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Outline

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Sources of gender productivity differentials in Africa: A cross-country comparison

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Abstract

This economic brief provides recent evidence on the extent of gender inequality in agricultural productivity and decomposes its main sources. The empirical analysis relies on micro-level survey datasets recently collected in Nigeria, Tanzania, and Uganda. In these countries, agriculture remains the mainstay of the economy and understanding the extent and sources of gender productivity gaps is crucial for building policy interventions and empowering women. Our econometric approach consists initially in estimating a model of agricultural productivity to uncover the impact of gender of the land manager. Then, a mean-based decomposition approach is applied to each country separately to underscore the sources of gender differences in agriculture. Finally, farmers' potential heterogeneity across the productivity distribution is accounted for using quantile regressions.

The main results suggest that, in the three countries, female managers of agricultural lands have a clear endowment disadvantage in most factors generating agricultural productivity such as farm size and use or intensity of non-labor inputs. The analysis finds that on average female-managed agricultural lands are 18.6, 27.4, and 30.6 percent less productive than their male counterparts in Nigeria, Tanzania, and Uganda, respectively. However, these gaps are not uniformly distributed across the productivity distribution, decreasing as we move towards the top of the distribution in Nigeria and Tanzania while increasing in Uganda. The decomposition of the sources of gender productivity differences indicates that in the three countries, endowment and structural disadvantages of female managers in land size, land quality, labor inputs, and household characteristics are the main drivers of gender gaps. However, the findings suggest that these different sources are not equally important across the three countries and warn against a-one-size-fit-all solution to tackle gender disparities in Africa's agriculture.

1 | Introduction

In Sub-Saharan Africa (SSA), women account for almost 50 percent of the agriculture labor force and make substantial contributions to the economy as farmers, entrepreneurs, and workers (FAO, 2011). However, they generally suffer from low access to credit and other financial services, and have less control over their resources. Compared to their male counterparts,

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female farmers applied lower rates of modern inputs, cultivate smaller agricultural lands, and achieve lower crop yields. Oftentimes, they are disadvantaged in terms of stocks of human and physical capital. These gender-based constraints also concern women's economic capacities and incentives, which in turn seriously undermine their potential to contribute to and partake of economic growth, affect their intra-household bargaining power and socio-economic status, and impede their land productivity and welfare status.

Women's agriculture underperformance is generally cited among the key causes of current low growth rates of agricultural productivity in Africa. Reducing these gender differentials and subsequently empowering women have therefore guided SSA countries' efforts and steered their policy plans, while the international development community has devoted considerable resources to the fight against the gender bias. For instance, in its 2012's World Development Report: Gender equality and development, the World Bank recognized the need to ensure gender equality as a way to increase productivity, income earnings, and poverty reduction (World Bank, 2012). More recently, the African Development Bank Group (AfDB) developed its Gender Strategy 2014-2018 wherein it committed itself into promoting women's economic empowerment as one promising way to fostering poverty reduction and accelerating economic development in Africa.

However, what do we actually know about the extent and sources of gender productivity differences among smallholder farmers in Africa? The response to this question is of utmost importance if we want to inform development policies aiming at empowering women and improving their livelihood conditions. Indeed, gender inequality in agriculture is often the consequence of gender biases in factors generating agriculture productivity. Consequently, to efficiently tackle gender productivity gaps, we first need to understand the nature and relative contribution of each of these factors in fuelling women's productivity deficits. It is only after the identification of the discriminating factors that policy interventions can be successfully undertaken.

Nonetheless, this exercise proves to be complicated by the scarcity of gender-disaggregated data in most developing countries. The empirical literature on gender productivity differentials in SSA, though particularly abundant (Goldstein and Udry, 2008 for Ghana; Alene et al, 2008 for Kenya; Peterman et al, 2011 for Nigeria and Uganda; Vargas Hill and Vigneri, 2011 for Ghana and Uganda; Kilic et al, 2013 for Malawi; Croppenstedt et al, 2013 for Ghana, Kenya, Malawi, and Nigeria: Aguilar et al, 2014 for Ethiopia; Backiny-Yetna and McGee, 2015 for Niger and Akresh, 2005 for Burkina Faso), suffers from at least two drawbacks. First, as pointed out by Kilic et al (2013), the overwhelming majority of the above studies are generally derived from case studies with limited geographic coverage and use nationally unrepresentative household surveys, thereby casting doubts on their external validity. Second, the limited existing evidences based on micro-data sets are either incomparable across countries due to methodological discrepancies and differences in sampling design or are outright outdated given current structural changes undergoing in most African countries. Owing not only to the contributing potentials of women in Africa's productivity growth but also to the amount of resources invested by both African governments and their development partners, it is imperative to undertake a careful empirical analysis and revisit our understanding of gender productivity differentials and their drivers in light of ongoing changes in the African agriculture landscape. Analyzing the extent of these gaps across smallholder farmers and distinguishing between different sources of the observed gaps will be crucial for the design of sound and empirically-driven policy instruments.

The aim of this brief is to contribute to the debate on the transformation of African agriculture by revisiting the empirical evidence on gender productivity differentials across SSA countries and deriving policy implications. Using publicly available, nationally representative, and country-comparable microeconomic surveys, namely the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA), we estimate gender gaps in three SSA countries (Nigeria, Tanzania, and Uganda) and highlight the sources of the observed differences across these countries.

This economic brief is organized as follows. The next section provides a background on agricultural gender issues in the 3 African countries under investigation. The third section gives a brief overview of the survey data, presents some key descriptive statistics relating to gender disparities in the African agricultural sector, and discusses the econometric models. The fourth section presents and discusses the main results of the econometric analysis of gender productivity gaps and decomposition of its sources. Finally, the last section presents the main conclusions and the policy implications of the findings.

2 | Background on gender issues in agriculture and rural development in Nigeria, Tanzania, and Uganda

In many SSA countries, gender issues have always been one of the most important sources of concern of policy makers. As many developing countries strive to maintain or improve the pace of their recently achieved economic growth, it is increasingly apparent that the question of gender disparities need to be tackled and women's participation into development be improved. However, what do we actually know about the extent of gender differences in SSA countries? In what follows, a series of figures gives a snapshot of some of the areas in which differences between men and women are striking.

