost surely due to highly non-random selection into being a female household head, especially one with a small family. Because there are many fewer female-headed households in Niger (about 12.5% of the sample) than in the other study countries (approximately 25% across all four countries), this finding may in part be an artifact of sampling variation, especially since it runs contrary to what one might naturally expect as the unique deviation of the lone predominantly Muslim country in the set. Overall, it does not appear that gender of the household head helps in explaining variation in the completeness of the markets facing rural households.

Distance variables are similarly uninformative. For each study country we estimated equation 12 including interactions and levels for four different distance variables (separately): distance from a paved road, distance from the closest town with 20,000+ inhabitants, distance from a large market,[11] and distance from the region or district capital. The majority of regression coefficients on distance variables were of negligible magnitude, and in no cases were the results of statistical and economic significance. Additionally, inclusion of distance controls did not have any significant effect on the coefficient estimate on household size, so that the estimated violation of the separability hypothesis was not attenuated in any of the samples. In the interest of space we have withheld this large set of null results. Those tables are available upon request. While it might be reasonable to conjecture that rural market failures would be most acutely felt in more remote areas, we find no evidence of such a pattern by any of several common measures of market access.

Lastly, we examine whether the degree of market failure varies with agro-climate. For each country we include in equation 12 a set of dummy variables and interactions with log household size for the relevant agro-ecological zones (AEZs). In each case we exclude the most common AEZ (at the country level). Because each country has only a small number of spatially correlated AEZs, we omit the location fixed effects and reintroduce price variables (as in Table 5).

To aid in interpretation, Table 9 shows the distribution of AEZs across households in each country sample, as well as the mean and s.d. of the log HH size variable. In most of the well-represented AEZs the mean of "Log HH size" is slightly greater than one.

Table 10 reports the regression results. In Malawi and Uganda there are no significant differences between AEZs. For Ethiopia, the only statistically significant difference (from the baseline category of cool, sub-humid tropics) is in the warm semi-arid areas, where smaller households in particular exhibit lower demand for agricultural labor. However, the interaction term with log of household size is not significantly different from zero in any of the AEZs and the magnitude and statistical significance of the coefficient estimate on log household size is essentially unchanged. In Niger there is likewise a level difference in conditional labor demand between AEZs, with greater demand in arid areas than semi-arid areas, but the interaction with log of household size is again not significant and there is no discernible effect on the log household size coefficient of interest. In Uganda there is no evidence of any effect of AEZ whatsoever.

[11] For households in Malawi the only available distance measure for markets was distance (km) to an ADMARC center.

Only in Malawi and Tanzania is there any indication that AEZ might affect the degree of rural market failures. In Malawi, although the AEZ variables have no independently statistically significant effect on labor demand, either on their own or interacted with household size, their inclusion does significantly reduce the magnitude of the estimated elasticity of labor demand with respect to labor endowments, although that estimate remains large (0.36) and statistically significant at the one percent level. So there is a significant effect, but rural market failures remain general and sizable in the Malawi data. In Tanzania, the function relating labor demand to household size in all of the included AEZs has a statistically different intercept and a slope from that of the excluded AEZ (warm sub-humid tropics). In all cases, conditional labor demand increases much more quickly with household size in the included AEZs than it does in the warm sub-humid tropics. Differences in the elasticity of labor demand with respect to household size range from 0.18 in the cool sub-humid tropics to 0.657 in the cool humid tropics. As long as we make comparisons only within Tanzania, this offers suggestive evidence that factor market failures are greater in areas outside of the warm sub-humid tropics that characterize the bulk of Tanzanian cultivation. This is not unsurprising, as it suggests that rural market failures are most acute where agricultural production is least concentrated.

4. Conclusions

Using a theoretically-grounded, reduced form test for complete and competitive markets, we have shown that the relationship between labor demand and household size is broadly consistent with the existence of pervasive multiple market failures across agrarian communities in five Sub-Saharan African countries. Despite widespread participation in labor and land markets by agricultural households across SSA, regression results based on a simple, reduced form exclusionary restriction derived from the first order necessary conditions of the household optimization problem indicate that household endowments influence factor demand in a way that is inconsistent with the separation hypothesis implied by the assumption of complete and competitive factor markets. This finding corresponds with the unconditional results suggested by simple kernel regressions of labor demand on household factor endowments. The overall conclusion supports the widespread but previously untested assumption among the development community: factor markets regularly fail African farmers. But we emphasize that the reduced form separation hypothesis tests implemented here, even though they rely on an analysis of labor market transactions, does not allow us to identify precisely *which* factor markets fail. In particular, these test results do not imply that labor markets fail, as violations of the separation hypothesis can occur even with perfectly functioning labor markets (Barrett 1996). The fact that a large share of agricultural households transact in rural labor and land markets suggests that the issue is less one of outright market absence than of structural barriers – perhaps related to financial intermediation, uncertain and expensive contract enforcement, weak physical infrastructure that results in high transactions costs, etc. – that impede efficient factor market functioning for most rural households. The fact that these market failures are not concentrated among households readily identified by location or gender signals that these market failures are general and structural.

As the development community and African governments increasingly intervene to try to rectify perceived market failures, the onus now falls on researchers to more precisely locate the sources and causes of factor market failures that impede productivity and income growth in rural Africa. Effective targeting of interventions depends on more precise, structural estimation that goes beyond the reduced form tests we offer in this paper. This will require methodological advances to take advantage of data now becoming available to help inform the design and evaluation of policies intended to help stimulate African agricultural and rural development.

