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Evidence from Uganda

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Abstract

Women comprise 50 percent of the agricultural labor force in Sub-Saharan Africa, but manage plots that are reportedly on average 20 to 30 percent less productive. As a source of income inequality and aggregate productivity loss, the country-specific magnitude and drivers of this gender gap are of great interest. Using national data from the Uganda National Panel Survey for 2009/10 and 2010/11, the gap before controlling for endowments was estimated to be 17.5 percent. Panel data methods were combined with an Oaxaca decomposition to investigate the gender differences in resource endowment and return to endowment driving this gap. Although men have greater access to inputs, input use is so low and inverse returns to plot size so strong in Uganda that smaller female-managed plots have a net endowment advantage of 12 percent, revealing a larger unexplained gap of 29.5 percent. Two-fifths of this unexplained gap is attributed to differential returns to the child dependency ratio and one-fifth to differential returns to transport access, implying that greater child care responsibilities and difficulty accessing input and output markets from areas without transport are the largest drivers of the gap. Smaller and less robust drivers include differential uptake of cash crops, and differential uptake and return to improved seeds and pesticides.

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Investigating the Gender Gap in Agricultural Productivity: Evidence from Uganda[†]

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I. INTRODUCTION

Women comprise 50 percent of the agricultural labor force in Sub-Saharan Africa, but manage plots that are 20-30% less productive than male-managed plots (FAO 2011). This agricultural productivity gap contributes to income inequality between women and men. In some cases, the productivity gap is also partially driven by an inefficient over-allocation of inputs to male-managed plots, resulting in large aggregate productivity losses for the agricultural sector (Akresh 2008; Udry 1996). The FAO estimates that closing the agricultural productivity gap globally could increase agricultural output in lower-income countries by 2.5% to 4%, reducing undernourishment by 12% to 17% or 100 million to 150 million individuals (FAO 2011).[1]

As sources of inequality and aggregate productivity loss, the country-level magnitude and drivers of the agricultural productivity gender gap (henceforth referred to as "the gap") are of great interest to policy makers. Investigation of the gap typically takes one of two approaches: 1) Inter-household analysis that uses agricultural production in female and male headed households as proxies for agricultural production on female and male-managed plots, and 2) Intra-household studies that use production on female and male-managed plots located within the same household as proxies for female and male-managed production in the overall sector.

Inter-household analysis commonly estimates the simple gap in mean yield between male and female households, and then tests whether the gap is driven by differences in resource endowment (distribution of resources) or return to resource endowment (technical efficiency).[2] The most common procedure for this test is to run a multivariate regression on the pooled sample of female and male-headed households and to observe whether there is a statistically significant correlation between gender of household head and yield after accounting for all observable endowments. If so, this remaining correlation is considered to result from a difference in technical efficiency between male and female headed households.

Another possibility is to estimate the technical efficiency of male and female-headed households using a stochastic production frontier and observe whether the mean difference in technical efficiency is statistically significant (Kinkingninhoun-Medagbe *et al.* 2010; Oladeebo and Fajuyigbe 2007).

Some inter-household analyses also test whether resources are allocated efficiently between male and female-headed households (allocative efficiency). One approach is to perform the above multivariate regression analysis with individual inputs, such as fertilizer or labor, as the dependent variable in place of yield. If there is a statistically significant correlation between input use and gender of household head after accounting for all observable characteristics, the input is considered to be allocated inefficiently between households. That is, given declining marginal returns to the input in question, redistribution of the input from male to female-headed households with the same characteristics but lower endowment of the resource in question would increase

[1] It is also commonly argued that redistributing household resources from men to women would improve efficiency through the channel of more optimal investment in human capital of the next generation - such as child health, education, clothing and nutrition (Bank 2011).
[2] For detailed reviews of the literature, see (Peterman, Behrman, and Quisumbing 2010; Quisumbing 1996)

overall agricultural yield in the sector (e.g. Horrell and Krishnan 2007). Another approach to test for allocative inefficiency is to estimate each input's marginal value product separately for male and female farmers and to observe whether this is above or below the input's factor price (Tiruneh *et al.* 2001).

Inter-household analyses of the gender gap tend to find a statistically significant and practically substantial gap in mean yield (or value of yield) of around 20-30% in favor of male farmers. The overwhelming conclusion from these studies has been that the gap is driven by differences in resource endowment between male and female headed households, rather than technical efficiency (Horrell and Krishnan 2007; Kinkingninhoun-Medagbe *et al.* 2010; Oladeebo and Fajuyigbe 2007), with a few exceptions (Holden, Shiferaw, and Pender 2001; Quisumbing 2001).

Characteristics accounted for in the tests for technical efficiency include physical inputs (organic and chemical fertilizer, crop protection chemicals, improved seed varieties, mechanization), human capital (labor, education, extension services, childbearing), quality of land and water access, land investment (duration left fallow, erosion control and water harvesting structures, planting of tree crops), access to credit and input and output markets, and informal institutional constraints (norms regarding division of crop production and assignment of household responsibilities).

One limitation of these tests for technical inefficiency is that they do not quantify the individual contribution of endowment differences relative to the simple difference in agricultural productivity. A detailed decomposition of the endowment gap would be useful for designing policy programs to close the gap and highlighting areas for future in-depth study.

Another limitation of inter-household studies is that, while the gap between male- and female-headed households is policy relevant in its own right, it is important to distinguish the inter-household gender gap from the overall gender gap. The majority of female-managed plots in Sub-Saharan Africa are located within male-headed households, the typical structure of which is fundamentally different from the typical structure of female-headed households. In particular, female-headed households are overwhelmingly characterized by cases where the husband has passed away, is a migrant laborer, or is polygamously married and member of a different household. Analysis of the inter-household gap therefore draws inference from a subset of female-managed plots quite distinct from the typical female-managed plot, and categorizes female-managed plots as "male" and vice-versa.

Finally, given fundamental differences between female-headed and male-headed households, these tests for technical inefficiency are likely to be invalid due to omission of important unobservable characteristics from the analysis.

To address the latter two concerns, intra-household analyses of the gender gap use plot-manager level agricultural data from panel surveys and restrict the study sample to households in which both male and female-managed plots are present. This allows these studies to use a fixed effects estimator to account for all unobserved household characteristics, as well as observed farmer and plot-level characteristics, substantially reducing the likelihood of omitted variables confounding the analysis.

The most rigorous of these studies first show that unobserved household characteristics and a set of plot-level characteristics are insufficient to completely explain the gap between female and male productivity. The authors then either introduce an omitted variable to explain the remaining gap, such as duration left fallow (Goldstein and Udry 2008) or physical and labor inputs (Udry 1996), or explore how the gap differs by household-level characteristics, either by introducing interaction terms (Akresh 2008) or re-running the analysis on separate samples (Akresh 2008; Peterman *et al.* 2011).

Intra-household studies performed so far have relied on small samples within geographically limited settings that raise concerns about the external validity of results within or across countries. The seminal paper, Udry *et al.* (1995), examines a sample of 150 households in six villages, while (Goldstein and Udry 2008) examine 60 married couples in four enumeration areas. We are aware of only one study (Akresh 2008) that examines nationally representative data using this method. There is no methodological reason that intra-household analysis cannot be performed on nationally representative panel data.

This intra-household analysis suffers from one of the same limitations of inter-household analysis in that, while it rigorously identifies one subset of characteristics that contribute to the gender gap, it does not quantify the contribution of the complete set of individual endowments to the gap. In cases where the gap is not fully explained (Peterman *et al.* 2011), the apparent difference in returns to endowments is not systematically explored.

A common solution to this problem in the labor economics literature has been to estimate the contribution of characteristics to the gap by examining changes in the coefficient on the gender indicator (the size of the gap) as covariates (characteristics) are sequentially introduced to the analysis.

Gelbach (2009), however, shows that the change in the coefficient on the gender indicator depends on the order in which the covariates are introduced and that estimates from this procedure are, in that sense, path dependent. Sequential addition of covariates also does not quantify differences in returns to inputs and characteristics between male and female farmers.