2.1 Gender differences in employment

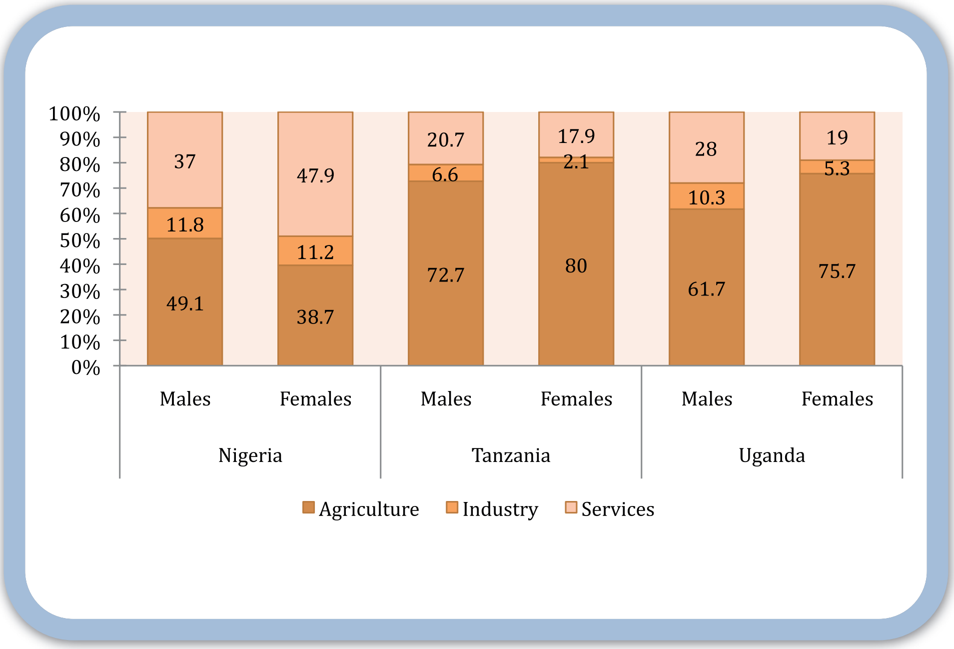
Figure 1 highlights the distribution of employment in agriculture, industry, and services by gender. What immediately jumps out of this figure is the share of employed women in agriculture. In Tanzania and Uganda particularly, employed women are more likely to work in agriculture than their male counterparts. In these 2 countries, agricultural female employment accounts for 80% in Tanzania and 75.7% in Uganda, while only 72.7% and 61.7% of employed males are likely to engage in agricultural activities. Nigeria is a major exception since not only the share of employed women is slightly lower than in services but also employed women are less likely to work in the agricultural sector. However, it is worth emphasizing that though employed, the proportion of women in informal employment or unpaid work is dispro-portionally higher than for their male counterparts.

These differences in the employment status between men and women originate from cultural, economic, sociological, and institutional factors that generally dictate labor division, access to and control over resources, often at the expense of women. For instance, while the proportion of employed Tanzanians working for wage or salaried work was around 16.2% in 2013, only 10.7% of women were employed for wage against 21.4% for men, representing a 50 percent gap. The gap is even wider in Uganda, where 22.2% of employed men but only 7.5% of employed women (or a 66.2% gender employment gap) worked for wage and/or salary in 2003 (World Bank, 2015). Moreover, even when rural women work for wages, it is more likely that they will be engaged in part-time employment or low-paid jobs. In female-headed households, this means that women cannot rely on a constant source of income throughout the year, which keeps then trapped into a vicious circle of low income, low consumption, high food insecurity, and poor health, not only for themselves but also for their children and other family dependants.

2.2 Gender disparities in land holding and ownership

Land is the most precious asset for those engaged in agriculture. In many regions, owning land is the evident sign of success, wealth, or social power. The magnitude of gender gaps in land holding[1] and ownership will therefore reveal the extent of effort needed for women empowerment since land access/ownership has a far-reaching consequence on farm productivity and income earnings.

Figure 1 Distribution of employment, by gender and sector



Source: World Bank, 2015

[1] Land holding refers to the management control over a land that may be owned, rented or allocated from common property resources and may be operated on a share-cropped basis (FAO, 2011).

Figure 2 reveals striking disparities in both land holding and ownership between men and women. The figure highlights some stark differences across the 3 countries under study. First, the proportion of women holding agricultural land is ridiculously low: on average, around 15% of them hold land, with variations ranging from 10% in Nigeria to 16.3% in Uganda and 19.7% in Tanzania. Second, in addition to being less likely to hold land, women are also discriminated with regards to land ownership. Indeed, Figure 2 indicates that in the 3 countries analyzed, women own around one thirteenth of all agricultural land. Again, inequality in land ownership is more acute in Nigeria where only 4% of agricultural lands are owned by women. Though still largely marginalized, women in Tanzania and Uganda fare relatively well since they possess 16 and 18% of agricultural land, respectively. As land-insecure farmers, women have often low social status and economic power that considerably impede their empowerment. This low percentage of women's land ownership may be partly explained by cultural and customary practices. In fact, in most rural areas, inheritance remains the main type of land acquisition; or women are less likely to inherit land when other male family members still exist, due particularly to the idea that women are not permanent members of the family and their ultimate objective is to marry and leave their birth family. Beside customary reasons, economic factors may also play a key role. Women are often more likely to be credit-constrained and combined with low earnings due to the prominence of part-time and/or unpaid work, they may be less likely to afford land acquisition.

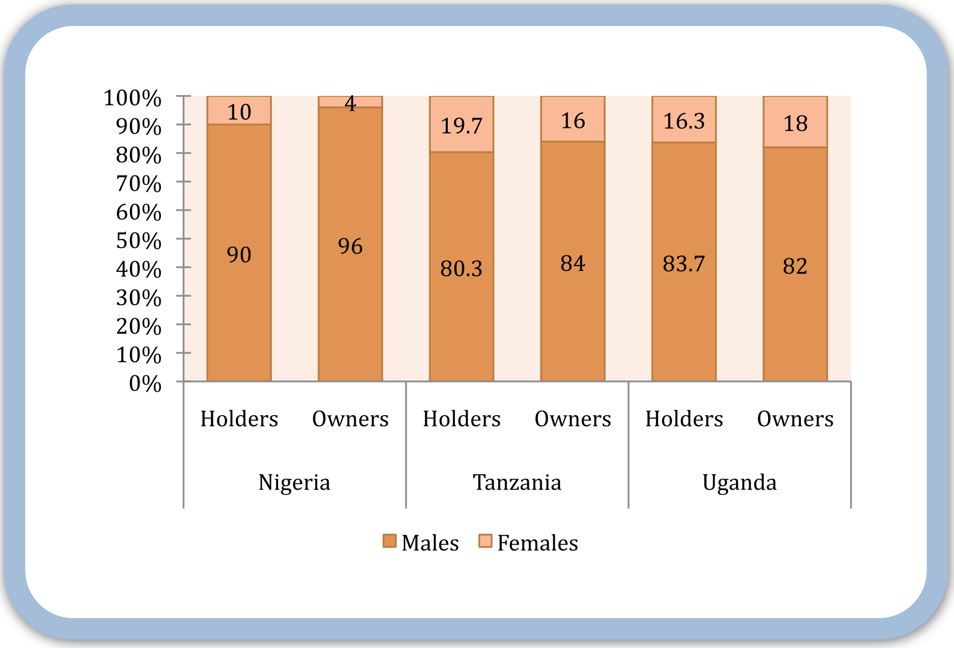
3 | Empirical analysis

3.1 Data sources

To document gender productivity gaps across Nigeria, Tanzania, and Uganda, we use the most recent available Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). We thus used the Nigeria General Household Survey collected between 2012 and 2013, the Tanzania National Panel Survey (2012-13), and the Uganda National Panel Survey (2011-12). Implemented by each country's national statistics agency under the overall guidance and supervision of the World Bank, the LSMS-ISA[2] datasets are nationally representative and cover all the geographical regions of the countries and apply relatively similar sampling design and survey questionnaires which is highly critical to undertake country-comparison analyses. The surveys collected information on almost all aspects of household and community activities.