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Figures

Figure 1. Kernel regression, non-household labor on land:labor endowment ratio, Ethiopia

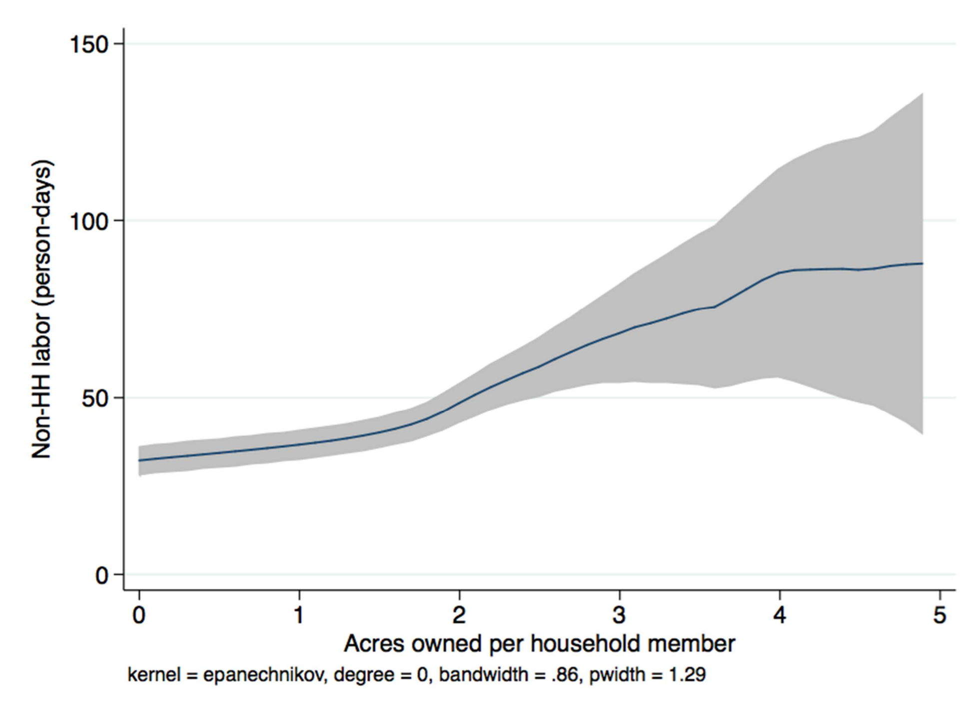


Figure 2. Kernel regression, total labor demand on household size, Ethiopia

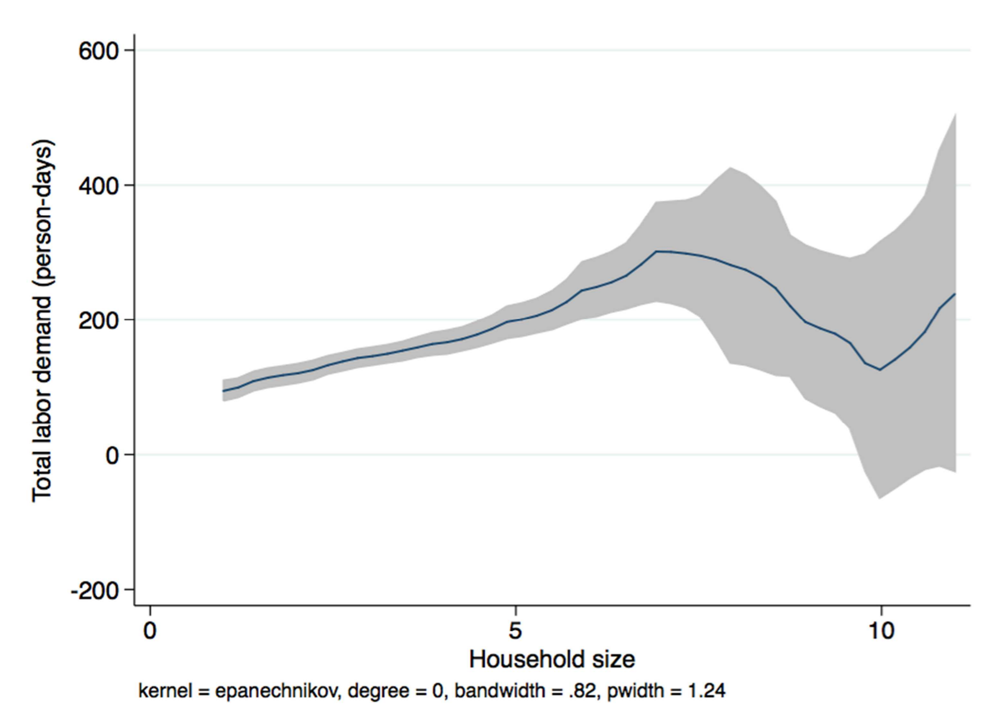


Figure 3. Kernel regression, non-household labor on land:labor endowment ratio, Malawi