In some cases, returns to characteristics are estimated over the female and male samples separately and compared to more clearly identify areas where differences in returns exist (Hill and Vigneri 2011). The relevance of these differences in returns is not clear, however, unless they are scaled to the size of the endowment for that characteristic.

An alternative procedure often applied in labor economics is the well-known Oaxaca-Blinder Decomposition (Blinder 1973; Oaxaca 1973), described in detail in section 4. Kilic, Palacios-Lopez, and Goldstein (2013) apply this procedure for the first time to the agricultural productivity gap. O-B decomposition is not path-dependent and, within a partial-equilibrium framework, quantifies the relative contribution of factors to the gap. It decomposes contributions to the simple difference into a component accounted for by endowments (endowment effect) and returns to these endowments (structural effect).

Kilic, Palacios-Lopez, and Goldstein (2013) find that female-managed plots in Malawi are 25% less productive than male-managed plots, and that 82% of this difference is explained by observable characteristics. They find that the primary contributions to the endowment gap are higher levels of adult male labor and selection of export crops, and that the primary contributions to the structural gap are the child dependency ratio (less time to devote to productive activities) and returns to male labor (possibly difficulty supervising male household labor). They use recentered influence function decomposition to show that these results hold throughout the productivity distribution.

This analysis is performed on cross-sectional data, however, that does not include within-household variation in gender of plot manager. In that sense, the decomposition is still an arbitrary procedure in that it relies on the assumption that the mean of unobservable characteristics conditional on observable characteristics is equal to zero – the zero conditional mean assumption (Fortin, Lemieux, and Firpo 2010) - and it is not clear which characteristics must be included in the analysis for this assumption to hold.

To increase the likelihood that zero conditional mean holds, we introduce panel-data methods to the O-B decomposition of the gender gap in agricultural productivity to account for unobserved community, household and farmer characteristics.

A potential drawback of our approach is that it cannot separately account for the contribution of observable household and farmer-level characteristics. To address this limitation, we first estimate the relative contribution of these characteristics by reducing the specification to control only for unobserved regional characteristics. This approach, however, suffers from the same omitted variable bias the fixed effects were meant to obviate.

As a robustness check, we therefore decompose the household and community-season fixed effects extracted from our full specification into components accounted for by specific observable variables. We are therefore able to simultaneously control for unobservable variables at the person, household, and community levels and to quantify the relative contribution of observable household, person and community characteristics to the gap.

II. Ugandan Context

The agricultural sector employs 66% of Uganda's working population and accounts for one-fourth of its GDP (World Bank Development Indicators 2013). The population growth rate of Uganda is one of the highest in the world (the UN predicts the population will double by 2050 in the most conservative scenario).

But despite the sector's clear importance to poverty reduction, inclusive economic growth and food security, agricultural productivity increases have stalled in recent years (2.2%) – below the population growth rate (3.2%), and well below the Comprehensive Africa Agriculture Development Programme (CAADP) target (6%). To address weakness in the sector, the government launched the 5 year Agricultural Sector Development Strategy and Investment Plan (DSIP) in 2010, which targets improvements in rural household incomes, food security, and malnutrition.

Women make up the majority of Uganda's agricultural labor force (53%) and a higher proportion of female workers are employed in agriculture (76%) than are male workers (62%). Thus the gap in productivity between male and female managed plots is of meaningful concern both to GDP growth and to the distribution of income between men and women.

Using a 2003 cross section collected from 123 communities in 8 of Uganda's 111 districts, (Peterman *et al.* 2011) estimate the size of the raw gender gap (the difference in mean value of crop production per acre between female and male farmers) for these areas to be 50%. This productivity gap remains statistically significant even after controlling for farmer and plot characteristics, inputs applied, and household fixed effects. The 2010 DSIP highlights the potential, in this context, for gender targeted interventions to achieve large productivity increases.

III. Data and Descriptive Statistics

We use data from the first two rounds of the Uganda National Panel Survey (UNPS), collected in 2009/2010 and 2010/2011 by the Uganda Bureau of Statistics (UBOS) with support from the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). The UNPS attempts to track and interview a nationally and regionally representative sample of 3,123 households interviewed for the Uganda National Household Survey (UNHS) in 2005/2006. The sample after attrition and the tracking of new split-off households was 2,975 for the 2009/2010 wave and 2,716 for the 2010/2011 wave.

Each household was interviewed twice per year, with six month intervals, and administered a comprehensive household questionnaire that collected disaggregated information on household demographics, education, health, labor, income sources, and access to financial services, assets, expenditure and consumption, among other topics. Households with agricultural activity were administered a detailed agricultural module that collected information on characteristics of the current land holding (owned, rented-in, and rented-out), as well as cropping and input decisions and crop output disaggregated at the plot-crop level. The agriculture module also includes information on training and extension services received by the household, livestock, and farm assets. Information on the harvest allows for clear identification of the plot owner(s), manager(s) and worker(s), including their gender.

We restrict our sample to season-plots for which non-zero crop harvest was reported during the relevant 6-month period, and for which none of our explanatory variables are missing. To allow the analysis to account for unobserved household-level characteristics, and to focus the analysis on within-household dynamics of similarly structured households, we restrict the sample to households in which the head is married, both the head and spouse cultivate at least one plot within the two sample years, and at least one plot is cultivated within each year. To simplify the analysis, we also exclude plots jointly managed by the head and spouse, although the results of our within-estimator (table 3) are consistent whether or not jointly-managed plots are included. Our final restricted sample thus includes 6,999 plots cultivated by 630 couples of which 3,499 are managed by females and the remaining 3,500 by the male spouses.

Table 1 presents the household-level descriptive statistics disaggregated by region. Sampled households include, on average, 7.1 household members, with a child dependency ratio, defined as the number of children under 10 years of age divided by number of household members over 10 years of age, of 0.7 children. Although female heads in the sample of married couple households are less than 3%, women on average managed close to 50% of their respective households' cultivated land. The share of woman-cultivated land, about 60%, is higher in the Western region than the rest of the regions where the share is reported to be less than the overall average.

As expected, subsistence farming is by far the most important source of livelihood to the sampled households, ranging from 52% in the Central region to 76% in the Northern region. It is consistent with the fact that the

Central region, with the location of Kampala and other major urban areas within this region, is relatively more commercialized while the Northern region, still recovering from the protracted civil conflict, is particularly a drought prone area. The importance of wage employment and non-agricultural enterprises in the Western region are more or less comparable to that of the Central region.

The mean value of household assets is highest in the Western region, followed by the Central, Eastern and North. The largest component of household assets is land (76%), followed by household dwelling (23%) and other physical assets (6%). Land value is by far highest in the Western Region, while value of household dwelling and physical assets is highest in the more urban Central region.

Plot-level descriptive statistics with significance tests of mean differences by gender of plot manager, as well as by region, are presented in Table 2. As can be seen, the figures exhibit a significant difference in the value of crop output per acre between male and female managed plots, productivity of the former being at the mean 23% higher than female managed plots.[3] This is widely in line with the gender gap observed elsewhere in Sub-Saharan Africa ranging from 20 to 30 (FAO 2011). Regional variations in productivity are evident; the Western being the most productive region (USD 192 per acre per season) followed by the Central (USD 159) and then the Northern (USD122) and Eastern (USD 108) regions, which are roughly about 15% and 25% below the country's average of USD 144 per acre per season.

The average plot size is estimated at 0.7 acres, with male managed plots being significantly larger (0.85 acres) than female managed ones (0.54 acres). Given the inverse farm size productivity relationship, an empirical regularity in Sub-Saharan Africa (Larson *et al.* 2012), this difference in plot size has implications for the observed productivity gap between male and female operated plots that will be seen in the econometric results below. On the other hand, self-reported plot characteristics do not otherwise seem to explain the observed gap in the value of crop output. Soil quality broadly defined as good, fair and poor is by and large similar across male and female managed plots; slightly significantly fewer plots (5.5% vs. 6.9%) of the former are reported to be poor quality than the latter. Almost all of the plots are rain-fed (96.7% of female plots vs. 95% of male plots). Although the proportion of irrigated land is extremely low across the entire sample, the share of male irrigated plots is twice that of female irrigated plots (2.6% vs. 1.3%). Male managed plot are also more likely to be flat (48% vs. 43%) and less likely to be hilly (8% vs. 12%). Distances of plots from the homestead appear to be overall balanced between male and female managed plots. And incidence of plot-level investment in the form of erosion control and water harvesting structures are the same even if slightly more of the male managed plots (83%) are owned by the household than female managed plots (81%).