The structure of these datasets allows the identification of the managers/owners of agricultural lands and their measurement using the Global Positioning System (GPS). All the subsequent analyses in this paper will thus be done at the manager level of agricultural land (plot in the cases of Nigeria and Tanzania, and parcel[3] in Uganda). The choice of land manager instead of household head may be justified as follows. First, using plot/parcel management in lieu of its ownership entails incorporating intra-household dynamics regarding agricultural activities. Indeed, male and female managers within the same

Figure 2 Proportion of agricultural land holders and owners, by gender



Source: FAO, 2015

[2] These datasets are freely available for download here.
[3] A parcel is understood here as a plot or a group of contingent plots cultivated by farmers.

household may have completely different approaches or perspectives to the land use, the type of input to apply, or the necessity or not to hire labor (Croppenstedt et al, 2013). Second, many agricultural households hold more than one plot/parcel which are not necessarily contingent or equally distant from their homestead. In this case, it is reasonable to assume that other family members may also be in charge of some plots concurrently with the household head. Third, as many empirical studies have recently showed, non- and off-farm employments are increasingly becoming important sources of income earnings, particularly in rural areas. In many cases, it is the household head that engages in off-farm or wage employment while the spouse or other family members manage the agricultural land. Therefore, using the manager of the cultivated land represents a more realistic viewpoint of actual agricultural practices and division of labor within the household.

For the purpose of this brief, agricultural productivity has been defined as the market gross value of output per unit of land (acre). Furthermore, for the sake of simplicity, we restricted the analysis to plots/parcels with a single manager and therefore excluded jointly-managed lands. In Uganda particularly, we only kept agricultural parcels with a single designed managers across all plots. We also dropped from the final samples lands with missing GPS-based measurements, production information, and plots/parcels without an identified manager. These various exclusions and simplifications left us with a final sample of 4,017 plots in Nigeria, 2,530 plots in Tanzania, and 1,160 parcels in Uganda representing 2,029 plots. The descriptive statistics and the results from the tests of mean differences between male and female managers are reported in Table 1. The table thus provides some initial insights of the (unadjusted) productivity differential between male- and female-managed agricultural lands about also across countries.

First and unsurprisingly, most lands are male-managed. Nigeria is the most unequal country with only 17.1% of plots being female-managed but this proportion jumps to 28.5% in Uganda and 34.9% in Tanzania. Second, in all the 3 countries, women are found less productive than their male counterparts, with a striking (unadjusted) gender productivity gap of 38.5% at the parcel level in Uganda. Though still positive, the productivity differentials are however statistically non significant at plot levels in Nigeria and Tanzania. Third, the observed gender productivity gaps in the 3 countries may be correlated to differences in land, manager and household characteristics as well as to differences in labor and non-labor inputs use.

Again, despite many similarities across the 3 countries, there are some stark particularities between them. In terms of plot/parcel characteristics, female managers are likely to cultivate smaller lands than their male counterparts. The significant farm size gaps range from 31.4% in Tanzania to 39.9% in Uganda, and up to 64.4% in Nigeria. However, if the inverse farm size-productivity relationship is found in these countries (Barrett, 1996), then larger sizes of male-managed lands may become a disadvantage for their agricultural productivity. Furthermore, female-managed lands are less likely to be irrigated or flatted in Nigeria or to be of good quality in the 3 countries.

Considering manager characteristics, (i) female managers are on average 5 years older and have 1.9 years less of schooling than male managers; and (ii) female managers are 21.3% points less likely to be household heads. Indeed, around 98% of male managers and 74% of female managers head their households. With respect to household characteristics, Table 1 reveals a neat demarcation between male and female-managed plots. The latter live in households that have on average 1.5 members smaller than the former. Male managers exhibit larger child dependency ratio only in Nigeria and Tanzania and their monthly consumption expenditures per adult equivalent are on average 15.6% greater than their female counterparts.

Finally, the table highlights some drastically different dynamics between female- and male-managed lands in regards to inputs use. The use of non-labor inputs such as organic and inorganic fertilizer, improved seeds, and pesticides, are generally considered positively correlated with land productivity. However, in SSA countries, the rates of adoption of these inputs are deceitfully low and Nigeria, Tanzania, and Uganda are no exception. Even in this context, these physical inputs are less commonly used by female managers. To further grasp the extent of disparities in non-labor inputs use between male and female managers, we plot Venn diagrams and explore the interaction of uses of inorganic fertilizer, improved seeds, and pesticides (Megan and Barrett, 2014). Figure 3 describes the set of conditional probabilities over the three inputs, with the overlapping area representing the use of at least 2 of the 3 selected inputs. Not only do the figures reveal important discrepancies in input uses but they also display a contrasting picture across countries.

In all cases, the proportion of female managers applying simultaneously inorganic fertilizer, improved seeds, and pesticides is lower than male managers'. On average less than 1% of female-managed agricultural lands used the three inputs. Across countries, Nigerian farmers are more likely to use exclusively inorganic fertilizer than Tanzanian and Ugandan farmers, while improved seeds are mostly used in Tanzania and pesticides in Uganda.

Finally, Table 1 confirms the prominence of labor inputs in the production process across the 3 countries. Except in Nigeria, there is no significant difference in the use of family members for

Table1 Key descriptive statistics and mean differences' tests by gender of the manager