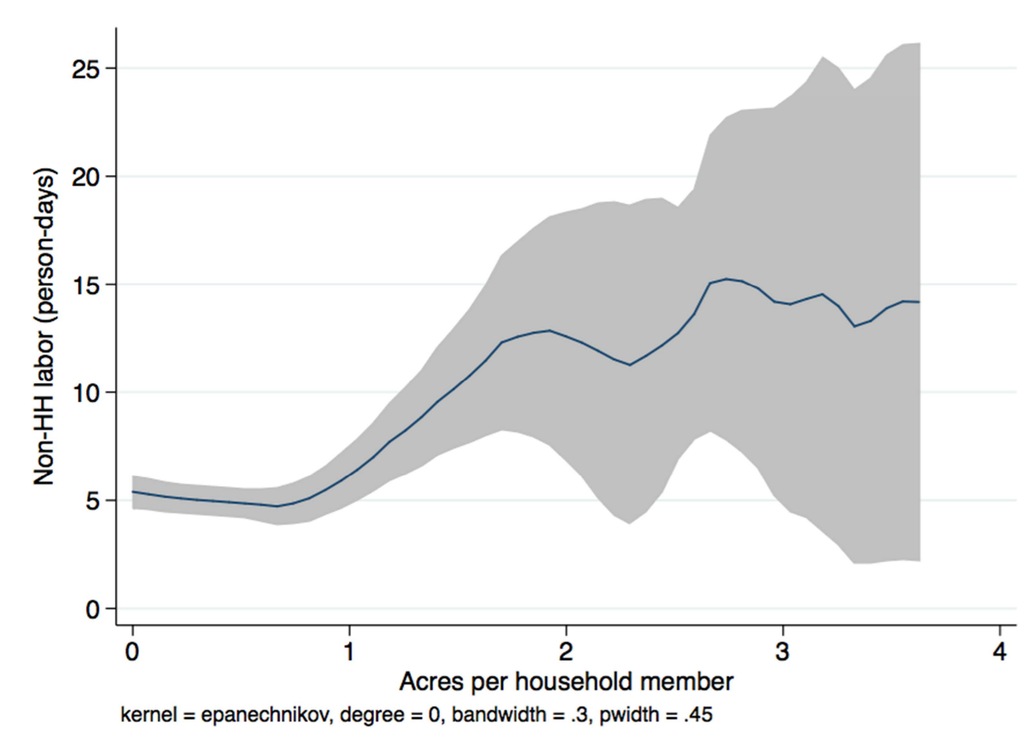


Figure 4. Kernel regression, total labor demand on household size, Malawi

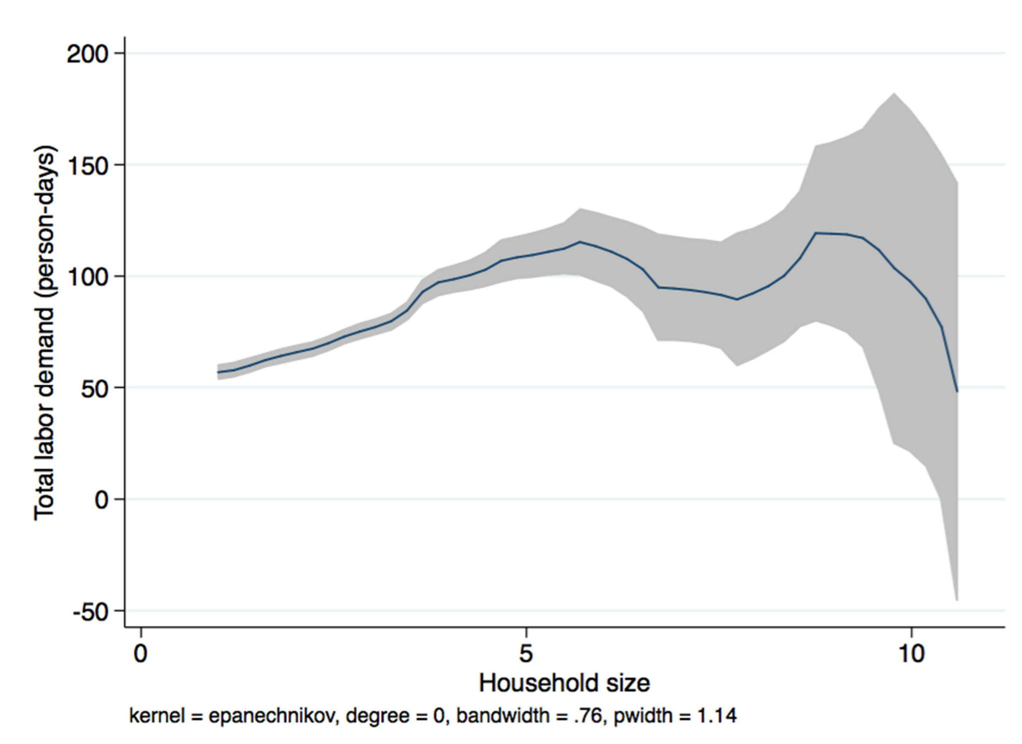


Figure 5. Kernel regression, non-household labor on land:labor endowment ratio, Niger