Unlike plot characteristics, the data show a clear distinction in plot manger characteristics. Female managers are on average 5.6 years younger and have 2.2 years less formal schooling than their male counterparts. Overall, access to extension services is very low, with about 20% and 10% of the plot managers receiving extension services under the government supported NAADS program[4] and other providers, respectively. Both types of

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[3] It is difficult to compare physical yield as plot managers cultivate different types of crops and we will lose substantial statistical power if we were to restrict the sample to just one crop. As a result, value of output per acre (in USD) is computed using unit values of each crop collected at the time of the survey.

[4]The National Agricultural Advisory Services Organization (NAADS) is a semi- autonomous public agency within the Ministry of Agriculture Animal Industry and Fisheries, responsible for public agricultural advisory/extension services in Uganda. The National Agricultural Advisory Services (NAADS) Programme was created in 2001 by an Act of Parliament

extension services are less likely to be received by female mangers: 23% of males vs. 17% of females, and 14% of males vs. 7% of females receive NAADS and other extension services, respectively.

Intensity of input application is often cited as a key determinant of the gender productivity gap. Material input use, however, is strikingly low in Uganda: improved seeds were used on 7%, manure on 4%, chemical fertilizer on 1% and pesticides/fungicides on 5% of plots. Despite these low levels of material input use, female managers are significantly less likely than males to apply any of the aforementioned. For female managed plots on which these inputs are applied, the quantity per acre is also significantly lower for both chemical fertilizers and pesticides/fungicides compared to male managed plots on which they are applied.

Given the subsistence nature of crop production, family labor is the main input applied to 96% of both male and female plots in the sample. Counterintuitively given the observed yield gap, female managed plots receive more labor days per acre of cultivated land (140 versus 121 days for male managed plots per acre). Since the data do not allow disaggregation of labor days by gender or age, we are unable to identify the difference, if any, in the composition of family labor applied to male and female managed plots. On average, hired labor is applied to 31% of male managed plots versus 23% of female managed plots, but the difference in number of days of hired labor per acre (9 vs. 7 days per acre) applied does not compensate the difference in family labor days per acre.

Aside from significant differences in labor inputs by gender, cropping patterns are also significantly different between male and female managed plots. Female mangers cultivate more roots, pulses and oilseeds, while male mangers are involved more in the cultivation of cereals, bananas and cash crops such as coffee. However, differentials in crop patterns by gender vary significantly across regions. In the Western region, 45% of land managed by men is planted under cash crops (including banana, which is a dual crop) versus on 17% across regions. In the North, a higher proportion of male managed land is dedicated to the cultivation of pulses and oil than female managed land, while the inverse in true for cereals. This variation in the repartition of activities between men and women could reflect either differences in cultural practice or agro climatic zone.[5]

IV. OLS Within-Estimator and Results

We first examine the existence and magnitude of the gender productivity gap following a standard approach in the empirical literature before delving into the factors that contribute to the potential male-female productivity differences. By restricting the sample to households with more than one plot that are separately cultivated by male and female mangers, the plot-level gender gap in agricultural productivity has thus typically been estimated using a simple yield function of the following form (Udry 1996):

$$Y_i = \beta Z_i + \gamma G_i + \lambda_h + \varepsilon_i, \tag{1}$$

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to specifically address constraints of lack of access to agricultural information, knowledge and improved technology among rural poor farmers in the country.

[5] The differences in means by gender disaggregated by regions are available upon request from the authors.

where Y_i is the log of yield (crop output per planted area) or value of yield for plot i; and Z_i is a vector of covariates including land characteristics, agricultural inputs per planted area (chemical, organic, labor, etc.), crop variety, and farmer characteristics; G_i is a binary variable capturing the gender of the manager of plot i; λ_h is a fixed-effect that captures all time-invariant characteristics of household h; and ε_i is an error term.[6] In some cases, this model is extended to include panel data and crop fixed effects.

In our case, we estimate the following equation:

$$Y_{it} = \beta X_{it} + \gamma G_{it} + \lambda_h + \varphi_{et} + \varepsilon_{it}, \qquad (2)$$

where Y_{it} is the log value of yield in 2005 USD on plot i during season t. X_{it} is a vector of characteristics for plot i in season t, which includes plot physical characteristics, plot manager characteristics, inputs (labor, non-labor), and cropping patterns. G_{it} is a binary variable capturing the gender of the manager of plot i in season t, λ_h is a fixed-effect that captures all time-invariant characteristics of household h, φ_{et} is a fixed-effect that captures all time-variant characteristics of community (enumeration area) e in season t, and ε_{it} is the error term.

We test the hypothesis that $\gamma = 0$ (that the yield on female-managed plots is not systematically different from the yield on male-managed plots). We first estimate a naïve regression only with the plot manger's dummy. We then control for all the covariates including household and time-variant community fixed effects. This would allow us to get an insight on the direction of the omitted variable bias in estimating the differences in productivity between male and female managed plots.

Econometric Results

Empirical results from estimating equation (2) are given in table 3. Specification 1 shows the "raw" gap between male and female-managed plots absent of any controls – this is 17.5% which is statistically different from zero at the 1% level. Specification 2 shows the final gap after adjusting for household and community-season fixed effects, plot characteristics (distance to plot, soil quality, slope and topography, irrigation, and tenure), farmer characteristics (age, education, exposure to extension), crop choice, and input use (labor, improved seed, fertilizer, and crop protection chemicals). A large and statistically significant gap of 37.7% exists after the inclusion of all parcel-level observables and household and community-season effects. This implies that omitted variable bias may underestimate the underlying productivity gap between male and female managed plots.

While the point estimate from this exercise is of interest, it does not allow us to account for the degree to which observable and unobservable characteristics contribute to the gender productivity gap. One solution would be to sequentially introduce covariates to the raw gap and estimate the contribution of each covariate as the change in the coefficient on the gender indicator resulting from its inclusion. These estimates would be biased, however, to the degree that the sign on the contribution could even be reversed, depending on the order in which the covariates were introduced (Gelbach 2009).

[6] Studies that rely on gender of the household head as an identification strategy rely on cross-section estimation and include household characteristics in lieu of household fixed effects.

Oaxaca-Blinder Decomposition and Results

To highlight the relative contribution of differences in endowments to the productivity gap, we instead decompose the full specification using the Oaxaca-Blinder approach standard in the labor economics literature (Fortin, Lemieux, and Firpo 2010). Specifically, we estimate the twofold Oaxaca-Blinder decomposition:

$$\bar{Y}_{MK} - \bar{Y}_{FK} = \sum_{k=1}^{K}[(\bar{X}_{MK} - \bar{X}_{FK})\hat{\beta}_{K}{}^{*}] + \sum_{k=1}^{K}[\bar{X}_{MK}(\hat{\beta}_{MK} - \hat{\beta}_{K}{}^{*})] + \sum_{ik=1}^{K}[\bar{X}_{FK}(\hat{\beta}_{FK} - \hat{\beta}_{K}{}^{*})] + (\hat{\beta}_{M0} - \hat{\beta}_{F0}), \quad (3)$$

where $\bar{Y}_{MK} - \bar{Y}_{FK}$ is the raw mean difference in log value of yield between male and female farmers, $\bar{X}_{MK}$ and $\bar{X}_{FK}$ are the average values of covariate *K* for men and women, respectively, $\hat{\beta}_{F0}$,$\hat{\beta}_{FK}$, $\hat{\beta}_{M0}$ and $\hat{\beta}_{MK}$ are the returns to covariate *K* estimated by the OLS model run over the female and male samples separately, and $\hat{\beta}_{K}{}^{*}$ are the returns to covariate *K* estimated by the OLS model run over the pooled sample of female- and male-managed plots.