	Nigeria				Tanzania				Uganda			
	Pooled sample	Male managers	Female managers	Diff	Pooled sample	Male managers	Female managers	Diff	Pooled sample	Male managers	Female managers	Diff
Harvest value												
Agricultural productivity (MU/acre)	166,007	167,018	161,090	5,928	196,136	203,084	183,178	19,906	1,071,459	1,203,419	739,559	463,860***
Plot/Parcel characteristics												
GPS-based area (acre)	1.33	1.49	0.53	0.96***	3.35	3.76	2.59	1.18***	2.02	2.83	1.70	1.13***
Plot/parcel is irrigatedΔ	0.16	0.20	0.00	0.20***	0.02	0.02	0.01	0.00	0.01	0.01	0.01	-0.00
Plot/parcel is flatΔ	0.61	0.73	0.00	0.73***	0.72	0.72	0.73	-0.01	0.48	0.49	0.46	0.48
Soil is of good qualityΔ	0.69	0.83	0.00	0.83***	0.47	0.48	0.44	0.04*	0.59	0.69	0.55	0.14***
Manager characteristics												
Age (in years)	50.71	49.82	54.99	-5.17***	50.67	47.95	55.75	-7.80***	47.47	46.06	48.03	-1.97**
Head of the household	0.93	0.99	0.63	0.36***	0.95	0.98	0.88	0.10***	0.78	0.97	0.70	0.28***
IlliteracyΔ	0.56	0.59	0.37	0.23***	0.66	0.75	0.47	0.28***	0.52	0.75	0.43	0.33***
Years of schooling	4.70	4.98	3.34	1.64***	4.51	5.20	3.23	1.97***	3.88	5.42	3.27	2.16***
Access to extension servicesΔ	0.13	0.14	0.06	0.08***	0.12	0.14	0.07	0.07***	0.23	0.26	0.23	0.03
Household characteristics												
Household size	7.01	7.43	4.97	2.46***	6.01	6.54	5.04	1.50***	7.66	7.95	7.54	0.41*
# of male adults	1.82	1.91	1.35	0.56***	1.54	1.81	1.04	0.78***	1.92	2.29	1.77	0.53***
# of female adults	2.02	2.00	2.11	-0.11**	1.70	1.63	1.83	-0.21***	2.39	2.24	2.45	-0.22**
# of children	3.17	3.51	1.50	2.01***	2.77	3.10	2.17	0.93***	3.35	3.42	3.32	0.10
Child dependency ratio	0.98	1.07	0.56	0.51***	0.94	0.96	0.90	0.06	1.04	0.96	1.07	-0.11*
Per adult equiv. household expenditure (MU)	41,949	43,946	32,241	11,705***	75,975	80,640	73,473	7,167***	50,447	50,958	50,270	687.46
Inputs												
Use of organic fertilizer (kg/acre)	8.98	10.61	1.05	9.56***	116.02	119.41	109.71	9.70	25.56	25.96	25.40	0.56
Use of inorganic fertilizer (kg/acre)	110.80	123.22	50.36	72.86***	4.05	4.95	2.38	2.57*	0.46	0.57	0.42	0.15
Use of pesticides (kg/acre)	1.44	1.33	1.97	-0.64	1.63	1.99	0.95	1.04***	0.04	0.07	0.03	0.04**
Use of improved seeds (kg/acre)	56.31	32.69	71.17	-38.48***	38.03	42.06	30.52	11.53*	105.86	140.18	92.21	47.97
Use of family labor (a)	1,914	1,601	3,440	-1839***	84.17	77.39	96.80	-19.41*	67.07	50.93	73.49	-22.56***
Use of male hired labor (Person-day/acre)	29.53	28.93	32.40	-3.47	2.15	2.20	2.04	0.15	1.54	1.30	1.66	-0.34
Use of female hired labor (Person-day/acre)	15.32	12.57	28.51	-15.95***	2.46	2.11	3.10	-0.98**	1.95	1.03	2.31	-1.28***
Use of child hired labor (Person-day/acre)	4.02	3.94	4.43	-0.50	0.48	0.57	0.31	0.26	0.11	0.11	0.11	0.00
Sample size	4,017	3,332 (82.95%)	685 (17.05%)		2,530	1,647 (65.10%)	883 (34.90%)		1,160	830 (71.55%)	330 (28.45%)	

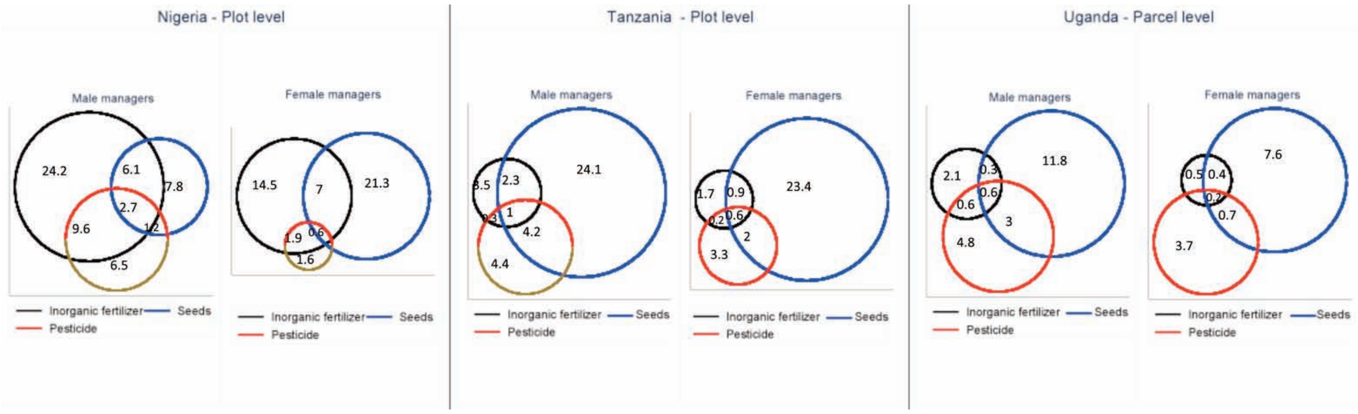
Source: Calculated by the authors based on the LSMS-ISA datasets of the respective countries
Note: MU: Monetary unity: Naira in Nigeria; Tanzania Shillings in Tanzania; Uganda Shillings in Uganda. (a): Hours of work in Nigeria and person-days in Tanzania and Uganda. The mean equality tests are constructed under the null hypothesis that male values of covariates are larger than their female counterparts. (***), (**), and (*) denote significance levels at 1, 5, and 10%, respectively. (Δ) stands for dummy variables.

agriculture between female and male managers. In the three countries, female managers are more likely to hire female workers during periods of soil preparation, weeding, or harvesting. However, it appears that on average the volume of labor (in hours or person-days) spent by family members of female managers is significantly more important than in families with male-managed plots/parcels.

3.2 Models of gender productivity gap

Following Kilic et al (2013), Aguilar et al (2013) and Backiny-Yetna and McGee (2015), an Oaxaca-Blinder (OB) decomposition approach is used to examine the sources of productivity differentials between male and female managers. Accordingly, we first run a model of determinants of agricultural productivity for each country and each gender group by including the same set of covariates reported in table 1 (see Box 1). The advantage of this approach is to isolate the impact of the gender of the land manager on the level of agricultural productivity after controlling for differences in other characteristics. However, given the inability of this model to identify the fundamental causes that trigger productivity differences between male and female managers, a decomposition procedure is also provided (Box 2). This helps understand whether the estimated productivity gaps are due to differences in the levels of observable characteristics between male and female managers (endowment effect) or due to the differences in the returns of these characteristics between both groups (structural effect), or even in differences in both the levels and returns of these observables (interaction effect).

Figure 3 Venn diagrams of three-way input uses by gender of land manager



Source: Calculated by the authors based on the LSMS-ISA datasets of the respective countries.

Box 1 Model of determinants of agricultural productivity

Let y be the natural log of the gross value of agricultural production per unit of land (our measure of productivity), g the gender of the plot/parcel manager, and $\mathbf{X}$ a $K+1$ dimension vector including the set of covariates of land, manager, and household characteristics, and labor and non-labor inputs use and intensity as reported in table 1. The determinants of agricultural productivity can then be modeled using the following production function:

$$y = \sum_{j=0}^{K} \alpha_j x_j + \beta g + \mu \quad , \qquad (1)$$

Where α_j and β are unknown parameters to be estimated and μ is a random error term assumed to be independently and identically distributed with mean zero and variance σ^2.