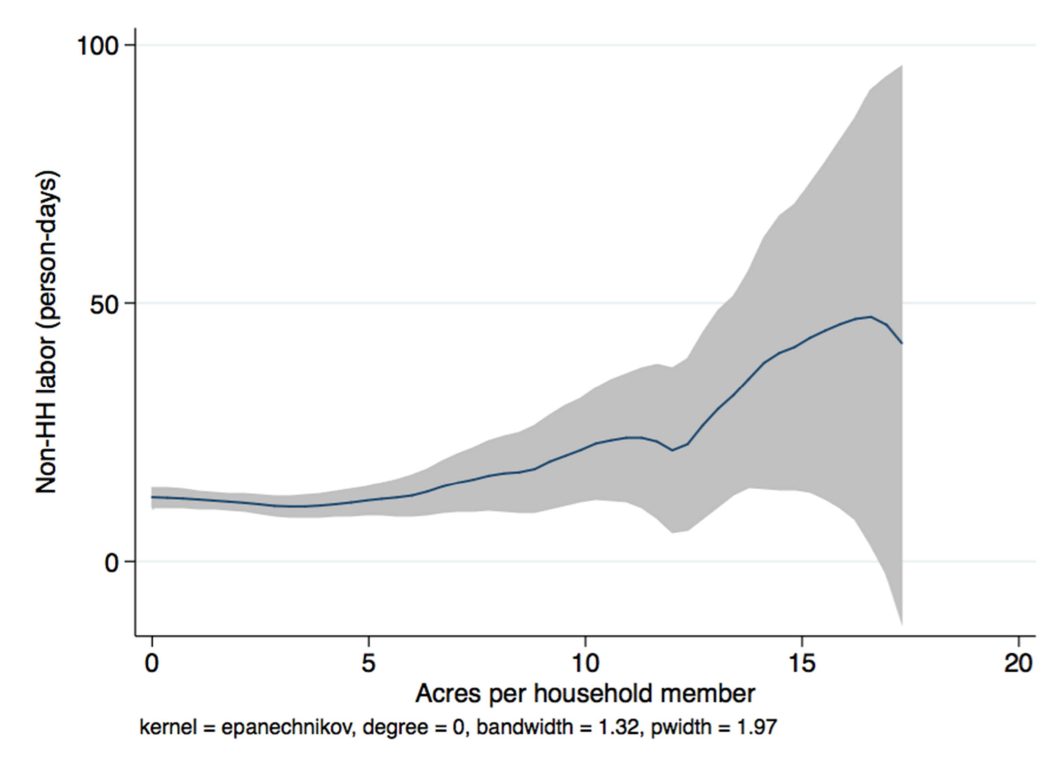


Figure 6. Kernel regression, total labor demand on household size, Niger

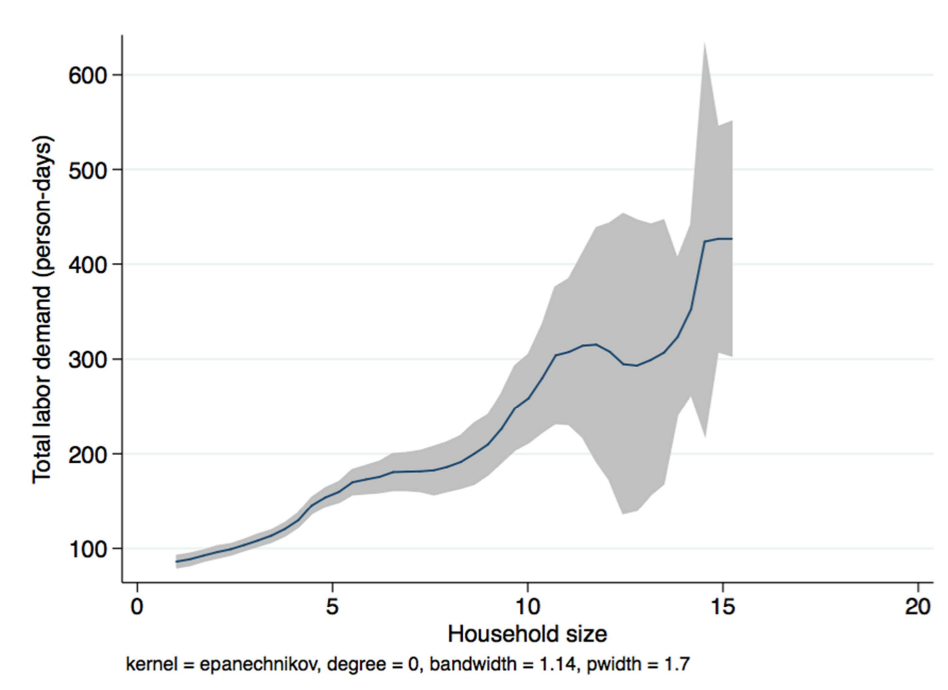


Figure 7. Kernel regression, non-household labor on land:labor endowment ratio, Tanzania