This approach decomposes the raw gap between male and female farmers into a component accounting for differences in endowment of covariates (evaluated at the mean of the estimated coefficients for the male and female samples) and a structural component reflecting differences in returns to endowment for female and male farmers. The aggregate contribution of endowments (the first term) is equal to the difference between the raw productivity gap and the remaining gap once all characteristics in the decomposition are accounted for. This term can be interpreted as the change in the value of output that would occur if female plot managers had the same values of X as male plot managers. The aggregate unexplained contribution (terms 2-4) is equal to the remaining gap once all characteristics in the decomposition are accounted for. The sum of these terms can be interpreted as the change in female value of output per hectare that would occur if men and women had the same returns to the coefficient vector ***X***.

The decomposition is performed within a partial equilibrium framework in that the comparison coefficients $\hat{\beta}_{K}{}^{*}$ are assumed fixed for the purpose of these counterfactual comparisons. Additionally, the aggregate decomposition assumes overlapping support, which requires that no single value of observed or unobserved characteristics is sufficient to identify group membership. This would be the case, for instance, if female plot-managers exclusively applied a given technology. Finally, the aggregate decomposition requires that the distribution of any omitted variables conditional on X be the same for the two groups (Fortin, Lemieux, and Firpo 2010).

The detailed decomposition separates the aggregate decomposition into endowment and unexplained components corresponding to the value of the terms for each individual variable *k* in equation (3). This relies on the additional assumptions of additive linearity and zero conditional mean – that the mean of any omitted variables conditional on ***X*** be zero. For cases where zero conditional mean does not hold, panel data methods can correct for the resulting omitted variable bias.

Results

Table 4 shows the O-B decomposition of the productivity gap accounting for unobserved household and community-season effects in column 1. Counterintuitively, female farmers have an endowment advantage of 12%. The majority of this advantage (72%) is accounted for by the smaller planted area of female-managed plots in the context of strong inverse returns to area planted. Using an earlier round of this panel data set (UNHS 2005/2006) (Carletto, Savastano, and Zezza 2013) corroborate the presence of strong inverse returns to planted area in Uganda and, furthermore, compare GPS and self-reported plot area measurement to show that this result is not a product of measurement error in self-reported land size.

The other major contributor to the female endowment advantage is the higher number of family labor days applied to female-managed plots per acre. This is partially, but not entirely, offset by higher application of hired labor to male-managed plots, so that the net contribution of family and hired labor accounts for the remainder of the female endowment advantage (25%). But the data do not allow us to disaggregate the endowment of family labor by gender or age.

Another striking result is that the combined contribution of material inputs to the gap, 1.8 percentage points, is insubstantial as a result of the extremely low overall application of these inputs. The strong statistical significance of the contribution from application of improved seeds and pesticides, and weak significance of the contribution from manure, however, suggest that material input use may become an important contributor to the gap as these technologies proliferate.

Although female cultivators are disadvantaged by being less likely to cultivate cash crops, they are partially compensated by greater likelihood to cultivate roots, pulses and oilseeds, so that the net contribution of crop choice to the gap is only 2.4 percentage points. However, female farmers who do plant banana and roots receive a much higher return from doing so than male farmers who plant these crops, an effect which entirely offsets the male advantage in crop selection.

The drawback of this approach is that the detailed decomposition can be applied only to parcel-level characteristics while accounting for unobserved household, person, and community-season characteristics. To get a sense of the contribution of observable household and community covariates, we estimate the decomposition again with only region-season fixed effects.

Column 2 of table 4 shows the O-B decomposition accounting for region-season level unobserved characteristics only. The most striking result from the decomposition of household-level characteristics is the extremely large and statistically significant contribution from return to the child dependency ratio of 13 percentage points, accounting for 74% of the overall gap. This implies that child-care activities differentially constrain female farmers' ability to supervise or perform labor activities on their plots.

Female productivity is also affected differentially by distance to nearest major road. This may reflect lower mobility due to household obligations, access to transport, or informal social institutions regarding female travel. The difference in return contributes 6 percentage points to the gap, but is only weakly significant.

Men benefited marginally from greater access to NAADS extension services (.4 percentage points) but received no greater return from this access. Return to the value of household livestock contributes 3.7 percentage points to the gap. The value of livestock is a proxy for male wealth since, outside female-headed households virtually all reported livestock is controlled by males. This is consistent with resource constraint in the context of credit-market failure.

Finally, unobservable characteristics associated with the Western region are strongly significant, and contribute 4 percentage points to the gap. Although the coefficients on age are large, the contribution of age of manager and age squared is jointly insignificant.

Robustness Check

However, removal of household and person-level unobservable characteristics may introduce bias into the decomposition in column (2) of table 4. As a robustness check, we therefore decompose the household and community-season fixed effects in the full specification given in column (1). We do so by extracting the household and community-season fixed effects ($\lambda_{h,}$ φ_{et}) from the separate male and female regressions. We then pool these fixed effects and regress them on a subset of household and community-season variables, respectively:

$$\lambda_h = \delta Z_{it} + \mu_{it} \tag{4}$$

$$\varphi_{et} = \rho F_{it} + \epsilon_{it} \tag{5}$$

where Z_{it} and F_{it} are vectors of characteristics for plot *i* in season *t* that are believed to be partially or fully absorbed by the household and community-season fixed effects, respectively, and μ_{it} and ϵ_{it} are error terms. Table 5 displays results of the fixed effects decompositions. This confirms the significant structural contribution of the child dependency ratio and distance to major road. The contribution of NAADS is again statistically significant but not practically substantial. While value of livestock is no longer significant, value of physical assets is.

Policy Implications

Although the decomposition does not identify a causal relationship between covariates and the gender gap, it does provide an exploratory basis for future research and policy design. For example, one implication is that low-cost interventions designed to release child-care constraints on female managers have the potential to substantially equalize the intra-household distribution of resources between male and female managers in Uganda and should be evaluated. Community-based child-care interventions are one possibility, although there is little existing evidence of their efficacy.

Given the disproportionate travel costs faced by female farmers, interventions that bring extension services closer to household dwellings, provide access to market information through mobile phones, or provide better access to transport may contribute to closing the gap. Another possibility would be to promote use of existing women's groups for commercial purposes, such as collective access to input and output markets.

Although input use is not widespread enough to contribute substantially to the aggregate gap, the extremely large ratio of male to female physical inputs applied and statistically significant contribution of material inputs to the gap suggest that programs to encourage adoption of these technologies should incorporate elements to ensure equal adoption by male and female farmers. For instance, programs that finance input purchase through mechanisms such as vouchers, loans, or transfers that are aligned with farmers' cash flow cycle could be explored.

Programs designed to promote female planting of high-value cash crops could also be explored, but should carefully assess the risk that male farmers claim a stake in plots on which cash crops are planted, resulting in heavy leakage of benefits from female to male farmers. Such programs should carefully ensure access to adequate output markets before the switch, and provide complimentary inputs and extension services critical to the success of the adopted crop.

Female managers' low endowment of hired labor provides weak evidence that there are constraints to them hiring labor. It will be insightful to evaluate projects that provide agents to help women farmers to find, supervise, and finance payment of hired labors.

V. Conclusion

This paper estimates the gender gap in agricultural productivity in Uganda, and unpacks this gap into portions accounted for by differences in household, plot-manager and parcel characteristics, and in returns to these characteristics. The main methodological contribution of the paper is to incorporate panel data methods into this decomposition to ensure that unobserved household, manager, and community characteristics are included in the accounting along with observable characteristics.

We find a simple difference in yield between female and male cultivated plots of 17.5%. After accounting for observed parcel characteristics and unobserved household, community, season and farmer characteristics, the unexplained difference in yield between male and female farmers is 29.6%. Female farmers cultivate smaller plots in a context with strong inverse returns to planted area, giving them a net endowment advantage of 12%.

Decomposing the unexplained difference in returns to characteristics (29.6%), we attribute two-fifths of this (12.5 percentage points) to a large difference in returns to the child dependency ratio. The productivity of female-managed plots also suffers more than the productivity of male-managed plots when the household is located further from the nearest major road, accounting for 6 percentage points of the gap.