This model is first estimated for the pooled sample for each country. The existence of a gender productivity gap can then be assessed by checking the significance of the coefficient β in (1). A negative and significant estimated coefficient will be indicative of productivity differential at the expense of female-managed plots/parcels and an inverse conclusion will be reached in the opposite case. We also estimated separately equation (1) for male and female-managed land to identify any significant differences in the impact of various covariates on agricultural productivity.

Box 2 Oaxaca-Blinder decomposition of sources of gender productivity gap

The decomposition starts with equation (1) which is estimated for the pooled sample as well as by gender of the plot/parcel manager as follows:

$$y_g = \sum_{j=0}^{K} \alpha_{gj} x_{gj} + \mu_g \quad , \qquad (2)$$

with $g = \{m; f\}$ and μ_g is again the gender-specific random error term assumed independently and identically distributed, with mean 0 and variable σ^2_g. The rationale behind the OB decomposition approach is therefore to show how much of the mean productivity difference, $G = E(y_m) - E(y_f)$, with $E(y_m)$ and $E(y_f)$ denoting the expected values of agricultural productivity by male and female managers, is accounted for by gender differences in the levels and returns of covariates X. Following Daymont and Andrisani (1984) and Jann (2008), the gender productivity differential G can be also written as:

$$G = E(y_m) - E(y_f) = \underbrace{[E(y_m) - E(y_f)]\beta_f}_{\text{Endowment effect}} + \underbrace{E(y_f)(\beta_m - \beta_f)}_{\text{Structural effect}} + \underbrace{[E(x_m) - E(x_f)](\beta_m - \beta_f)}_{\text{Interaction effect}} , \qquad (3)$$

It follows from equation (3) that gender productivity differential can be explained by three factors:

a. Differences between male and female managers in the levels of observable covariates X. Accordingly, the first component in equation (3) gives the proportion of the estimated productivity gap explained by male and female differences in the levels of those covariates and is called the endowment effect.
b. Differences in the returns of the covariates X. The second, called the structural or coefficient effect, measures the part of the productivity differential attributable to differences in the returns of covariates (including the estimated coefficient of the intercept).
c. Finally, the last component, the interaction effect, captures the portion of productivity gap coming from simultaneous differences in both the predictors and their estimated coefficients.

A positive value of the second component will imply that male managers have a structural advantage over female managers in regards to the specific covariate while a negative value suggests a female structural advantage. The same reasoning holds for the other partial effects in (3).

4 | Main findings

This section presents the empirical results relating to the drivers of agricultural productivity, analyzes the differential impact of various covariates on land exclusively managed by males and females, and decomposes the sources of the estimated productivity gaps.

4.1 Gender and agricultural productivity

Table 3 presents the preliminary results to understand the impact of gender of land manager and other covariates on agricultural productivity. The table conveys the following key messages:

First, in all the three countries, the gender of plot/parcel manager negatively and significantly affects the log gross value of yield levels. In other words, being a female manager is detrimental to reaching higher productivity levels.

After controlling for other factors, these preliminary results point out that on average being a female manager reduces the expected productivity level by 50.8% in Nigeria, while the (unadjusted) female productivity disadvantage drops to 17.5% and 8.5% in Uganda and Tanzania, respectively. This result is consistent with empirical findings by Kilic et al (2013), Aguilar et al (2013) and Backiny-Yetna and McGee (2015).

Second, the results highlight a strong inverse relationship between the value of yield and the farm size. A one percent increase in the plot/parcel size is expected to reduce the value of yield by 0.44%, 0.29%, and 0.39% in Nigeria, Tanzania, and Uganda, respectively. As explained previously, this result might

Table 3 Pooled OLS Regressions of the determinants of agricultural productivity across countries
Dependent variable: Log (Agricultural productivity)

	Nigeria	Tanzania	Uganda
Manager characteristics			
Female manager	-0.508 (0.085)***	-0.085 (0.049)*	-0.175 (0.021)***
Age	-0.001 (0.002)	-0.004 (0.001)***	0.005 (0.004)
Years of schooling	0.011 (0.005)**	0.008 (0.007)	0.024 (0.017)
Access to extension services	0.134 (0.084)	0.197 (0.094)**	0.004 (0.120)
Plot/Parcel characteristics			
GPS-based area	-0.436 (0.034)***	-0.293 (0.031)***	-0.389 (0.074)***
Plot/parcel is irrigated	0.351 (0.345)	0.792 (0.203)***	-0.144 (0.214)
Plot/parcel is flat	-0.309 (0.295)	0.063 (0.050)	-0.004 (0.098)
Self-reported soil quality	0.024 (0.501)	0.168 (0.053)***	0.211 (0.106)**
Non-labor inputs			
Use of organic fertilizer	0.242 (0.511)	0.073 (0.267)	-0.141 (0.506)
Use of inorganic fertilizer	0.470 (0.143)***	0.235 (0.347)	0.463 (0.407)
Use of pesticides	0.201 (0.098)**	0.293 (0.133)**	0.268 (0.226)
Use of improved seeds	0.307 (0.113)***	0.007 (0.096)	0.173 (0.269)
Log of organic fertilizer	0.119 (0.094)	-0.006 (0.046)	0.089 (0.114)
Log of inorganic fertilizer	0.143 (0.032)***	0.187 (0.087)**	0.193 (0.210)
Log of pesticides	0.014 (0.065)	0.015 (0.073)	-0.084 (0.375)
Log of improved seeds	0.074 (0.029)***	0.165 (0.045)***	0.132 (0.075)*
Labor inputs			
Use of family labor	0.208 (0.137)	0.379 (0.277)	0.304 (0.066)***
Use of male hired labor	0.455 (0.097)***	0.155 (0.125)	0.425 (0.273)
Use of female hired labor	0.091 (0.115)	0.090 (0.099)	0.225 (0.304)
Use of child hired labor	0.309 (0.209)	0.333 (0.206)	0.818 (0.563)
Log of family labor (a)	0.078 (0.017)***	0.290 (0.033)***	0.484 (0.073)***
Log of male hired labor	0.229 (0.033)***	0.188 (0.058)***	0.226 (0.124)*
Log of female hired labor	-0.055 (0.046)	0.044 (0.046)	-0.042 (0.122)
Log of child hired labor	-0.075 (0.101)	-0.046 (0.088)	-0.028 (0.321)
Household characteristics			
Household size	-0.049 (0.018)***	0.011 (0.02)	0.033 (0.039)
# of male adults	0.031 (0.030)	-0.003 (0.053)	-0.034 (0.061)
# of female adults	0.057 (0.034)*	0.005 (0.044)	-0.032 (0.062)
Child dependency ratio	0.091 (0.047)*	-0.007 (0.045)	0.024 (0.098)
Log household expenditure	0.141 (0.059)**	0.205 (0.047)***	0.068 (0.470)
Observations	4,017	2,530	1,160
R-squared	0.352	0.380	0.275

Calculated by the authors based on the LSMS-ISA datasets of the respective countries.
Note: (***), (**), and (*) denote significance levels at 1, 5, and 10%, respectively. (Δ) stands for dummy variables.