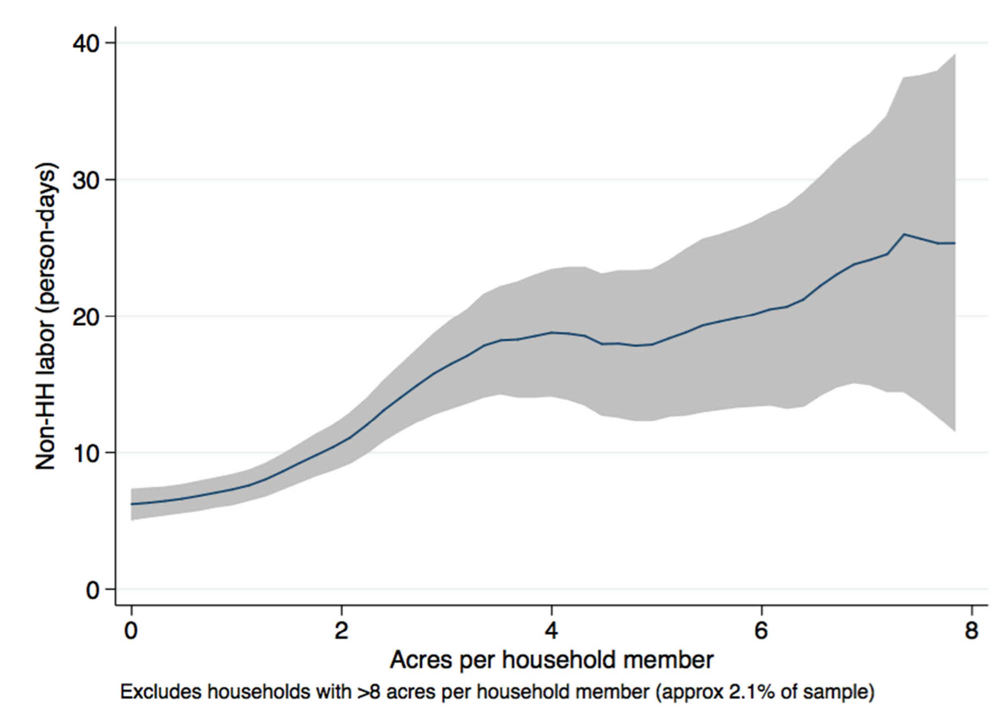


Figure 8. Kernel regression, total labor demand on household size, Tanzania

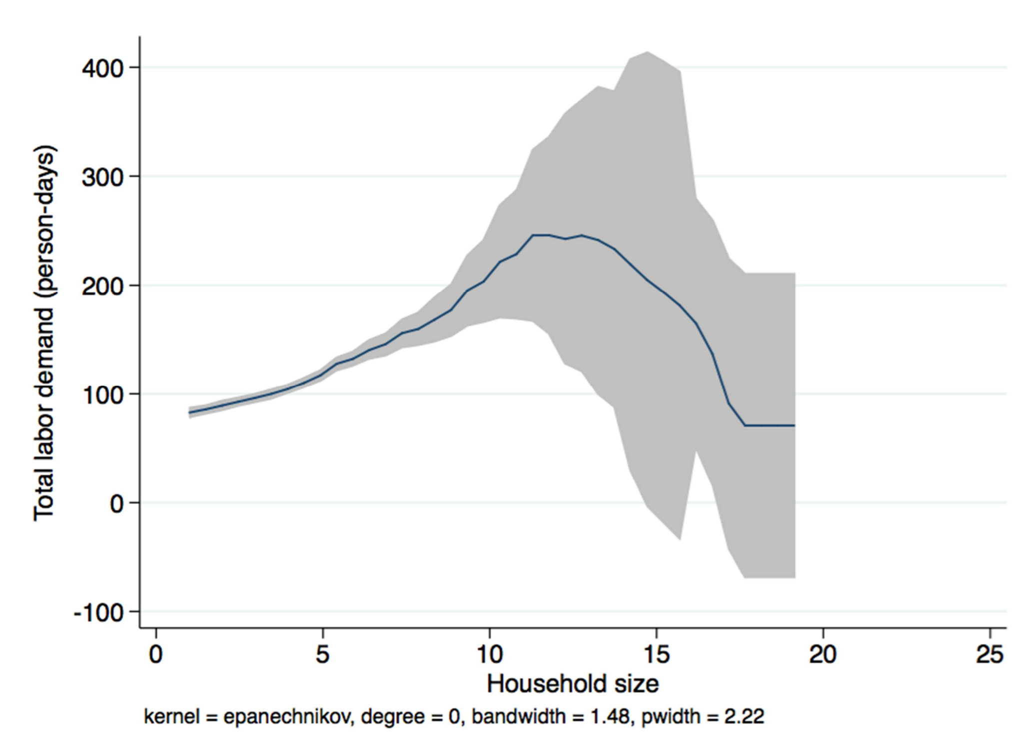


Figure 9. Kernel regression, non-household labor on land:labor endowment ratio, Uganda

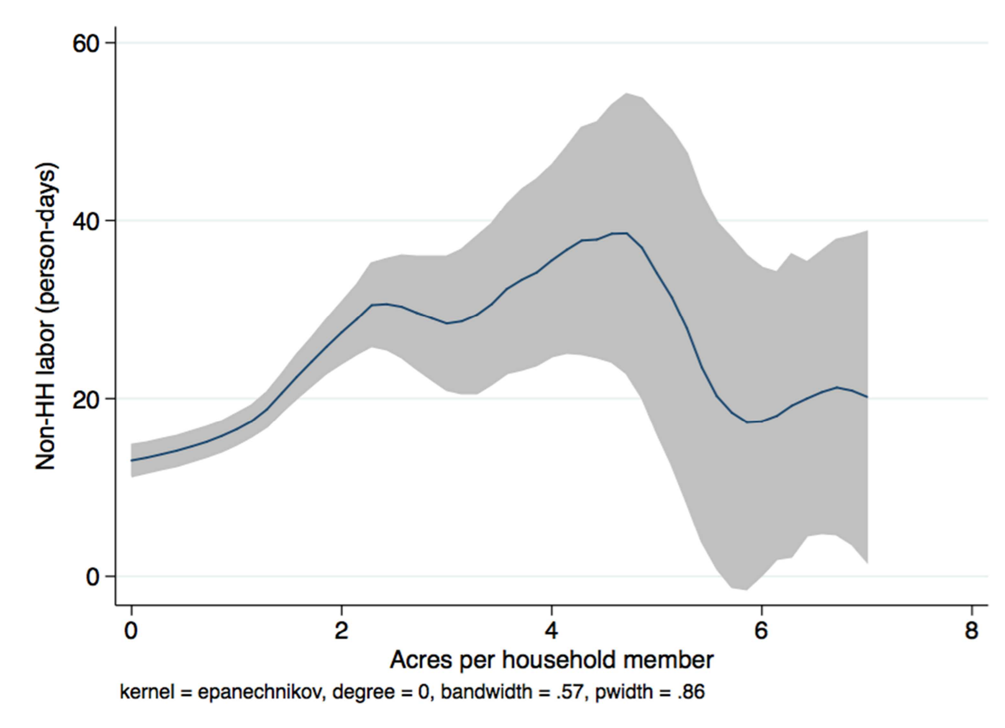
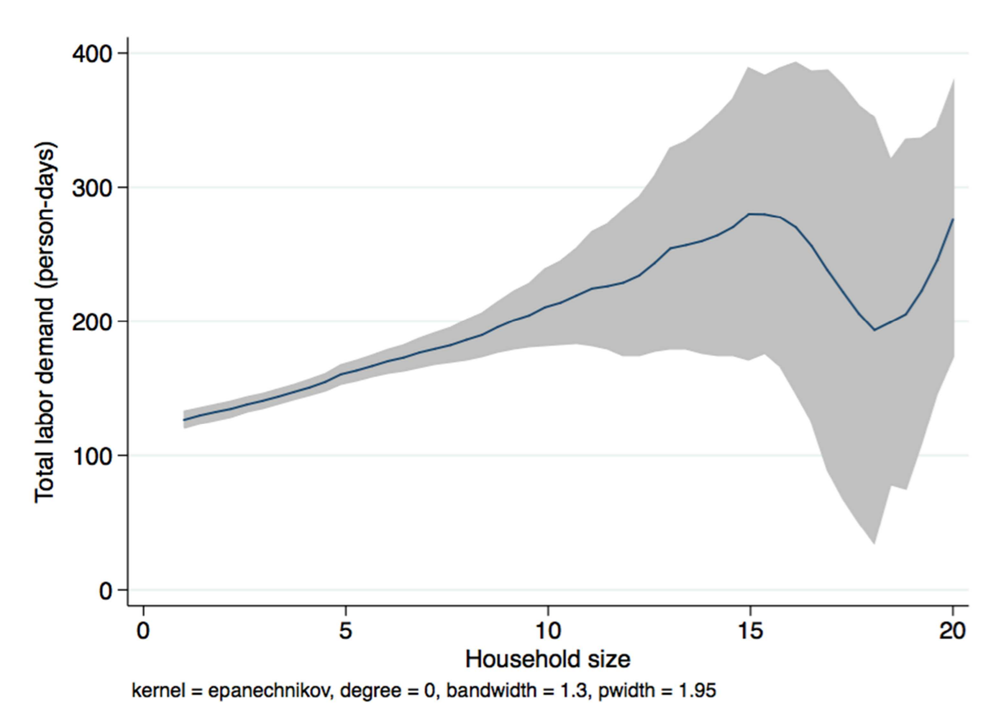