In contrast to other country contexts, physical inputs (fertilizer, crop protection chemicals and improved seed) are applied by so few Ugandan farmers that they account for only a small portion of the gender productivity gap (1.9 percentage points). Even so, the statistical significance (if small size) of the contribution of improved seed and crop protection chemicals imply that widespread adoption of physical inputs would substantially widen the gap if the distribution of inputs between male and female managed plots were not equalized in the process.

Male farmer specialization in cash crops, such as coffee and banana, contributes marginally to the gap (2.4 percentage points), even though female farmers who plant these crops receive a higher return from doing so than male farmers who plant them. Female managers are slightly less likely to receive NAADS extension service (.5 percentage points), but we do not find that receipt of this service is less beneficial for female than for male managers.

On net, female managers apply more days of family labor to their plots than male managers. Females are less likely to hire labor, but the net effect is a labor endowment advantage (3.2 percentage points), although our data do not separate family labor by gender or age type.

Finally, male-managed plots receive a structural advantage from unobserved aspects of cultivation in the Western region (4.0 percentage points), possibly related to male-dominated intensive cultivation of cash crops in the area. Likewise, unobserved aspects of cultivation in the Central region slightly reduce the disadvantage faced by female farmers (1.7 percentage points).

Although the decomposition does not identify a causal relationship between these characteristics and the gender gap, it does provide an exploratory basis for future research and policy design. In particular, the results encourage research and policy projects targeted at moderating differential constraints from child care responsibilities within households and travel limitations in areas without transport infrastructure, as well as at equalizing adoption of high-value cash-crops and physical inputs such as improved seeds, chemical fertilizer and crop protection chemicals.

Table 1: Household-Level Characteristics by Region

	Total	Central	Eastern	Northern	Western
Household Characteristics					
Number of Household Members	7.1	7.6	7.7	6.5	6.9
Household Headed by Female	2.6%	2.7%	1.9%	3.5%	2.0%
Percentage of Household Land Cultivated by Female Manager	47.5%	42.7%	41.2%	45.5%	59.3%
Child Dependency Ratio (Number of Children Under 10 Years of Age/Number of Household Members 10 Years of Age or Older)	0.70	0.74	0.71	0.71	0.66
Number of Children Under 2 Years of Age	0.56	0.59	0.58	0.57	0.50
Number of Female Adults (15 Years and Above)	1.58	1.70	1.65	1.40	1.63
Number of Male Adults (15 Years and Above)	1.75	1.82	1.80	1.64	1.78
Number of Female Young Adults (10-15 Years)	0.60	0.62	0.70	0.51	0.59
Number of Male Young Adults (10-15 Years)	0.58	0.63	0.66	0.53	0.52
Sources of Income					
Household Earned Income from Non-Farm Enterprise	49.7%	55.1%	45.3%	57.8%	40.7%
Subsistence Farming Is the Most Important Source of Earnings for Household	63.8%	51.7%	63.9%	75.6%	57.7%
Commercial Farming Is the Most Important Source of Earnings for Household	3.1%	2.2%	2.4%	5.5%	1.6%
Wage Employment Is the Most Important Source of Earnings for Household	14.9%	18.8%	15.8%	6.7%	21.1%
Non-Agricultural Enterprises Is the Most Important Source of Earnings for Household	16.1%	23.2%	14.6%	11.2%	18.6%
Household Assets					
Value of Household Livestock (USD)	322	232	348	312	372
Value of Household Assets (USD - Includes House and Land)	5178	5645	4692	3978	6765
Value of Household Land	3698	3211	3181	3245	5064
Value of Household Dwelling and Other Buildings	1187	1907	1159	562	1474
Value of Household Physical Assets Excluding Land and Buildings	293	526	352	170	227
Number of Observations (Households)	630	112	156	199	163

Table 2: Plot-Level Characteristics by Gender of Plot Manager

	Total	Exclusively Male Managed	Exclusively Female Managed	
Yield				
Value of Output per Acre (USD)	144	158	129	***
Plot Characteristics				
Area of Plot in Acres	0.69	0.85	0.54	***
Good Land Quality	61.4%	62.3%	60.6%	
Fair Land Quality	32.3%	32.1%	32.4%	
Poor Land Quality	6.2%	5.5%	6.9%	**
Irrigated	1.9%	2.6%	1.3%	***
Rain-Fed	95.9%	95.0%	96.7%	***
Swamp/Wetland	2.2%	2.3%	2.0%	
Hilly	9.9%	7.9%	11.9%	***
Flat	45.4%	47.8%	43.0%	***
Gently sloped	38.2%	38.9%	37.6%	
Steep	3.2%	2.8%	3.6%	*
Valley	3.1%	2.5%	3.8%	***
Distance from Homestead to Plot				
Less than 15 Min	65.0%	66.4%	63.5%	**
15 Min - 30 Min	16.3%	15.5%	17.1%	*
30 Min - 60 Min	11.9%	10.9%	12.9%	***
1 Hour - 2 Hours	5.7%	5.8%	5.5%	
Over 2 Hours	1.2%	1.3%	1.0%	
Tenure & Investment				
Land Owned by the Household	82.2%	83.2%	81.1%	**
Erosion Control/Water Harvesting Facility is Located on the Plot	31.7%	32.1%	31.3%	
Labor Inputs				
Any Family Labor Used on Plot	96.1%	96.2%	96.0%	
Family Labor Days per Acre	130	121	140	**
Any Hired Labor Used on Plot	26.9%	30.5%	23.3%	***
Hired Labor Days per Acre	8.2	9.3	7.1	***
Non-Labor Inputs				
Improved Seed Applied	6.7%	9.2%	4.2%	***
Purchased Seed Applied	25.3%	29.2%	21.3%	***
Value of Seed per Acre (USD)	3.98	4.27	3.69	
Any Manure Applied	4.1%	4.7%	3.5%	***
Kilograms of Manure per Acre	40	35	45	
Any Chemical Fertilizer Applied	1.2%	2.1%	0.4%	***
Value of Fertilizer per Acre (USD)	0.64	1.17	0.12	***
Any Crop Protection Chemicals Applied (pesticides, fungicides, etc.)	4.9%	7.0%	2.8%	***
Value of Crop Protection Chemicals per Acre (USD)	0.79	1.19	0.39	***
Number of Observations (Plots)	6999	3500	3499	

Table 2 (Continued): Plot-Level Characteristics by Gender of Plot Manager

	Total	Exclusively Male Managed	Exclusively Female Managed	
Cropping Patterns				
Plot is Intercropped	32.5%	33.3%	31.8%	
Proportion of Plot Planted with Roots	27.9%	22.5%	33.3%	***
Proportion of Plot Planted with Pulses and Oils	26.1%	23.2%	29.1%	***
Proportion of Plot Planted with Cereals	24.0%	25.7%	22.2%	***
Proportion of Plot Planted with Banana	12.9%	14.3%	11.5%	***
Proportion of Plot Planted with Coffee	3.9%	6.5%	1.3%	***
Proportion of Plot Planted with Other Cash Crops	2.4%	4.1%	0.7%	***
Proportion of Plot Planted with Vegetables	1.7%	2.3%	1.2%	***
Proportion of Plot Planted with Fruits	1.0%	1.3%	0.7%	**
Proportion of Plot Planted with Other	0.0%	0.0%	0.0%	
Plot Manager Characteristics				
Age of Plot Manager	42.5	45.3	39.7	***
Education Years of Plot Manager	5.4	6.5	4.3	***
Plot Manager Received Government (NAADS) Extension Services	19.9%	22.9%	16.9%	***
Plot Manager Received Other Extension Services	10.0%	13.5%	6.6%	***
Number of observations (Plots)	6999	3500	3499	

Stars are significance levels for t-tests of the equality of means between male and female managed plots.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Log Value of Yield Within-Estimator