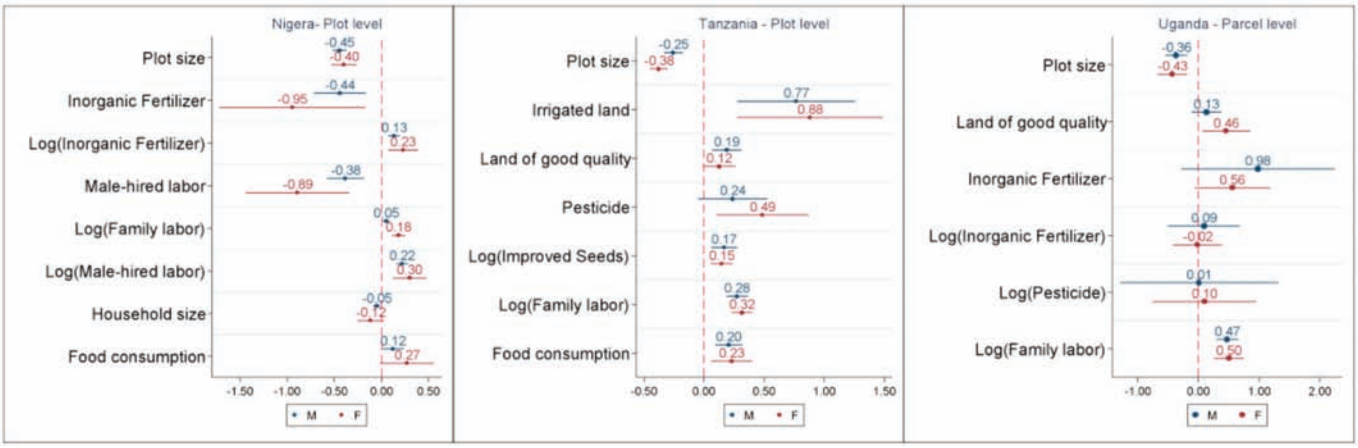
suggest that female managers would have an advantage over male managers since they cultivate on average smaller farms. However, since productivity differences between male and female managers still persist, other factors might be at play to explain the level of agricultural productivity.

Accordingly, Table 2 indicates important differences between the 3 countries as to the impact of non-labor inputs, particularly in the use and intensity of modern inputs. Irrespective of the selected country, the log of improved seeds use per acre is positively associated with land productivity. As shown in the Venn diagrams (Figure 3), farmers are more likely to apply improved seeds than other modern inputs, and so particularly in Tanzania. However, the insignificance of most variables capturing the use and intensity of non-labor inputs is indicative of the low application rates of these inputs by African farmers, be they male or female.

Fourth, the use and intensity of family and hired labor are found to statistically and positively influence the value of yields. Except in Nigeria, the estimated labor elasticities are higher for family labor and hired male labor, suggesting that in Tanzania and Uganda family members working on farm and hired male workers are more productive than other types of labor inputs. Finally, covariates associated with manager and household characteristics do not globally influence agricultural productivity and when they do individually, their effect remains marginal. For instance, the years of schooling seem to have a very small impact on the productivity levels in the three countries.

This can be partly explained by the fact that education attainment is very low in those countries (see Table 1) and the comparative advantage of educated farmers (mostly with primary education level) is too low to affect yield levels or help them adopt and apply

Figure 4 Predictive margins by gender of the land manager



Source: Calculated by the authors based on the LSMS-ISA datasets of the respective countries.

better agricultural practices than less educated. Agricultural productivity is also positively correlated with access to extension services by the farmer, although the impact is only statistically significant in Tanzania.

The graphs in Figure 4 compare the impact of covariates that are simultaneously significant in both the male and female regressions using the productivity equation (2). The graphs depict differences in the magnitude of predictors on female and male productivity levels and provide for each covariate the predictive marginal effects derived from equation (2) and their confidence intervals. In Nigeria, all the jointly significant coefficients display the same signs but only diverge on their magnitude.

Hence, increases in plot size have slightly more negative effects on male-managed plots than on females'. Counterintuitively, the use of inorganic fertilizer has a negative effect on yield values whereas its intensity has the opposite effect. The same pattern also applies to the use and intensity of hired male labor. Unlike in Nigeria, the inverse yield-farm size hypothesis is strongly verified on female-managed lands in Tanzania and Uganda. In these 2 countries, the remaining simultaneously significant covariates positively influence the estimated levels of agricultural productivity.

4.2 Decomposition of the sources of gender productivity gaps in Nigeria, Tanzania, and Uganda

From the preceding sections, the empirical analyses have identified the existence of gender productivity gaps in the three countries under investigation. However, what is more relevant, particularly for policy makers, is to understand the reasons behind these gaps so as to propose measures and interventions likely to reduce or even close the gap.

Table 4 provides the results of the Oaxaca-Blinder decomposition of the gender productivity gap in Nigeria, Tanzania, and Uganda. It summarizes the main findings by group of covariates (see table 2. The regression-based OB decomposition method reports a gender productivity differential of 18.6% in Nigeria, 27.4% in Tanzania, and 30.6% in Uganda. The magnitude of these gaps are in line with those recently estimated in other SSA countries gathering LSMS-ISA datasets: In Niger, Backiny-Yetna and McGee obtained 18.3%; in Malawi, Kilic et al (2013) estimated the gender gap at 25.4%, while in Ethiopia, Aguilar et al (2013) found a gender difference of the order of 23.4%. This recurrent pattern therefore denotes a constant feature of African agriculture where female managers are globally less productive. However, what distinguish the 3 countries under investigation from one another are the sources of these gaps and their relative contributions to the estimated productivity differentials.

In Nigeria, the endowment and structural effects are of opposite signs and represents each more than 300% of the estimated productivity difference. Accordingly, the endowment effect, i.e. the proportion of the gender productivity gap due to differences in the levels of observables between male and female managers, accounts for negative 312% of the gender gap while the structural effect, i.e. the portion of the gender differential attributable to the returns of the same observables, explains 400% of the gap magnitude. This means that in Nigeria female farmers would benefit more from better endowments than their male counterparts while these latter have a clear structural advantage when it comes to the returns of observable characteristics. Conversely, in Tanzania and Uganda, male managers enjoy both endowment and structural advantages over their female counterparts. However, even in these 2 countries, the relative contributions of the sources of gender gaps are neatly different. Indeed, differences between male and female managers in the average characteristics of factors generating agricultural productivity represent the main causes of the observed gender differential in Uganda (+121.2% of the gap against +59.5% in Tanzania). On other hand, it appears from Table 4 that in Tanzania, it is mainly female structural disadvantages in the returns of observable covariates that are to blame for their lower productivity levels. In that country, the structural effect explains 83.6% of the observed gender gap, while in Uganda, it accounts only for 10.5%. These different dynamics across the 3 countries should warn policy makers against a one-fit-all solution or intervention aiming at helping female farmers to move out of productivity traps they are generally caught into. Hence, before designing policy interventions to reduce or close this gap, a special emphasis should therefore be put on the identification and understanding of the fundamental sources of female disadvantages in agricultural production processes.