Figure 10. Kernel regression, total labor demand on household size, Uganda



Tables

Table 1. Household-level summary statistics for all study countries

	Ethiopia			Malawi			Niger			Tanzania			Uganda		
	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N
Household size	5.24	2.2	3094	4.96	2.29	2666	6.78	3.53	2339	5.55	2.95	2630	6.64	3.46	2135
Male head = 1	0.81		3094	0.77		2666	0.92		2339	0.75		2630	0.71		2135
Education of head (yrs)	1.61	2.72	3039	5.22	4.18	2646	0.87	2.35	2339	4.58	3.37	2582	4.69	3.34	1813
Number of males	2.66	1.52	3094	2.4	1.53	2666	3.37	2.09	2339	2.7	1.8	2630	3.22	2.09	2135
Number of females	2.56	1.38	3094	2.56	1.44	2666	3.41	2.11	2339	2.85	1.78	2630	3.43	2.11	2135
No. plots own/cultivate	11.69	7.33	3094	2.05	1.13	2666	3.04	1.96	2339	2.3	1.32	2630	5.65	2.69	2135
Acres own	2.81	5.25	3094	1.58	1.73	2666	11.98	19.65	2339	5.31	10.51	2630	3.29	10.27	2135
--- share cultivate	0.76	0.26	2790	0.99	0.1	2043	0.98	0.12	1969	0.81	0.34	2341	0.9	0.24	1952
--- share rent out				0.01	0.07	2043	0.01	0.08	1969	0.02	0.12	2341	0	0.05	1952
--- share fallow	0.03	0.11	2790	0.01	0.06	2043	0.01	0.07	1969	0.15	0.31	2341	0.07	0.2	1952
--- share other	0.22	0.24	2790	0	0.01	2043	0.01	0.07	1969	0.03	0.14	2341	0.02	0.14	1952
Acres cultivate	2.7	4.23	3094	1.92	1.73	2666	13.62	19.05	2339	4.31	7.93	2630	2.98	7.41	2135
--- share own	0.82	0.32	2810	0.79	0.39	2588	0.81	0.35	2202	0.86	0.32	2409	0.79	0.34	2073
--- share rent/borrow	0.18	0.32	2810	0.21	0.39	2588	0.19	0.35	2202	0.14	0.32	2409	0.21	0.34	2073
Maize: acreage	0.49	1.83	2826	1.45	1.27	2567				2.2	4.13	2402	0.41	2.21	2075
Sorghum: acreage	0.37	1.12	2826				2.42	4.49	2127						
Rice: acreage				0.03	0.23	2567				0.44	2.13	2402	0.03	0.21	2075
Millet: acreage							6.14	8.25	2127						
Other grains: acreage	1.01	1.54	2826	0.03	0.24	2567	0.13	0.74	2127	0.39	2.45	2402	0.21	0.88	2075
Tubers: acreage	0.02	0.09	2826	0.04	0.31	2567	0.05	0.41	2127	0.57	2.11	2402	0.94	5.14	2075
Pulses/nuts: acreage	0.32	0.88	2826	0.22	0.51	2567	4.56	6.44	2127	0.49	5.18	2402	0.62	2.47	2075
Cash crops: acreage	0.24	0.79	2826	0.18	0.57	2567	0	0.06	2127	0.34	2.25	2402	0.23	1.47	2075
Other crops: acreage	0.23	0.55	2826	0.01	0.1	2567	0.37	1.85	2127	0.31	1.83	2402	0.61	3.29	2075

Notes: "Other" categories cover missing data from the same column, e.g., "Other grains" in Tanzania includes sorgum and millet acreage; sample limited to panel households

Table 2. Participation in land rental markets

	Ethiopia*	Malawi	Niger	Tanzania	Uganda
N	3094	2666	2339	2630	2135
Household rents land out	6.1%	0.9%	1.2%	3.4%	0.4%
Household rents land in	19.5%	13.1%	7.3%	6.2%	18.1%
Household rents or borrows land in	30.3%	28.4%	27.7%	23.2%	36.6%
Acres rented out (mean)	0.500	0.017	0.098	0.139	0.006
Acres rented out (sd)	1.344	0.219	1.028	1.774	0.121
Acres rented in (mean)	0.480	0.451	1.912	0.444	0.551
Acres rented in (sd)	1.382	1.093	6.537	1.291	2.639

*Acres rented out is not identifiable in the ISA Ethiopia data; reported statistics are for "other" uses of land, which appears to be an upper bound on land rentals

Table 3. Percent of agricultural households hiring labor

Country	Activity	Number of households	Percent hiring workers
Ethiopia	*Cultivation*	3091	18.5%
	Harvest	2666	20.9%
	Overall	2666	30.2%
Malawi	*Non-harvest*	2605	32.6%
	Harvest	2605	16.0%
	Overall	2605	42.0%
Niger	*Preparation*	2339	19.5%
	Cultivation	2339	37.4%
	Harvest	2339	18.6%
	Overall	2339	47.8%
Tanzania	*Planting*	2630	18.5%
	Weeding	2630	18.9%
	Fertilizing	2630	2.6%
	Harvest	2630	16.0%
	Overall	2630	30.8%
Uganda	*Overall*	2109	46.8%