	(1)	(2)	(3)
	Raw Mean Gap	**Within-Household Gap**	**Full Specification**
Managed by Female	-0.175***	-0.232***	-0.355***
	(0.029)	(0.042)	(0.053)
Distance 15 Min - 30 Min			0.007
			(0.051)
Distance 30 Min - 60 Min			0.029
			(0.056)
Distance 1 Hour - 2 Hours			0.008
			(0.085)
Distance Over 2 Hours			0.091
			(0.143)
Soil quality: Fair			-0.104**
			(0.041)
Soil quality: Poor			-0.115
			(0.082)
Hilly Parcel			0.007
			(0.072)
Valley Parcel			-0.038
			(0.112)
Gentle Slope Parcel			0.110**
			(0.045)
Steep Slope Parcel			0.022
			(0.143)
Irrigated Parcel			-0.299***
			(0.111)
Swamp/Wetland Parcel			0.371***
			(0.125)
Planted Acres (log)			-0.265***
			(0.028)
Rented Parcel			0.159***
			(0.050)
Manager is Under 30 Years of Age			0.436**
			(0.206)
Manager is 30-40 Years of Age			0.345**
			(0.167)
Manager is 40-50 Years of Age			0.330**
			(0.138)
Manager is 50-60 Years of Age			0.254**
			(0.110)
Manager Received NAADS Extension Services			0.115**
			(0.055)
Manager Received Other Extension Services			0.024
			(0.068)

Education Years of Manager			-0.004
			(0.009)
% Planted with Bananas			0.284***
			(0.073)
% Planted with Coffee			0.312***
			(0.110)
% Planted with Fruits			0.509**
			(0.214)
% Planted with Other Cash Crops			0.941***
			(0.188)
% Planted with Other			1.523
			(1.028)
% Planted with Pulses and Oils			0.149***
			(0.044)
% Planted with Roots			0.303***
			(0.048)
% Planted with Vegetables			0.119
			(0.125)
Intercropped			0.352***
			(0.035)
Family Labour Days per Acre (log)			0.255***
			(0.025)
Hired Labour Days per Acre (log)			0.116***
			(0.027)
Reverse Dummy for Family Labor			0.992***
			(0.124)
Reverse Dummy for Hired Labor			-0.022
			(0.082)
Any Pesticides Applied			0.197**
			(0.085)
Any Manure Applied			0.152**
			(0.075)
Any Fertilizer Applied			-0.107
			(0.171)
Improved Seeds			0.183***
			(0.059)
Any Erosion Control Or Water Harvesting Structure On Parcel			0.094* (0.048)
Constant Term	4.345***	4.358***	2.374***
	(0.020)	(0.031)	(0.185)
Number of Observations	6,999	6,999	6,999

Specifications 2 & 3 Include Household and Community-Season Fixed Effects
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Log Value of Yield Oaxaca Decomposition by Gender of Plot Manager

	(1) Parcel Characteristics Decomposition		(2) Individual & Community Characteristics Decomposition	
Panel A : Aggregate Decomposition				
Male Group Value of Yield (log)	4.345***		4.345***	
	(0.021)		(0.021)	
Female Group Value of Yield (log)	4.169***		4.169***	
	(0.020)		(0.020)	
Difference in Value of Yield	0.175***		0.175***	
	(0.029)		(0.029)	
Explained Portion of Difference	-0.120***		-0.111***	
	(0.029)		(0.022)	
Unexplained Portion of Difference	0.296***		0.287***	
	(0.028)		(0.030)	
Panel B : Detailed Decomposition				
	Explained	**Structural**	**Explained**	**Structural**
Parcel Characteristics				
Distance from Homestead to Plot	-0.000	0.100	0.000	-0.016
	(0.001)	(0.064)	(0.001)	(0.057)
Land Quality	0.002	0.010	0.003	0.004
	(0.002)	(0.029)	(0.002)	(0.020)
Topology	0.002	0.039	0.001	0.024
	(0.003)	(0.044)	(0.003)	(0.029)
Water Source	-0.003	0.008	-0.002	0.000
	(0.002)	(0.008)	(0.002)	(0.005)
Planted Acres (log)	-0.086***	-0.086**	-0.093***	-0.065*
	(0.010)	(0.043)	(0.010)	(0.038)
Rented Parcel	-0.003*	0.004	-0.003*	0.010
	(0.002)	(0.016)	(0.001)	(0.013)
Aggregate of Crop Selection	0.024***	-0.203***	0.023***	-0.164***
	(0.008)	(0.054)	(0.008)	(0.053)
% Planted with Bananas	0.008***	-0.052***	0.008***	-0.047***
	(0.003)	(0.014)	(0.003)	(0.014)
% Planted with Coffee	0.016***	-0.006	0.014***	-0.004
	(0.004)	(0.006)	(0.004)	(0.004)
% Planted with Fruits	0.003*	0.001	0.003*	0.004
	(0.002)	(0.004)	(0.001)	(0.003)
% Planted with Other Cash Crops	0.032***	-0.002	0.032***	-0.004
	(0.005)	(0.005)	(0.005)	(0.004)
% Planted with Other	-0.000	0.001	-0.000	0.001
	(0.001)	(0.001)	(0.000)	(0.001)
% Planted with Pulses and Oils	-0.009***	-0.033*	-0.010***	-0.029
	(0.003)	(0.020)	(0.003)	(0.020)
% Planted with Roots	-0.033***	-0.070***	-0.032***	-0.072***
	(0.005)	(0.021)	(0.005)	(0.021)
% Planted with Vegetables	0.001	-0.000	0.003*	-0.002
	(0.001)	(0.004)	(0.001)	(0.004)
Intercropped	0.005	-0.042**	0.005	-0.012
	(0.004)	(0.019)	(0.004)	(0.018)
Aggregate of Labor	-0.032***	-0.017	-0.023***	-0.168
	(0.009)	(0.235)	(0.008)	(0.205)
Family Labor Days per Acre (log)	-0.052***	0.067	-0.044***	-0.080
	(0.009)	(0.181)	(0.008)	(0.155)

Hired Labor Days per Acre (log)	0.021***	-0.019	0.022***	-0.005
	(0.006)	(0.035)	(0.006)	(0.032)
Reverse Dummy for Family Labor	-0.003	-0.001	-0.003	-0.014
	(0.005)	(0.010)	(0.004)	(0.009)
Reverse Dummy for Hired Labor	0.002	-0.064	0.002	-0.069
	(0.005)	(0.110)	(0.005)	(0.103)
Aggregate of Physical Inputs	0.019***	0.009	0.025***	0.007
	(0.005)	(0.011)	(0.005)	(0.010)
Any Pesticides Applied	0.009***	-0.002	0.015***	0.002
	(0.003)	(0.007)	(0.003)	(0.006)
Any Manure Applied	0.002*	0.008	0.000	0.006
	(0.001)	(0.006)	(0.001)	(0.006)
Any Fertilizer Applied	-0.002	-0.002	-0.002	-0.001
	(0.002)	(0.003)	(0.002)	(0.003)
Improved Seeds	0.010***	0.006	0.012***	-0.000
	(0.003)	(0.007)	(0.003)	(0.006)
Any Erosion Control or Water Harvesting Structure	0.001	0.017	0.001	0.015
	(0.001)	(0.029)	(0.001)	(0.019)
Individual & Community Characteristics				
Manager Received NAADS Extension Services			0.005**	0.005
			(0.002)	(0.013)
Manager Received Other Extension Services			0.000	0.007
			(0.003)	(0.009)
Education Years of Manager			0.010	-0.072*
			(0.009)	(0.043)
Value of Household Assets			-0.004**	0.031
			(0.002)	(0.020)
Value of Household Livestock			-0.000	0.036***
			(0.000)	(0.013)
Child Dependency Ratio			-0.000	0.125***
			(0.001)	(0.042)
Number of Household Members			0.001	0.028
			(0.001)	(0.074)
Age of Manager Binary Variables			-0.001	0.001
			(0.007)	(0.013)
HH Distance to Nearest Major Road (Km)			-0.003	0.061*
			(0.002)	(0.034)
Deviation from Average Rainfall & Squared Deviation from Average Rainfall			-0.002	0.017
			(0.001)	(0.025)
Western Region			-0.036***	0.040***
			(0.005)	(0.014)
Northern Region			-0.003	-0.004
			(0.003)	(0.015)
Eastern Region			-0.007**	-0.008
			(0.003)	(0.012)
Central Region			-0.003	-0.017*
			(0.003)	(0.010)
Household Fixed Effects	-0.021	0.060		
	(0.032)	(0.039)		
Community-Season Fixed Effects	-0.022	0.374***		
	(0.032)	(0.098)		
Constant Term		-0.020		0.390*
		(0.249)		(0.231)
Number of Observations	6,999		6,999	
note: *** p<0.01, ** p<0.05, * p<0.1				