The last part of Table 4 provides a detailed decomposition of the 3 sources of gender gap. Again, each country stands out when compared with others. In Nigeria, the endowment effect is almost entirely explained by differences in plot characteristics between male and female managers (86.7% of the total endowment effect). Indeed, as explained previously, it is in Nigeria where the land size gap (-64.4%) is the largest and where female managers simultaneously cultivate less irrigated land of relatively poor/average quality.

Table 4 Sources of gender productivity gaps in Nigeria, Tanzania, and Uganda – Decomposition by groups of covariates

	Nigeria			Tanzania			Uganda		
1. Gender differential									
Mean male productivity	11.307 (0.051)***			10.901 (0.071)***			12.881 (0.082)***		
Mean female productivity	11.121 (0.106)***			10.627 (0.117)***			12.574 (0.118)***		
Gender gap	**0.186 (0.104)***			**0.274 (0.119)****			**0.306 (0.136)****		
2. Aggregate decomposition	Endowment effect	Structural effect	Interaction effect	Endowment effect	Structural effect	Interaction effect	Endowment effect	Structural effect	Interaction effect
Total	-0.581	0.750	0.017	0.163	0.229	-0.118	0.371	0.032	-0.097
	(0.129)***	(0.092)***	(0.115)	(0.149)	(0.176)	(0.199)	(0.136)***	(0.126)	(0.128)
Share of total gap	-312.4%	403.2%	9.2%	59.5%	83.6%	-43.1%	121.2%	10.5%	-31.7%
3. Detailed decomposition									
Manager characteristics	0.037 (0.038)	0.161 (0.328)	-0.042 (0.040)	0.018 (0.085)	0.320 (0.646)	0.071 (0.096)	0.012 (0.060)	0.179 (0.401)	-0.077 (0.074)
Land characteristics	-0.504 (0.096)***	0.084 (0.105)	-0.073 (0.092)	0.045 (0.056)	-0.091 (0.208)	-0.020 (0.056)	0.148 (0.077)*	-0.215 (0.174)	0.012 (0.083)
Non-labor inputs	0.029 (0.048)	0.023 (0.061)	0.027 (0.051)	0.021 (0.028)	0.102 (0.080)	0.031 (0.030)	-0.021 (0.022)	0.029 (0.058)	-0.003 (0.027)
Labor inputs	-0.057 (0.052)	0.556 (0.243)*	0.016 (0.052)	-0.113 (0.055)**	0.128 (2.272)	0.043 (0.035)	0.233 (0.078)***	2.239 (0.957)**	-0.015 (0.077)
Household characteristics	-0.087 (0.092)	-1.650 (1.759)	0.090 (0.098)	0.193 (0.151)	-5.854 (3.369)*	-0.243 (0.209)	-0.000 (0.047)	-4.824 (1.739)***	-0.013 (0.055)

Source: Calculated by the authors based on the LSMS-ISA datasets of the respective countries.
Note: Clustered-robust standard errors are reported into parentheses. (***), (**), and (*) denote significance levels at 1, 5, and 10% respectively. All the group variables in the detailed decomposition were previously defined (see Table 1).

The negative endowment effect therefore suggests that policies targeted at improving women's endowments in both the quantity and quality of cultivated land might be more effective in addressing the productivity than in Tanzania or Uganda, for example. In Tanzania, differences in labor inputs significantly explain the largest part of the endowment effect (69.3%) while in Uganda it is both differences in parcel characteristics (39.8%) and in labor inputs (62.8%) that are its main drivers.

Similar to the endowment effect, the sources of the structural effect vary across countries. The use and intensity of labor inputs as a whole appear to be more effective on male-managed lands in Nigeria and Uganda whereas household characteristics strongly affect the magnitude of the structural effect on female-managed lands in Tanzania and Uganda. Finally, the fact that differences in non-labor inputs do not explain any of the components of the OB decomposition is indicative of their use by only a small portion of farmers in those countries.

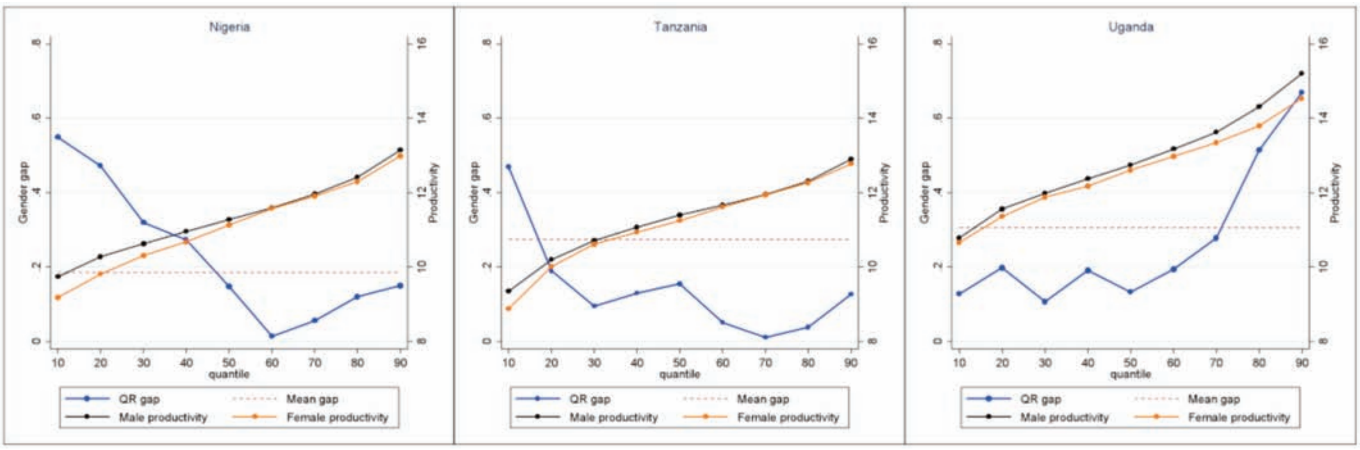
4.3 Going beyond the mean decomposition: gender gaps across the productivity distribution

The gender productivity gaps from the previous section were computed by comparing an average male manager with an average female manager. The analysis thus implicitly assumed that the estimated gender gaps were uniformly distributed across the productivity distribution. But, this may not necessarily be the case and may hide large variations in the gender gap depending on where we are on the productivity distribution. For instance, the gap between the lowest-productive female managers and the lowest-productive males and between the highest-productive women and men may diverge substantially from those obtained using mean decomposition approaches.

To go beyond the Oaxaca-Blinder decomposition approach, we analyze gender gaps across the entire productivity distribution in Nigeria, Tanzania, and Uganda using a quantile regression (QR) framework (Firpo et al, 2009). This enables us to investigate the extent to which the gender of plot/parcel manager influence the location, scale, and shape of the productivity distribution. Graphs in Figure 5 plot the gender productivity gaps when considering the entire productivity distribution and both the estimated male and female productivities at each decile. Key messages can be drawn from these figures.