Table 4. Summary statistics of variables used in regressions

	Ethiopia	Malawi	Niger*	Tanzania	Uganda
Log labor demand (person-days)	4.257	3.851	4.287	4.332	4.756
	1.302	0.989	0.982	0.974	0.776
Log area (acres)	0.496	0.384	2.13	1.179	0.818
	1.332	0.82	1.124	1.05	1.001
Log median wage (local curr.)	2.768	5.563	6.998	7.82	8.761
	1.083	0.539	0.443	0.489	0.649
Log HH size	1.157	0.862	1.029	1.033	1.229
	0.457	0.454	0.46	0.498	0.571
Prime male share	0.326	0.408	0.431	0.408	0.361
	0.207	0.229	0.185	0.233	0.223
Prime female share	0.378	0.479	0.499	0.459	0.42
	0.21	0.238	0.167	0.229	0.226
Elderly female share	0.136	0.071	0.027	0.078	0.124
	0.204	0.206	0.111	0.192	0.208
N	2499	2556	2183	2346	2047

Notes: Authors' calculations from LSMS-ISA data sets

Table 5. Regression results from parsimonious OLS specification

	Ethiopia	Malawi	Niger	Tanzania	Uganda
Log area (acres)	0.489***	0.528***	0.343***	0.444***	0.379***
	(0.040)	(0.048)	(0.026)	(0.027)	(0.033)
Log median wage	0.036	-0.121**	-0.155	-0.077	0.012
	(0.051)	(0.052)	(0.107)	(0.065)	(0.043)
Log HH size	0.379***	0.399***	0.635***	0.399***	0.211***
	(0.055)	(0.061)	(0.061)	(0.043)	(0.044)
Prime male share	0.446**	0.036	0.008	-0.085	0.223*
	(0.186)	(0.140)	(0.198)	(0.136)	(0.128)
Prime female share	0.152	-0.068	-0.216	-0.147	0.314**
	(0.247)	(0.132)	(0.214)	(0.140)	(0.131)
Elderly female share	-0.371**	0.108	-0.416	-0.249	0.042
	(0.171)	(0.165)	(0.286)	(0.187)	(0.166)
Constant	3.454***	3.993***	4.045***	4.056***	3.869***
	(0.251)	(0.283)	(0.802)	(0.516)	(0.402)
R-squared	0.33	0.278	0.301	0.321	0.312
N	2499	2556	2183	2346	2047

Notes: Standard errors in parentheses; standard errors clustered at the level of the zone (Ethiopia), TA (Malawi), grappe (Niger) or district (Tanzania and Uganda); sampling weights used for all regressions; dependent variable is the log of total labor demand, defined as total person-days employed on all plots; children under age 15 are counted as 0.5 adults; harvest labor is excluded for ET, MW, NG, and TZ, but included for UG because it cannot be separately distinguished; population shares defined with respect to adults > age 14

Table 6. Regression results from parsimonious OLS specification w/ location FE

	Ethiopia	Malawi	Niger	Tanzania	Uganda
Log area (acres)	0.530***	0.447***	0.324***	0.421***	0.380***
	(0.045)	(0.045)	(0.029)	(0.029)	(0.032)
Log HH size	0.377***	0.515***	0.609***	0.488***	0.237***
	(0.045)	(0.056)	(0.070)	(0.046)	(0.039)
Prime male share	0.531***	0.061	0.141	-0.078	0.238*
	(0.138)	(0.128)	(0.195)	(0.134)	(0.137)
Prime female share	0.21	-0.069	-0.152	-0.124	0.312**
	(0.182)	(0.129)	(0.223)	(0.137)	(0.138)
Elderly female share	-0.214	0.085	-0.480*	-0.209	0.028
	(0.139)	(0.166)	(0.288)	(0.192)	(0.166)
Constant	3.230***	3.295***	4.052***	3.634***	3.019***
	(0.132)	(0.121)	(0.221)	(0.120)	(0.127)
District/zone FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.47	0.415	0.5	0.44	0.42
N	2765	2556	2183	2364	2047

Notes: Standard errors in parentheses; standard errors clustered at the level of the zone (Ethiopia), TA (Malawi), grappe (Niger) or district (Tanzania and Uganda); sampling weights used for all regressions; dependent variable is the log of total labor demand, defined as total person-days employed on all plots; children under age 15 are counted as 0.5 adults; harvest labor is excluded for ET, MW, NG, and TZ, but included for UG because it cannot be separately distinguished; population shares defined with respect to adults > age 14

Table 7. Regression results with district FE and both land and labor endowments

	Ethiopia	Malawi	Niger	Tanzania	Uganda
Log acres cultivated	0.529***	0.409***	0.298***	0.418***	0.362***
	(0.048)	(0.049)	(0.035)	(0.034)	(0.041)
Log HH size [A]	0.377***	0.519***	0.602***	0.488***	0.233***
	(0.045)	(0.056)	(0.071)	(0.046)	(0.039)
Log acres owned [B]	0.001	0.039***	0.024*	0.002	0.016
	(0.016)	(0.012)	(0.013)	(0.014)	(0.015)
Prime male share	0.531***	0.021	0.165	-0.077	0.241*
	(0.138)	(0.130)	(0.193)	(0.134)	(0.136)
Prime female share	0.209	-0.107	-0.136	-0.123	0.315**
	(0.183)	(0.133)	(0.222)	(0.137)	(0.139)
Elderly female share	-0.214	0.053	-0.473	-0.209	0.023
	(0.139)	(0.168)	(0.290)	(0.192)	(0.168)
Constant	3.231***	3.393***	4.066***	3.636***	3.051***
	(0.134)	(0.125)	(0.224)	(0.121)	(0.138)
District/zone FE	Yes	Yes	Yes	Yes	Yes
F-test (joint sig of [A] & [B])	35.08	45.56	42.12	56.54	18.38
R-squared	0.47	0.42	0.502	0.44	0.42
N	2765	2556	2183	2364	2047