Table 5: Decomposition of Extracted Fixed Effects by Gender of Plot Manager

Panel A : **Individual Fixed Effect**		
	Explained	**Structural**
Manager Received NAADS	0.006***	0.011
Extension Services	(0.002)	(0.010)
Manager Received Other Extension	-0.006**	0.025***
Services	(0.003)	(0.007)
Education Years of Manager	-0.018**	-0.044
	(0.007)	(0.037)
Value of Household Assets	-0.005***	0.022
	(0.002)	(0.017)
Value of Household Livestock	-0.001	0.007
	(0.001)	(0.011)
Child Dependency Ratio	-0.004**	0.101***
	(0.002)	(0.035)
Number of Household Members	0.001	-0.174***
	(0.001)	(0.058)
Age of Manager	-0.042***	0.021*
	(0.007)	(0.011)
Panel B : **Community-Season Fixed Effect**		
HH Distance in (KMs) to Nearest	-0.000	0.832***
Major Road	(0.003)	(0.033)
Deviation from Mean Rainfall and	0.046	-1.627***
Squared Deviation from Mean Rainfall	(0.058)	(0.036)
Number of observations	**6,999**	

note: *** p<0.01, ** p<0.05, * p<0.1

Appendix Table A: Plot-Level Characteristics by Region

	Total	Central	Eastern	Northern	Western
Yield					
Value of Output per Acre (USD)	144	159	108	122	192
Plot Characteristics					
Area of Plot in Acres	0.69	0.85	0.68	0.63	0.67
Good Land Quality	61.4%	72.5%	53.1%	62.3%	60.9%
Fair Land Quality	32.3%	20.6%	39.8%	31.3%	34.3%
Poor Land Quality	6.2%	7.0%	7.1%	6.3%	4.8%
Irrigated	1.9%	4.0%	2.7%	1.2%	0.7%
Rain-Fed	95.9%	92.4%	94.9%	97.0%	97.7%
Swamp/Wetland	2.2%	3.7%	2.4%	1.7%	1.6%
Hilly	9.9%	8.9%	1.1%	3.0%	26.6%
Flat	45.4%	29.2%	57.9%	55.7%	32.7%
Gently sloped	38.2%	53.6%	36.4%	38.3%	29.8%
Steep	3.2%	2.5%	3.6%	1.2%	5.7%
Valley	3.1%	5.8%	0.9%	1.7%	5.1%
Distance from Homestead to Plot					
Less than 15 Min	65.0%	64.5%	66.3%	68.6%	59.7%
15 Min - 30 Min	16.3%	19.2%	13.9%	15.0%	18.0%
30 Min - 60 Min	11.9%	12.4%	13.7%	8.4%	14.1%
1 Hour - 2 Hours	5.7%	2.7%	5.5%	6.3%	7.1%
Over 2 Hours	1.2%	1.2%	0.5%	1.7%	1.1%
Tenure & Investment					
Land Owned by the Household	82.2%	82.5%	79.0%	86.9%	79.3%
Erosion Control/Water Harvesting Facility is Located on the Plot	31.7%	46.2%	28.3%	24.8%	33.2%
Labor Inputs					
Any Family Labor Used on Plot	96.1%	95.5%	96.4%	95.3%	97.0%
Family Labor Days per Acre	130	144	122	94	169
Any Hired Labor Used on Plot	26.9%	20.4%	26.5%	31.0%	26.9%
Hired Labor Days per Acre	8.2	4.7	7.6	9.9	9.0
Non-Labor Inputs					
Improved Seed Applied	6.7%	7.9%	8.1%	9.9%	1.0%
Purchased Seed Applied	25.3%	15.4%	23.3%	38.0%	18.6%
Value of Seed per Acre (USD)	3.98	2.06	3.15	4.36	5.57
Any Manure Applied	4.1%	9.5%	1.5%	0.2%	7.4%
Kilograms of Manure per Acre	40	98	10	0	75

Appendix Table A (Continued): Plot-Level Characteristics by Region

	Total	Central	Eastern	Northern	Western
Any Chemical Fertilizer Applied	1.2%	2.4%	1.2%	1.2%	0.5%
Kilograms of Fertilizer per Acre	0.74	1.62	0.33	0.76	0.51
Value of Fertilizer per Acre (USD)	0.64	0.62	0.26	1.42	0.12
Any Crop Protection Chemicals Applied (pesticides, fungicides, etc.)	4.9%	11.0%	4.9%	2.7%	3.5%
Value of Crop Protection Chemicals per Acre (USD)	0.79	1.34	0.50	0.16	1.41
Cropping Patterns					
Plot is Intercropped	32.5%	44.7%	34.8%	28.5%	27.1%
Share of Plot Planted with Roots	27.9%	26.9%	29.2%	29.5%	25.5%
Share of Plot Planted with Pulses and Oils	26.1%	17.9%	22.8%	32.1%	27.6%
Share of Plot Planted with Cereals	24.0%	18.0%	31.2%	26.7%	18.2%
Share of Plot Planted with Banana	12.9%	24.3%	9.2%	3.9%	19.3%
Share of Plot Planted with Coffee	3.9%	8.7%	3.7%	0.7%	4.7%
Share of Plot Planted with Other Cash Crops	2.4%	0.6%	1.9%	4.1%	2.1%
Share of Plot Planted with Vegetables	1.7%	1.5%	1.5%	1.9%	1.8%
Share of Plot Planted with Fruits	1.0%	2.0%	0.5%	1.1%	0.8%
Share of Plot Planted with Other	0.0%	0.1%	0.0%	0.0%	0.1%
Plot Manager Characteristics					
Age of Plot Manager	42.5	43.4	44.6	41.5	41.2
Education Years of Plot Manager	5.4	6.9	5.4	4.9	5.0
Plot Manager Received Government (NAADS) Extension Services	19.9%	11.9%	16.3%	28.4%	18.6%
Plot Manager Received Other Extension Services	10.0%	12.6%	7.0%	14.9%	5.4%
Number of Observations (Plots)	6999	1231	1711	2177	1880

Appendix Table B: Log Value of Yield Within-Estimator

	(1)	(2)	(3)	(4)	(5)	(6)
	Raw Gap	**Fixed Effects Only**	**Plot Characteristics**	**Plot Manager Characteristics**	**Cropping Choices**	**Inputs Applied**
Managed by Female	-0.175***	-0.232***	-0.382***	-0.433***	-0.409***	-0.355***
	(0.029)	(0.042)	(0.040)	(0.059)	(0.054)	(0.053)
15 Min - 30 Min			0.024	0.026	0.036	0.007
			(0.056)	(0.056)	(0.053)	(0.051)
30 Min - 60 Min			0.058	0.062	0.074	0.029
			(0.061)	(0.060)	(0.058)	(0.056)
1 Hour - 2 Hours			0.051	0.052	0.052	0.008
			(0.091)	(0.090)	(0.087)	(0.085)
Over 2 Hours			0.057	0.057	0.089	0.091
			(0.140)	(0.139)	(0.148)	(0.143)
Soil Quality: Fair			-0.114***	-0.114***	-0.134***	-0.104**
			(0.044)	(0.044)	(0.043)	(0.041)
Soil Quality: Poor			-0.084	-0.088	-0.146*	-0.115
			(0.084)	(0.085)	(0.082)	(0.082)
Hilly Parcel			0.017	0.020	0.035	0.007
			(0.079)	(0.078)	(0.076)	(0.072)
Gentle Slope Parcel			0.133***	0.135***	0.143***	0.110**
			(0.047)	(0.048)	(0.045)	(0.045)
Steep Slope Parcel			0.010	0.031	0.075	0.022
			(0.175)	(0.172)	(0.155)	(0.143)
Valley Parcel			-0.062	-0.059	-0.027	-0.038
			(0.127)	(0.128)	(0.122)	(0.112)
Irrigated Parcel			-0.387***	-0.374***	-0.286**	-0.299***
			(0.121)	(0.123)	(0.122)	(0.111)
Swamp/Wetland Parcel			0.362***	0.361***	0.430***	0.371***
			(0.129)	(0.130)	(0.136)	(0.125)
Planted Acres (log)			-0.439***	-0.441***	-0.447***	-0.265***
			(0.023)	(0.024)	(0.023)	(0.028)
Rented Parcel			0.134***	0.133***	0.170***	0.159***
			(0.052)	(0.052)	(0.053)	(0.050)
Manager Is Under 30 Years of Age				0.447**	0.450**	0.436**
				(0.217)	(0.210)	(0.206)
Manager Is 30-40 Years of Age				0.346**	0.348**	0.345**
				(0.176)	(0.172)	(0.167)
Manager Is 40-50 Years of Age				0.325**	0.353**	0.330**
				(0.142)	(0.142)	(0.138)
Manager Is 50-60 Years of Age				0.229**	0.280**	0.254**
				(0.113)	(0.111)	(0.110)
Manager Received NAADS Extension Services				0.145**	0.131**	0.115**
				(0.057)	(0.056)	(0.055)
Manager Received Other Extension Services				0.061	0.056	0.024
				(0.070)	(0.071)	(0.068)
Education Years of Manager				-0.001	-0.003	-0.004
				(0.010)	(0.010)	(0.009)
% Planted with Bananas					0.170**	0.284***
					(0.075)	(0.073)
% Planted with Coffee					0.139	0.312***
					(0.112)	(0.110)
% Planted with Fruits					0.366*	0.509**
					(0.208)	(0.214)