First, irrespective of the country, the gender gap is distributed unevenly across the productivity distribution. Moreover, both the estimated male and female productivities are increasing in the three countries as we move towards higher deciles, though at different rates. Another interesting point that stands out from these graphs is that all the estimated gender differentials are positive at each decile. Hence, even when we assume heterogeneity of farmers along the productivity distribution,

Figure 5 Predicted gender gaps, male and female productivity by country and quantile



Source: Calculated by the authors based on the LSMS-ISA datasets of the respective countries.

female managers appear to be always disadvantaged. Second, in Nigeria, the productivity gap lies above its mean value (the horizontal dashed line) at lower productivity levels, drops below the mean between the 40th and 50th percentile, keeps falling until the 60th percentile, before starting to increase afterwards. The same pattern can be detected in Tanzania with the notable difference that the intersection between the QR and the mean gaps intervenes earlier, between the first and second deciles.
Uganda shows a completely different shape of productivity distribution. In contrast to Nigeria and Tanzania, the QR gap is lower than the mean gap at low productivity levels and has an increasing trend.

Third, the comparison of the gender gaps at specific points of the distribution reveals the extent of differences across the three countries. First, take the difference of the gender gaps obtained at the 90th and 10th percentiles. In Nigeria, the gender gap is 15% for the top of tenth of farmers, compared to the 54.9% for farmers at the bottom tenth of the distribution, giving a difference of -39.9%. In Tanzania, these gaps are respectively of 12.6% and 46.9%, representing a differential of -34.3%. This means that in those countries, it would be easier for female managers to advance towards the top of the productivity ladder once their endowment and structural disadvantages have been eliminated than for instance in Uganda where the gender gap for the highest productive farmers is 66.9% against only 12.7% for the lowest productive. This also indicates that measuring gender gaps at the mean of the productivity distribution may sometimes give an incomplete or even an inaccurate picture of the extent of differences between male and female managers. Hence, a more prudent approach would require to confirm the conclusions from mean comparison approaches by insights from other methods, such as conditional or unconditional quantile regressions.

5 | Conclusion and policy implications

Structural transformation of Africa's agriculture is a prerequisite for enhancing agricultural productivity, food security and poverty reduction in the continent. However, a critical ingredient of such a transformation is gender equality, given its potential impact on social inclusion and employment generation. Unfortunately, available evidence reveals that Africa's agricultural landscape is characterized by gender inequalities disproportionately against women. These gender-based differences ranged from access to productive resources, low rates of technology adoption to economic capacities and incentives. Hence, a good understanding of the extent and sources of gender productivity gaps is imperative for the success of policy interventions aiming at empowering women. Against this backdrop, this brief investigates the gender inequality in agricultural productivity and highlights the key drivers of productivity differentials between male and female manages.

Empirical results are derived using publicly available, nationally representative, and country-comparable microeconomic surveys recently collected in Nigeria, Tanzania, and Uganda as part of the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). The main results suggest that, in the three countries, female managers of agricultural lands have a clear endowment disadvantage in most factors generating agricultural productivity such as farm size and use or intensity of non-labor inputs. Furthermore, the analysis finds that on average female-managed agricultural lands are 18.6, 27.4, and 30.6 percent less productive than their male counterparts in Nigeria, Tanzania, and Uganda, respectively. However, these gaps are not uniformly distributed across the productivity distribution, decreasing as we approach towards the top of the distribution in Nigeria and Tanzania while increasing in Uganda.

The decomposition of the sources of gender productivity differences indicates that in the three countries, endowment and structural disadvantages of female managers in land size, land quality, labor inputs, and household characteristics are the main drivers of gender gaps. Nonetheless, the brief has shown that these different sources are not equally important across the three countries.

The nature of these dynamics across the 3 countries should warn policy makers against a one-fit-all solution or intervention aiming at helping female farmers to move out of productivity traps they are generally caught into. From a policy perspective, the results of this study have important implications for policy targeting. Eliminating the gender gaps in agriculture would produce tangible benefits by unlocking women's productivity potential. Accordingly, beyond gains in production, consumption and poverty, other non-negligible indirect gains could be realized from achieving gender equality in agriculture or from substantially reducing its current magnitude. These indirect effects include increases in female managers' bargaining power and improvements in their social status as their earnings increase, better child nutrition, health, and education attainment in households with female-managed plots.

To benefit from these direct and/or indirect effects of closing or reducing the gender productivity differentials, necessary measures need to be taken by policy makers. First, as clearly highlighted in the paper, discriminatory laws or customs prevent many women in Sub-Saharan Africa to acquire and/or hold land.

Hence, improvements in land tenure systems and fight against both iniquitous laws and constraints in accessing land are crucial if we target gender productivity inequality. Second, reforming customary land rights, often developed at the expense of women, may help increase land inheritance and ownership by women. Finally, reducing gender productivity gaps will also require tackling gender gaps in accessing modern inputs, extension and financial services (credits and insurance, in particular), and in the levels of human and social capital (FAO, 2011).

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Annex 1 - Definition of key variables used

Category	Variables	Definition
Manager characteristics	Female manager	1 if female manager
	Age	Log values of the age of manager in complete years
	Years of schooling	Complete years of schooling of the manager
	Access to extension services	1 if manager had access to extension services
Plot/Parcel characteristics	GPS-based area	Log of GPS-based cultivated plot/parcel
	Plot/parcel is irrigated	1 if plot/parcel is irrigated
	Plot/parcel is flat	1 if plot/parcel is flat
	Self-reported soil quality	1 if soil is of good quality
Non-labor inputs	Use of organic fertilizer	1 if manager applied organic fertilizer
	Use of inorganic fertilizer	1 if manager applied inorganic fertilizer
	Use of pesticides	1 if manager applied pesticides
	Use of improved seeds	1 if manager applied improved seeds
	Log of organic fertilizer	Log values of quantities of organic fertilizer used per acre
	Log of inorganic fertilizer	Log values of quantities of inorganic fertilizer used per acre
	Log of pesticides	Log values of quantities of pesticides used per acre
	Log of improved seeds	Log values of quantities of improved seeds used per acre
Labor inputs	Use of family labor	1 if manager used family labor on plot/parcel
	Use of male hired labor	1 if manager hired male labor
	Use of female hired labor	1 if manager hired female labor
	Use of child hired labor	1 if manager hired child labor
	Log family labor (a)	Log values of hours/person-days of family labor per acre
	Log of male hired labor	Log values of person-days of male hired labor per acre
	Log of female hired labor	Log values of person-days of female hired labor per acre
	Log of child hired labor	Log values of person-days of child hired labor per acre
Household characteristics	Household size	Number of household members
	# of male adults	Number of male adults aged between 15 and 65 years old
	# of female adults	Number of female adults aged between 15 and 65 years old
	Child dependency ratio	Number of people aged 0-14 over number of people aged 15-64
	Log household expenditure	Log values of monthly household expenditures per adult equivalent

Source: NGHS (2012-13), TNPS (2012-13), and UNPS (2011-12)