Notes: Standard errors in parentheses; standard errors clustered at the level of the zone (Ethiopia), TA (Malawi), grappe (Niger) or district (Tanzania and Uganda); sampling weights used for all regressions; dependent variable is the log of total labor demand, defined as total person-days employed on all plots; children under age 15 are counted as 0.5 adults; harvest labor is excluded for ET, MW, NG, and TZ, but included for UG because it cannot be separately distinguished; population shares defined with respect to adults > age 14; for households with zero acres owned, "Log acres owned" = ln(0.01); F-test statistic is for a test of the joint significance of "Log HH size" and "Log acres owned"; all F-stats are signficant at the 10e-8 level

Table 8. Regressions results with controls for gender of household head

	Ethiopia	Malawi	Niger	Tanzania	Uganda
Log acres cultivated	0.530***	0.446***	0.329***	0.422***	0.380***
	(0.045)	(0.045)	(0.029)	(0.029)	(0.033)
Log HH size	0.414***	0.508***	0.673***	0.470***	0.258***
	(0.075)	(0.073)	(0.068)	(0.056)	(0.043)
Prime male share	0.548***	0.068	0.147	-0.081	0.246*
	(0.140)	(0.130)	(0.199)	(0.139)	(0.140)
Prime female share	0.211	0.005	-0.374	-0.114	0.278**
	(0.176)	(0.157)	(0.242)	(0.171)	(0.134)
Elderly female share	-0.231	0.183	-0.838***	-0.193	-0.018
	(0.140)	(0.211)	(0.310)	(0.229)	(0.160)
Head is female	0.117	-0.067	0.455**	-0.047	0.086
	(0.168)	(0.131)	(0.206)	(0.123)	(0.084)
Head is female x Log HH size	-0.225	0.001	-0.408**	0.067	-0.061
	(0.137)	(0.129)	(0.165)	(0.104)	(0.058)
Constant	3.200***	3.269***	4.090***	3.645***	3.000***
	(0.150)	(0.130)	(0.231)	(0.126)	(0.131)
R-squared	0.471	0.416	0.503	0.44	0.42
N	2765	2556	2183	2364	2047

St. errors clustered at EA level; sample weights used

Table 9. Log household size across agro-ecological zones

		Warm/ arid	Warm/ semi-arid	Warm/ sub-humid	Warm/ humid	Cool/ arid	Cool/ semi-arid	Cool/ sub-humid	Cool/ humid
Ethiopia	Count	34	133	101	7	1	868	1102	511
	Log HHS (mean)	1.28	1.11	1.10	0.97	0.69	1.17	1.19	1.15
	Log HHS (sd)	0.41	0.48	0.48	0.49		0.46	0.44	0.47
Malawi	Count		1191	789			271	305	
	Log HHS (mean)		0.85	0.85			0.88	0.94	
	Log HHS (sd)		0.45	0.46			0.43	0.47	
Niger	Count	416	1767						
	Log HHS (mean)	0.94	1.05						
	Log HHS (sd)	0.42	0.47						
Tanzania	Count		168	1355	28		88	658	45
	Log HHS (mean)		0.94	1.04	0.96		1.04	1.04	1.05
	Log HHS (sd)		0.47	0.50	0.51		0.55	0.48	0.42
Uganda	Count			62	1064			321	567
	Log HHS (mean)			1.21	1.25			1.22	1.20
	Log HHS (sd)			0.52	0.57			0.55	0.59

Table 10. Regression results with agro-ecological zones

	Ethiopia	Malawi	Niger	Tanzania	Uganda
Log acres cultivated	0.488***	0.528***	0.336***	0.439***	0.381***
	(0.041)	(0.048)	(0.026)	(0.027)	(0.033)
Log median wage	0.01	-0.124**	-0.212*	-0.094	-0.002
	(0.060)	(0.055)	(0.112)	(0.067)	(0.044)
Log HH size	0.357***	0.355***	0.659***	0.272***	0.225***
	(0.072)	(0.088)	(0.065)	(0.065)	(0.058)
AEZ T, W, A	-0.366		0.395**		
	(0.366)		(0.156)		
AEZ T, W, A x Log HH size	-0.276		-0.104		
	(0.183)		(0.108)		
AEZ T, W, S-A	-0.736*			-0.407**	
	(0.381)			(0.162)	
AEZ T, W, S-A x Log HH size	0.348			0.229*	
	(0.320)			(0.123)	
AEZ T, W, H	-0.953			-0.751***	
	(0.653)			(0.158)	
AEZ T, W, H x Log HH size	0.034			0.561***	
	(0.347)			(0.124)	
AEZ T, W, S-H		-0.049			0.258
		(0.102)			(0.172)
AEZ T, W, S-H x Log HH size		0.064			-0.039
		(0.112)			(0.131)
AEZ T, C, A	0.024				
	(0.183)				
AEZ T, C, A x Log HH size	0.06				
	(0.133)				
AEZ T, C, S-A		-0.078		-0.487**	
		(0.146)		(0.234)	
AEZ T, C, S-A x Log HH size		0.123		0.436***	
		(0.128)		(0.133)	
AEZ T, C, H	-0.17			-0.738**	0.069
	(0.191)			(0.325)	(0.114)
AEZ T, C, H x Log HH size	-0.08			0.657***	0.004
	(0.105)			(0.177)	(0.083)
AEZ T, C, S-H		-0.153		-0.388***	0.007
		(0.135)		(0.115)	(0.106)
AEZ T, C, S-H x Log HH size		0.111		0.180*	-0.076
		(0.130)		(0.101)	(0.077)
R-squared	0.348	0.278	0.308	0.337	0.319
N	2499	2556	2183	2346	2047

St. errors clustered at EA level; sample weights used; for agro-ecological zones, T="Tropics", W="Warm", C="Cool", A="Arid", S-A="Semiarid", H="Humid", S-H="Subhumid"; most common AEZ is omitted in each regression, which is: TCS-H for Ethiopia, TWS-A for Malawi, TWS-A for Niger, TWS-H for Tanzania, TWH for Uganda; all regressions control for share in HH population of prime age males, prime age females, and elderly females.