% Planted with Other Cash Crops					1.070***	0.941***
					(0.180)	(0.188)
% Planted with Other					1.639	1.523
					(1.044)	(1.028)
% Planted with Pulses and Oils					0.146***	0.149***
					(0.046)	(0.044)
% Planted with Roots					0.232***	0.303***
					(0.050)	(0.048)
% Planted with Vegetables					0.215	0.119
					(0.132)	(0.125)
Intercropped					0.409***	0.352***
					(0.035)	(0.035)
Family Labor Days per Acre (log)						0.255***
						(0.025)
Hired Labor Days per Acre (log)						0.116***
						(0.027)
Reverse Dummy for Family Labor						0.992***
						(0.124)
Reverse Dummy for Hired Labor						-0.022
						(0.082)
Any Pesticides Applied						0.197**
						(0.085)
Any Manure Applied						0.152**
						(0.075)
Any Fertilizer Applied						-0.107
						(0.171)
Improved Seeds						0.183***
						(0.059)
Any Erosion Control or Water Harvesting Structure on Parcel						0.094*
						(0.048)
Constant Term	4.345***	4.358***	4.075***	3.789***	3.404***	2.374***
	(0.020)	(0.031)	(0.046)	(0.145)	(0.147)	(0.185)
Number of observations	6,999	6,999	6,999	6,999	6,999	6,999

note: *** p<0.01, ** p<0.05, * p<0.1

Appendix Table C: Log Value of Yield Within-Estimator (Including Jointly Managed Plots)

	(1)	(2)	(3)	(4)	(5)	(6)
	Raw Gap	**Fixed Effects Only**	**Plot Characteristics**	**Plot Manager Characteristics**	**Cropping Choices**	**Inputs Applied**
Managed by Female	-0.179***	-0.240***	-0.402***	-0.428***	-0.392***	-0.342***
	(0.027)	(0.040)	(0.038)	(0.054)	(0.050)	(0.049)
Managed by Male and Female Jointly	0.574***	0.368***	0.480***	0.466***	0.277***	0.245***
	(0.043)	(0.047)	(0.046)	(0.052)	(0.048)	(0.046)
15 Min - 30 Min			-0.026	-0.023	0.005	-0.008
			(0.048)	(0.048)	(0.046)	(0.043)
30 Min - 60 Min			0.003	0.004	0.039	0.008
			(0.052)	(0.052)	(0.051)	(0.049)
1 Hour - 2 Hours			-0.014	-0.012	0.013	-0.019
			(0.081)	(0.080)	(0.078)	(0.076)
Over 2 Hours			0.075	0.078	0.131	0.145
			(0.133)	(0.134)	(0.141)	(0.134)
Soil Quality: Fair			-0.096***	-0.095***	-0.105***	-0.076**
			(0.037)	(0.037)	(0.036)	(0.036)
Soil Quality: Poor			-0.080	-0.085	-0.126*	-0.099
			(0.073)	(0.073)	(0.070)	(0.070)
Hilly Parcel			0.042	0.045	0.074	0.056
			(0.069)	(0.068)	(0.066)	(0.065)
Valley Parcel			-0.071	-0.069	-0.032	-0.036
			(0.109)	(0.110)	(0.104)	(0.097)
Gentle Slope Parcel			0.143***	0.144***	0.151***	0.118***
			(0.042)	(0.042)	(0.040)	(0.040)
Steep Slope Parcel			0.061	0.066	0.104	0.052
			(0.144)	(0.143)	(0.126)	(0.119)
Irrigated Parcel			-0.343***	-0.343***	-0.278***	-0.299***
			(0.105)	(0.108)	(0.104)	(0.097)
Swamp/Wetland Parcel			0.310***	0.304***	0.367***	0.313***
			(0.115)	(0.116)	(0.120)	(0.111)
Planted Acres (log)			-0.447***	-0.447***	-0.458***	-0.288***
			(0.020)	(0.020)	(0.020)	(0.025)
Rented Parcel			0.065	0.063	0.136***	0.127***
			(0.045)	(0.045)	(0.046)	(0.044)
Manager Is Under 30 Years of Age				0.235	0.231	0.226
				(0.209)	(0.200)	(0.193)
Manager Is 30-40 Years of Age				0.190	0.194	0.188
				(0.178)	(0.170)	(0.163)
Manager Is 40-50 Years of Age				0.199	0.230*	0.205
				(0.143)	(0.138)	(0.132)
Manager Is 50-60 Years of Age				0.110	0.151	0.134
				(0.104)	(0.100)	(0.097)
Manager Received NAADS Extension Services				0.115**	0.104**	0.100**
				(0.052)	(0.051)	(0.049)
Manager Received Other Extension Services				0.101	0.097	0.069
				(0.064)	(0.066)	(0.064)

Education Years of Manager				-0.002	-0.005	-0.006
				(0.010)	(0.010)	(0.009)
% Planted with Bananas					0.272***	0.347***
					(0.066)	(0.064)
% Planted with Coffee					0.152	0.313***
					(0.094)	(0.094)
% Planted with Fruits					0.368*	0.520**
					(0.199)	(0.203)
% Planted with Other Cash					1.056***	0.962***
					(0.168)	(0.175)
% Planted with Other					1.627	1.536
					(1.047)	(1.026)
% Planted with Pulses and Oils					0.114***	0.125***
					(0.043)	(0.041)
% Planted with Roots					0.245***	0.310***
					(0.046)	(0.045)
% Planted with Vegetables					0.228*	0.132
					(0.128)	(0.119)
Intercropped					0.427***	0.372***
					(0.031)	(0.031)
Family Labour Days per Acre (log)						0.239***
						(0.021)
Hired Labour Days per Acre (log)						0.105***
						(0.023)
Reverse Dummy for Family Labor						0.968***
						(0.109)
Reverse Dummy for Hired Labor						-0.038
						(0.069)
Any Pesticides Applied						0.160**
						(0.079)
Any Manure Applied						0.226***
						(0.057)
Any Fertilizer Applied						-0.103
						(0.160)
Improved Seeds						0.175***
						(0.054)
Any Erosion Control or Water Harvesting Structure on Parcel						0.096**
						(0.041)
Constant Term	4.355***	4.431***	4.109***	3.887***	3.535***	2.556***
	(0.019)	(0.029)	(0.043)	(0.155)	(0.152)	(0.174)
Number of Observations	8,588	8,588	8,588	8,588	8,588	8,588

note: *** p<0.01, ** p<0.05, * p<0.1

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